Report Review Form

Report Title: Environmental Impact Assessment (EIA) Report For Bawdwin Project by Win Myint Mo Industries Co., Ltd.	
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Checked Date: 20/09/2023	**Signature:**
Summary: EIA Report This document presents the **Environmental Impact Assessment (EIA)** report as required for Bawdwin Project.	**Approved by: U Tin Aung Moe (Director)**

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Bawdwin Project

Environmental Impact Assessment
Glossary and abbreviations

October 2023

Bawdwin Project

Prepared for

Win Myint Mo Industries Company Limited

Prepared by

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Glossary

32 Mile tailings dumps *n.* the site located southeast of Namtu smelter complex adjacent to Namtu Camp where tailings from the Namtu pre-war concentrator plant site were stored and are being reprocessed. The site is located on the Namtu concession.

32 Mile facility *n.* the Namtu pre-war concentrator plant site which is located adjacent to the 32-Mile point of the railway. The site is located on the Namtu concession.

A

access road *n.* primary transport route to, from and within the project area.

acid mine drainage (AMD) *n.* outflow of acidic and often metallic water from the mine, ore or mine waste (tailings and waste rock).

adit *n.* horizontal tunnel into a mine for access or drainage.

airshed *n.* an air mass within a defined geographic area that behaves consistently with respect to the dispersion of emissions.

anthropogenic *adj.* relating to, or resulting from, human activity.

apron feeder *n.* a mechanical piece of equipment used in material handing operations to transfer material to other equipment or extract material (ore/rock) from storage stockpiles, bins or hoppers at a controlled rate of speed.

aquatic ecology *n.* the biological system comprising plants and animals living or found in or near water.

aquifer *n.* an underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials (gravel, sand, or silt).

artisanal mining *v.* the mining of minerals by an independent individual (not associated with a mine or mining company).

B

batter *n.* the inclined section of the open-pit wall, which comprises a series of benches and batters.

Bawdwin concentrator plant *n.* the concentrator plant located adjacent to the Bawdwin open pit mine and opposite the Marmion Shaft.

Bawdwin mine *n.* the underground mine, open pit mine and associated infrastructure located at Bawdwin, currently not operating.

Bawdwin area *n.* includes Bawdwin mine villages and infrastructure, Wallah Gorge and Tiger Camp.

Bawdwin concession *n.* the concession covering the Bawdwin mine, Wallah Gorge and Tiger Tunnel.

Bawdwin open pit *n.* the open cut mine located adjacent to the Marmion Shaft.

Bawdwin underground mine *n.* the underground workings of the Bawdwin mine comprising eleven levels.

Bawdwin village *n.* the ward containing the Bawdwin mine villages which are located upstream (Bawdwin upper village) and downstream (Bawdwin lower village) of the mine site and include Tiger Camp.

bench *n.* working surface of an open pit mine that is progressively reduced to a narrow permanent feature of the open pit wall as each level is developed.

BJV *n.* joint venture operating agreement between Win Myint Mo Industries Co., Ltd. (WMM), Myanmar Metals Limited (MYL) and East Asia Power Global Mining Co., Ltd. (EAP) who have committed to redeveloping the Bawdwin mine.

biodiversity *n.* the variety among all living things including the different plants, animals and microorganisms, the genetic information they contain, and the ecosystems that they form.

blasting *v.* the use of explosives to break rock.

bund *n.* an earth, rock, or concrete embankment constructed to prevent the migration of liquids or the transmission of noise.

C

catchment *n.* the area from which water drains to a specific watercourse or waterbody.

Chin Lode *n.* the small copper-rich orebody located north of the Shan Lode.

China Lode *n.* the main orebody developed by the Bawdwin underground mine and more recently the Bawdwin open pit mine**.**

concentrate *n.* a mixed assemblage of ore minerals that is a saleable product of the project. The project will produce lead-silver concentrate and zinc concentrate.

concentrator plant *n.* a processing plant that uses crushing, grinding, floatation and chemicals to separate minerals from ore to produce a mineral concentrate.

confluence *n.* the area where two or more rivers meet, such as where a tributary meets a major river.

D

decommissioning *v.* the process of preparing a mine for closure. It begins at the end of mining and involves demolition and disposal of all unwanted infrastructure and services.

diamond drilling *v.* form of drilling which uses a rotary drill with a diamond drill bit attached to create holes and allow a core sample to be extracted.

displacement *v.* physical displacement (relocation or loss of shelter) and economic displacement (loss of assets or access to assets that leads to loss of income sources or other means of livelihood) as a result of project-related land acquisition and/or restrictions on land use (IFC, 2012).

disturbance *v.* the disruption of existing features or conditions.

E

earthworks *v.* engineering works created through the moving or processing of parts of the earth's surface involving quantities of soil or unformed rock.

easement *n.* a right to cross or otherwise use someone else's land for a specified purpose.

ecosystem *n.* an interacting system of animals, plants, other organisms and non-living parts of the environment.

ecosystem services *n.* benefits to humans provided by the natural environment and from healthy ecosystems. For example, food and water; flood and disease control; spiritual, recreational, and cultural benefits; and supporting services such as nutrient cycling that maintain the conditions for life on Earth.

ecotoxicity *n.* the potential for biological, chemical or physical stressors to affect ecosystems.

effluent *n.* waste material that may be discharged into the environment.

embankment *n.* an area of material used to support a roadway or to hold back water.

endemic *adj.* native to a certain area.

ER valley *n.* the valley located southeast of Bawdwin open pit mine into which waste rock has been dumped. The watercourse draining the valley is a tributary of Nam Pangyun stream.

ER valley waste rock dump *n.* the waste rock dump in ER valley that is actively eroding.

F

feed hopper *n.* a funnel shaped piece of equipment which feeds material into the next section of the grinding circuit.

flume *n.* a manmade channel for transport and redirection of water.

fractured rock aquifer *n.* where groundwater is stored in the fractures, joints, bedding planes and cavities of the rock mass and water availability is largely dependent on the nature of the fractures and their interconnection.

fugitive dust *n.* very small particles suspended in the air from the physical movement of soil, vehicle movements, heavy machinery operation and wind.

G

Gossan Quarry *n.* open pit mine within the Bawdwin concession that was operated from the early 1980s until 2009 to access lower grade ore.

grizzly *n.* a metal grid/screen used to remove rocks over a certain size.

ground penetrating radar *n.* a non-destructive method of detecting subsurface structures using electromagnetic radiation.

groundwater *n.* water stored in rock and soil below the land surface.

groundwater dependent ecosystem *n.* ecological community that rely on groundwater to meet some or all of their requirements.

H

halo zone *n.* the area of lower-grade ore located surrounding the main ore body.

haul road *n.* a road used to transport material within the project area.

hazardous material/waste *n.* any solid, liquid or contained gaseous substance with properties that make it potentially dangerous or harmful to human health, safety and/or the environment.

headwaters *n.* the origin or source of a stream or river.

high density polyethylene *n.* a strong, corrosion resistant material used to construct pipes and liners.

hydraulic conductivity *n.* a measure of the ability of water to pass through soil or rock.

hydraulic connectivity *n.* a measure of hydraulic interaction between aquifers, between different parts of the same aquifer, and between groundwater and surface water systems.

hydraulic loading *n.* added pressure on groundwater in a water-bearing unit beneath and surrounding a water-filled structure, such as a dam.

I

indicated (mineral resource classification) *adj.* available drillhole and channel sampling data and geological interpretation are sufficient to reasonably estimate the geological and grade continuity of a mineral resource.

inferred (mineral resource classification) *adj.* available drillhole and channel sampling data and geological interpretation are sufficient to imply but not verify geological and grade continuity of a mineral resource.

intangible heritage *n.* the practices, representations, expressions, knowledge, skills – as well as the instruments, objects, artefacts and cultural spaces associated therewith – that communities, groups and, in some cases, individuals recognise as part of their cultural heritage and transmit from generation to generation.

International Finance Corporation *n.* an international financial institution that is a member of the World Bank Group that offers investment, advisory, and asset-management services to encourage private-sector development in less developed countries.

J

jaw crusher *n.* a crusher which reduces the size of rocks by compression.

JORC Code *n.* The Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves is a professional code of practice that sets minimum standards for public reporting of minerals exploration results, mineral resources and ore reserves according to the levels of confidence in geological knowledge and technical and economic considerations.

K

Karst *n.* landscape features (including caves) within limestone which form as a result of the limestone being dissolved.

L

lithology *n.* general physical characteristics of a rock or the rocks in a particular area.

lode *n.* deposit of metalliferous ore that fills or is embedded in a fissure (or crack) in a rock formation or a vein of ore that is deposited or embedded between layers of rock.

M

Marmion Shaft *n.* the vertical shaft constructed to develop the Bawdwin underground mine in the early 20th century.

Meingtha Lode *n.* the orebody located southeast of the China Lode beneath ER valley.

milling operations *n.* process of reducing materials to a powder of fine or very fine size.

mineral resource *n.* concentration of material of economic interest in or on the earth's crust.

mineralisation *n.* the chemical alteration, replacement, and enrichment of minerals.

mounding *v.* locally raised groundwater levels normally as result of concentrated groundwater recharge.

Myitnge River *n.* the major watercourse flowing generally southerly through Namtu. Also referred to as Namtu River.

N

Nam La *n.* the watercourse flowing parallel to Nam Pangyun stream through Namtu and discharging to the Namtu River upstream of the Namtu smelter complex.

Nam La catchment *n.* area where water is collected by the natural landscape and feeds the Nam La.

Nam Pangyun catchment *n.* area where water is collected by the natural landscape and feeds the Nam Pangyun.

Nam Pangyun Reservoir *n.* existing reservoir at the headwaters of a tributary of the Nam Pangyun, north of the mine, that was established to provide water for historic mine activities.

Nam Pangyun *n.* the watercourse flowing through the Bawdwin mine site and discharging to the Namtu River downstream of the Namtu smelter complex.

nameplate capacity *n.* intended full-load sustained output of a facility.

Namtu *n.* the town located west of Lashio on the Namtu River and comprising two parts, Namtu Camp located south of the river and Panghai north of the river.

Namtu-Bawdwin *n.* the area encompassing the Bawdwin mine site, Bawdwin village, Wallah Gorge, Tiger Camp, Tiger Tunnel, and Namtu.

Namtu concession *n.* the concession covering Namtu smelter complex, Namtu Town and 32 Mile facilities.

Namtu pre-war concentrator plant *n.* the concentrator plant ruins located at 32 Mile, adjacent to the tailings dumps.

Namtu River *n.* the major watercourse flowing generally southerly through Namtu. Also referred to as Myitnge River.

Namtu smelter complex *n.* the Namtu concentrator plant, smelter and refinery and associated infrastructure.

NEQ Guidelines *n.* National Environmental Quality (Emission) Guidelines.

non-hazardous waste *n.* any unwanted or unusable solid, liquid or gaseous substance that does not pose an immediate hazard to human health, safety and/or the environment.

O

ore *n.* a naturally occurring material which is rich in a metal(s) or valuable mineral that can be extracted.

ore body *n.* the mass of naturally occurring ore material.

open-pit mining *adj.* the process of excavating rock or minerals from the earth by their removal from an open pit.

overburden *n.* rock or soil overlying an ore body.

P

perennial *adj.* lasting for a long or infinite time.

phytotoxic *adj.* toxic to plants.

$PM_{2.5}$ *n.* particulates with a diameter less than 2.5 µm.

PM_{10} *n.* particulates with a diameter less than 10 µm.

polymetallic *adj.* containing more than metal, usually used in reference to a mine or ore in which multiple metals can be economically recovered.

processing infrastructure *n.* a new process plant and associated infrastructure including laboratory, reagents storage, water supply, workshop, warehouse and tailings storage facilities.

project footprint *n.* the area of land disturbed or occupied by the proposed activities or facilities (e.g., mine pit, tailings storage facilities, waste rock dump, haul roads).

R

reagent *n.* in ore processing this is a chemical added during the mineral concentration process to cause/aid a chemical reaction

recharge *v.* water inflow to aquifers.

refine *v.* to process mineral to its pure state.

regolith. *n.* unconsolidated material overlying the bedrock and beneath the subsoil layer.

rehabilitation *n.* the process of stabilising and revegetating disturbed areas (for example, mine batters) to create a stable, non-polluting landform and self-sustaining vegetation.

resettlement *n.* defined as a process of planning and implementing activities that manage the effects of displacement.

resource *n.* in the context of minerals, a concentration of minerals reasonably well known by its location, quantity, grade and continuity, which has a reasonable prospect of economic extraction.

reverse circulation drilling *v.* a method of drilling in which the drilled material is continuously transported to the surface as drilling occurs.

revegetation *n.* the process of preparing disturbed land to establish the right conditions to encourage a new vegetative cover by natural processes such as plant colonisation and succession, or manmade/active accelerated processes such as direct seeding or seed propagation and planting.

riparian vegetation *n.* plants and vegetation along the edges of a watercourse.

S

saprolite aquifer *n.* an aquifer within a chemically weathered rock that forms in the lower zones of soil horizons and represents deep weathering of the bedrock surface.

sedimentation *n.* the process in which sediment settles or is deposited.

sedimentation basin/pond *n.* a dedicated pond/site that captures sediment by allowing it to settle from water.

Shan Lode *n.* the orebody located northwest of the China Lode in the Nam Pangyun stream valley.

sidecast *v.* reject waste material that has been excavated and dumped to or over the side, rather than hauling it away.

significance assessment *n.* values-based approach that assesses the potential significance of impacts by considering the sensitivity of values to change, and the magnitude of change that they are predicted to experience as a result of project related activities.

slag *n.* glass-like by-product left over after a desired metal has been separated from its raw ore. Slag is usually a mixture of metal oxides and silicon dioxide.

smelter *n.* a processing plant for smelting a metal from its ore.

smelting *v.* an extractive metallurgical process of applying extreme heat to ore in order to extract a base metal such as silver, iron, lead and copper.

spillway *n.* structure used to provide the controlled release of overflows from a dam into a downstream area.

stope *n.* an excavation in a mine working or quarry in the form of a step or notch.

supernatant *n.* the liquid overlying a deposit of settled or precipitated material.

T

tailings *n.* the unrecoverable and uneconomic metals, minerals, chemicals, organics and process water that are left over after the process of separating the valuable fraction from the uneconomic fraction (gangue) of an ore.

tailings storage facility *n.* a dam constructed to store tailings.

tangible heritage *n.* the sites, places, structures/buildings and artefacts that form part of the cultural heritage of communities or groups.

terrestrial ecosystem *n.* land-based community of organisms and the interactions of biotic and abiotic components in an area.

Tiger Camp *n.* the settlements (collectively) located adjacent to Wallah Gorge.

Tiger Tunnel *n.* the adit constructed from Wallah Gorge to Level 6 in the Bawdwin underground mine.

trash screen *n.* protective screen for removing detritus from the pulp stream ahead of a processing unit.

trommel *n.* a cylindrical gridded screen which separates large particles from the SAG mill discharge.

V

village tract *n.* an administrative area within a township comprising several villages.

W

Wallah Gorge *n.* the site adjacent to Tiger Tunnel portal that contains the historical rail sidings, ore wagon dumper, ore bins and 360-degree spiral railway downstream of the ore bins.

ward *n.* an administrative area within a larger village.

waste rock *n.* all material, other than ore, excavated from a mine in order to recover the ore.

waste rock dump *n.* constructed landform for the disposal of overburden and waste rock.

watercourse *n.* a creek, stream, river or other water channel, either natural or man-made, temporary or permanent.

weightometer *n.* a device installed on a conveyer belt to continuously weigh material.

weir *n.* a dam or barrier which alters the flow of a watercourse.

Abbreviations and acronyms

Abbreviations and acronyms	Full term/name
µm	micrometre
AC	acid consuming

Abbreviations and acronyms	Full term/name
ACL	added contaminant limit
ADB	Asian Development Bank
Ag	silver
AMD	acid mine drainage
AMSL	above mean sea level
ASL	above sea level
ANC	acid neutralising capacity
ANCOLD	Australian National Committee on Large Dams
ANZ	Australia and New Zealand (referring to ambient water quality guidelines)
ARI	average recurrence interval
ASX	Australian Stock Exchange
BMMC	Base Metal Mining Co Ltd
BJV	Bawdwin Joint Venture
BMR	Bright Mountain Resources Myanmar Ltd
CBO	community based organisation
CDIV	construction versus design intent verification
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CSA	CSA Global Pty Ltd
Cu	copper
dB	decibel
dBA	A-weighted decibel
DFS	definitive feasibility study
DGSE	Department of Geological Survey and Mineral Exploration
DGV	default guideline value
DOH	Department of Health
DoM	Department of Mines
DZGD	Dry Zone Greening Department
EAO	ethnic armed organization
EAP	East Asia Power Global Mining Co., Ltd.
EC	electrical conductivity
ECC	environmental compliance certificate
ECD	Environment and Conservation Department, Ministry of Natural Resources and Environmental Conservation
EIA	environmental impact assessment
EIL	ecological investigation level
EITI	Extractive Industries Transparency Initiative

Abbreviations and acronyms	Full term/name
EMP	environmental management plan
EPCM	engineering, procurement and construction management
ERP	emergency response plan
ESH	environmental safety and health
ESMF	environmental and social management framework
ESMP	environmental and social management plan
FD	Forest Department
FE	finite element
FoS	factor of safety
FPNCC	Federal Political Negotiations and Consultative Committee
ft	feet
GAD	General Administration Department
GDE	groundwater dependent ecosystem
GDP	gross domestic product
GV-high	upper guideline value (of ANZ ambient water quality guidelines)
ha	hectares
HCI	hydrochloric acid
HDPE	high density polyethylene
IBC	intermediate bulk containers
ICMM	International Council of Mining and Metals
ICOMOS	International Council on Monuments and Sites
IEE	initial environmental examination
IFC	International Finance Corporation
ISO	International Organization for Standardization
IUCN	International Union for Conservation of Nature
IWL	integrated waste landform
JORC	Joint Ore Reserves Committee
KBA	key biodiversity area
KIA	Kachin Independence Army
km	kilometres
ktpa	kilotonnes per annum
kV	kilovolts
ME-1	No.1 Mining Enterprise, Ministry of Natural Resources and Environmental Conservation
MED	Merlin Diamonds Ltd
MIC	Myanmar Investment Commission

Abbreviations and acronyms	Full term/name
MNDAA	Myanmar National Democratic Alliance Army
MONREC	Ministry of Natural Resources and Environmental Conservation
MPA	maximum potential acidity
MSA	mining services area
MSDP	Myanmar Sustainable Development Plan
Mt	million tonnes
Mtpa	million tonnes per annum
MYL	Myanmar Metals Limited
NAF	non-acid forming
NAG	net acid generation
NAPP	net acid producing potential
NCA	Nationwide Ceasefire Agreement
NDWQ Guidelines	National Drinking Water Quality Guidelines
NEPM	National Environmental Protection Measure
NEQ Guidelines	National Environmental Quality (Emission) Guidelines
NGO	non-governmental organisation
NIHC	National Infrastructure Holdings Company Limited
NIOS	National Institute for Occupational Safety and Health
NSW	New South Wales, Australia
OMS	operations, maintenance and surveillance
OSA	on-stream analysis
PAP	project-affected persons
PAF	potentially acid forming
Pb	lead
PFS	prefeasibility study
PMF	probable maximum flood
PMP	probable maximum precipitation
ppv	peak particle velocity
PS	IFC Performance Standard
PSC	Production Sharing Contract
ppm	parts per million
QAQC	quality assurance and quality control
RC	reverse circulation
RCSS	Restoration Council of Shan State
RHC	rural health centre

Abbreviations and acronyms	Full term/name
RL	reduced level
RO	reverse osmosis
ROM	run-of-mine
SAG	semi-autogenous grinding
SAZ	Self-Administered Zone
SHEC	Safety, Health, Environment and Communities
SOE	State-Owned Enterprises
SSA	Shan State Army
STP	sewage treatment plant
TCEQ	Texas Commission on Environmental Quality
TICCIH	The International Committee for the Conservation of the Industrial Heritage
TDS	total dissolved solids
TNLA	Ta'ang National Liberation Army
TSF	tailings storage facility
TSS	total suspended solids
UNESCO	United Nations Educational, Scientific and Cultural Organisation
USEPA	United States Environmental Protection Authority
UWSA	United Wa State Army
UXO	unexploded ordnance
VMS	volcanogenic massive sulfide
W/VTA	Ward or Village-Tract Administrator
WAD	weak acid dissociable (of cyanide)
WGS	World Geodetic System
WHO	World Health Organisation
WMM	Win Myint Mo Industries Company Limited
WRD	waste rock dump
XRF	x-ray fluorescence
Zn	zinc

Win Myint Mo Industries Company Limited

Bawdwin Project

Environmental Impact Assessment
Executive summary

October 2023

Bawdwin Project

Prepared for

Win Myint Mo Industries Company Limited

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Rev0	1	electronic	Rob Cicchini (BJV)	05/02/2021
Rev1	1	electronic	Win Myint Mo Industries Co., Ltd.	22/09/2023

Disclaimer

This report has been prepared within the terms of references (TOR) adopted for this report and those of the contract with the client according to the prevailing active Laws, Rules, Regulations, and Procedures within the framework of Myanmar Environmental Impact Assessment Procedure 2015. We do not assume any responsibility or liability in regard with any matters beyond the scope of the TOR and the contract.

Data analysis, impact assessment, devising mitigation measures and report formulation were carried out based on the information/plan/processes provided by the project proponent, available secondary data and information, and onsite observation and measurement of E Guard's environmental study team in line with the relevant national and international guidelines and standards. While we do take effort to ensure that the information contained in this report is reliable and accurate, we disclaim no responsibility for errors and omissions which might occur despites of our reasonable skill and care.

Drawings, sketches, maps, and other illustrative figures used for demonstrative and/or descriptive purposes in this report are not to be considered as neither approved boundary nor accepted territory not recognized properties extend of any kind. In case of dual or multiple meanings of the wordings, it is advisable to take the most relevant meaning within the context of the concerned areas discussed in this report.

The personal, organizational, and commercial data and information contained in this report were included solely upon the demand and requirements of concerned authority, and we have no intention of breaching the privacy or disclosing the trade secrets whatsoever.

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Plates

Executive summary

Introduction

Win Myint Mo Industries Company Limited propose to redevelop the 600-year old Bawdwin mine (the 'Bawdwin project'), a lead-zinc-silver mine in northern Shan State, Myanmar. The Bawdwin project is located approximately 385 kilometres (km) northeast of the capital of Myanmar and approximately 11 km east of Namtu, which is 40 km east of Lashio, the capital of Shan State, as shown in Figure ES.1.

The existing Bawdwin mine has an open pit, underground workings and associated processing infrastructure. The Bawdwin project will involve expanding the existing open pit and construction of new mineral processing and supporting infrastructure. The project has a 13-year mine life and will process ore at a rate of up to 3.0 million tonnes (Mt) per annum to produce lead-silver and zinc concentrates. There is the potential for further expansion of the mine, which could extend the life of the mine up to 50 years. The lead, silver and zinc mineral resource at Bawdwin is estimated at approximately 100 Mt.

WMM contracted Coffey Myanmar Limited and Valentis Services Limited (Coffey & Valentis) to prepare the Environmental Impact Assessment in accordance with the Environmental Impact Assessment Procedure legislated by the Myanmar *Environmental Conservation Law 2012*. Although Coffey & Valentis prepared the draft EIA report for Bawdwin project, they can't continue report preparation in current situation. So WMM contacted E Guard Environmental Services in May 2023 for EIA report revising of Bawdwin project. E Guard environmental Services started report preparation on 1st June 2023.

Background

The Bawdwin mine is one of the longest operating and most important base metal mines in the world with a history of mining dating back to the beginning of the fifteenth century. The history of the Bawdwin mine can be separated into five broad phases:

- The early discovery and possible working of the ore interpreted from the archaeological record.
- Chinese mining commencing in 1412 and continuing until 1868. During this phase silver was mined in the Nam Pangyun and ER valleys. Ore was smelted onsite, with the lead-rich slag dumped within the Nam Pangyun Valley. Plates ES.1 and ES.2 show evidence of Chinese mining in the Bawdwin area.
- Limited minor workings by the Kachin and Shan people between 1868 to 1901.
- British colonial period and post-colonial period from 1901 until the nationalisation of the mine in 1962. This period commenced with reprocessing of the lead-rich slag in the early 1900s and developed into open cut and underground mining. The period between 1928 and 1938 were the most stable and productive years of the mine, when production reached its peak of approximately 500,000 tons of ore being processed each year. Plate ES.3 shows a probably British drive adjacent to Chinese workings.

- Nationalised period of the mine from 1962 to 2009. Mining continued on a small scale and ceased in 2009.

Number 1 Mining Enterprise (ME-1), a State-owned mining enterprise under the Ministry of Natural Resources and Environmental Conservation (MONREC), entered into a production sharing contract with Win Myint Mo Industries Co., Ltd. (WMM) on December 31, 2009. Since that time, the mine and processing facilities have been in care and maintenance. The workforce has been retained under the production sharing permit and contract conditions, and conduct care and maintenance activities.

In late 2020, WMM commenced construction of a haul road to support a small-scale mining operation to develop the oxide resources of the existing pit ahead of the Bawdwin project.

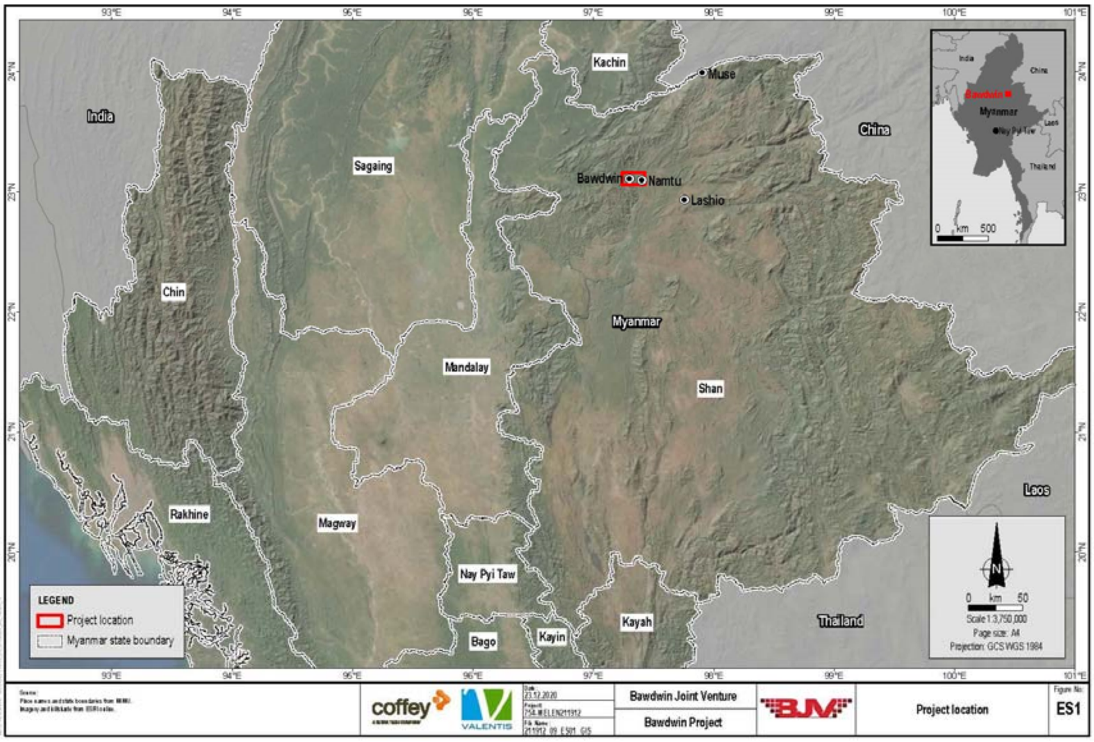


Figure ES.1 Project location

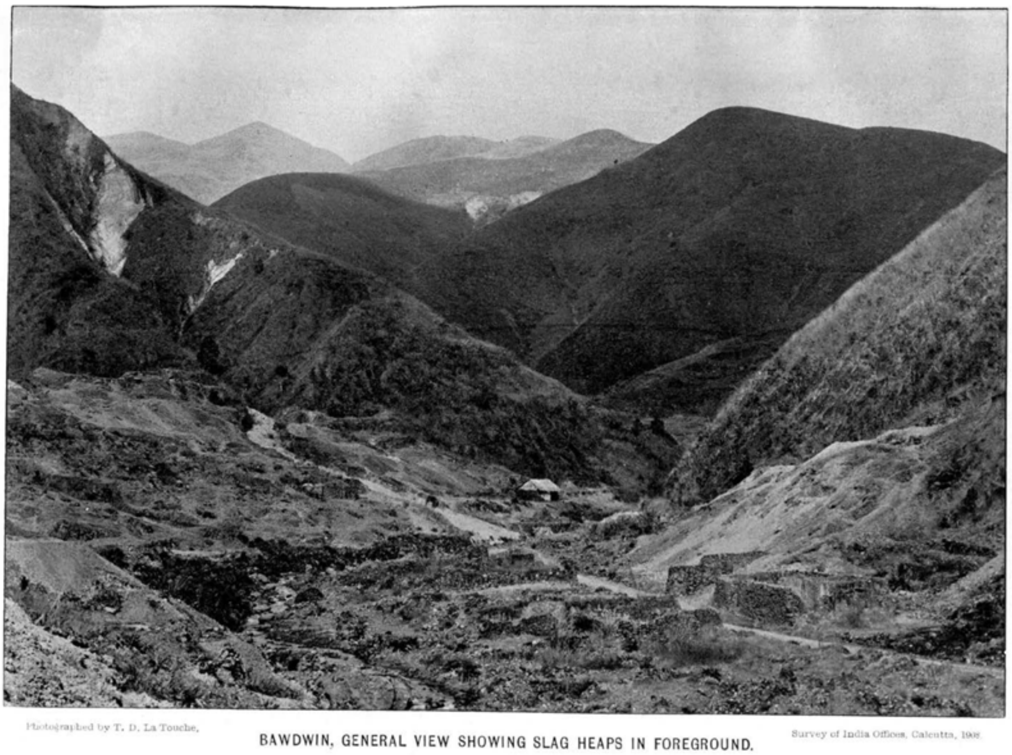


Plate ES.1 Nam Pangyun valley at Bawdwin in 1907 with ruins of Chinese stone huts in the right foreground and slag heaps along the valley sides

Plate ES.2 Chinese underground workings in Goldhole Valley

Plate ES.3 Probable British drive in Goldhole Valley, immediately adjacent to Chinese workings

Oxide mining and crushing by WMM is expected to commence in mid-2021 and will continue until the Bawdwin project commences ore mining. The oxide mining operation is being undertaken under existing licencing and approvals and is outside the scope of this EIA.

Plates ES.4 to ES.6 depict the existing environment at Bawdwin mine, including the steep terrain and Nam Pangyun valley, the open pit and supporting infrastructure of historic value.

Project proponent

The project proponent is Win Myint Mo Industries Company Limited. WMM holds a production sharing permit and contract with ME-1 of MONREC to undertake production of lead, silver and zinc at the Bawdwin Mine. The contract was entered into in December 2009. WMM is part of National Infrastructure Holdings Company Limited, which is a Myanmar investment group focused on infrastructure-related projects and employs over 4,000 people.

Plate ES.4   Steep terrain near Bawdwin

Plate ES.5   Nam Pangyun valley facing Bawdwin upper village and the open pit

Plate ES.6   Marmion Shaft headframe and winding house

Policy, legal and institutional framework

The mining sector is regulated by MONREC principally through the Department of Mines and Department of Geological Survey and Mineral Exploration along with four mining State-Owned Enterprises, with ME-1 being the most relevant to the project.

Rights to conduct work and produce mineral products at the Bawdwin concession is currently governed by the Production Sharing Contract between ME-1 and WMM. Redevelopment of the Bawdwin mine will require an extension to the large-scale production permit, as it is a significant economic deposit, requires substantial investment in complex technology, and has a mine life of 13 years, with the potential to extend up to 50 years if underground mining is found to be economically feasible.

Under the *Myanmar Investment Law 2016***,** major and/or sensitive projects, including proposed large-scale mineral production projects, require prior investment approvals from the Myanmar Investment Commission (MIC), a government body comprised of a number of key government representatives. This includes a requirement for MIC approval of foreign investment in the production project, sought be way of an application based on the financial, technical and related projections of the proposed project. Given the foreign investment, its size and significance of the Bawdwin mine a MIC permit will be required. The permit outlines key project requirements and sets out any investment concessions an investor may receive for a project.

Negotiations are underway to vary the Production Sharing Contract to extend its term and adjust share allocations based on the resource defined in WMM's feasibility study.

The project will be undertaken in line with relevant laws, rules and guidelines including:

- *Myanmar Mines Law 1994*.
- *Environmental Conservation Law 2012*.
- Environmental Conservation Rules 2014.
- National Environmental Quality (Emission) Guidelines 2015.
- Environmental Impact Assessment Procedure 2015.

A range of cross-sectoral laws and rules are also applicable to the project, requiring additional approvals.

The Environmental Conservation Law and Environmental Conservation Rules establish a requirement for EIA. In accordance with sub-section (b) of Section 42 of the Environmental Conservation Law, the EIA Procedure was issued in 2015 to provide guidance for environmental impact assessment for the development of projects that may have an adverse impact.

The EIA Procedure outlines the required level of assessment, which depends on the nature and scale of the development. All new projects and project expansions having the potential to cause adverse impacts are required to submit an EIA and obtain approval in the form of an Environmental Compliance Certificate (ECC) which sets out the conditions on which a project is approved.

Section 23 of the EIA Procedure outlines the initial steps for the environmental and social approvals process. The main steps include:

- The project proponent submits a project proposal to MONREC for initial screening. The project proposal was submitted by WMM to ME-1 for the Bawdwin project was submitted in October 2018 and resubmitted in March 2019 following advice from the Environmental Conservation Department (ECD).
- MONREC (in association with relevant statutory authorities) assesses the project proposal and determines the need for and level of environmental assessment with consideration of EIA Procedure Annex 1 Categorization of Economic Activities for Assessment Purposes.
- The Ministry then designates the project as either an EIA Type Economic Activity, an Initial Environmental Examination report Type Economic Activity, or neither and therefore not requiring an EIA. In May 2019, the General Manager on behalf of the Managing Director designated the project as an EIA Type Economic Activity.
- The project proponent submits details of the environmental consultant that will conduct the EIA (third party confirmation from ECD). In August 2019, the Director on behalf of the Director General (MONREC) approved the third-party application for Coffey & Valentis to act as the EIA consultants for the project.
- Although Coffey & Valentis started preparation EIA scoping report for Bawdwin project, they can't continue report preparation in current situation. So, the project proponent submits the other third party selection form that will continue conducting EIA report. In 19th May 2023, the Director on behalf of the Director General (MONREC) approved the third-party application for E Guard Environmental Services to act as the EIA consultants for this project.

An overview of the approvals process for an EIA Type Economic Activity is shown in **Error! Reference source not found.**.

Section 62 to 63 of the EIA Procedure outline the required content of the EIA Report and the Environmental Management Plan. This report has considered these requirements as well as the 2018 draft Myanmar Mining EIA Guidelines and international standards in developing the EIA and ESMP structure and content.

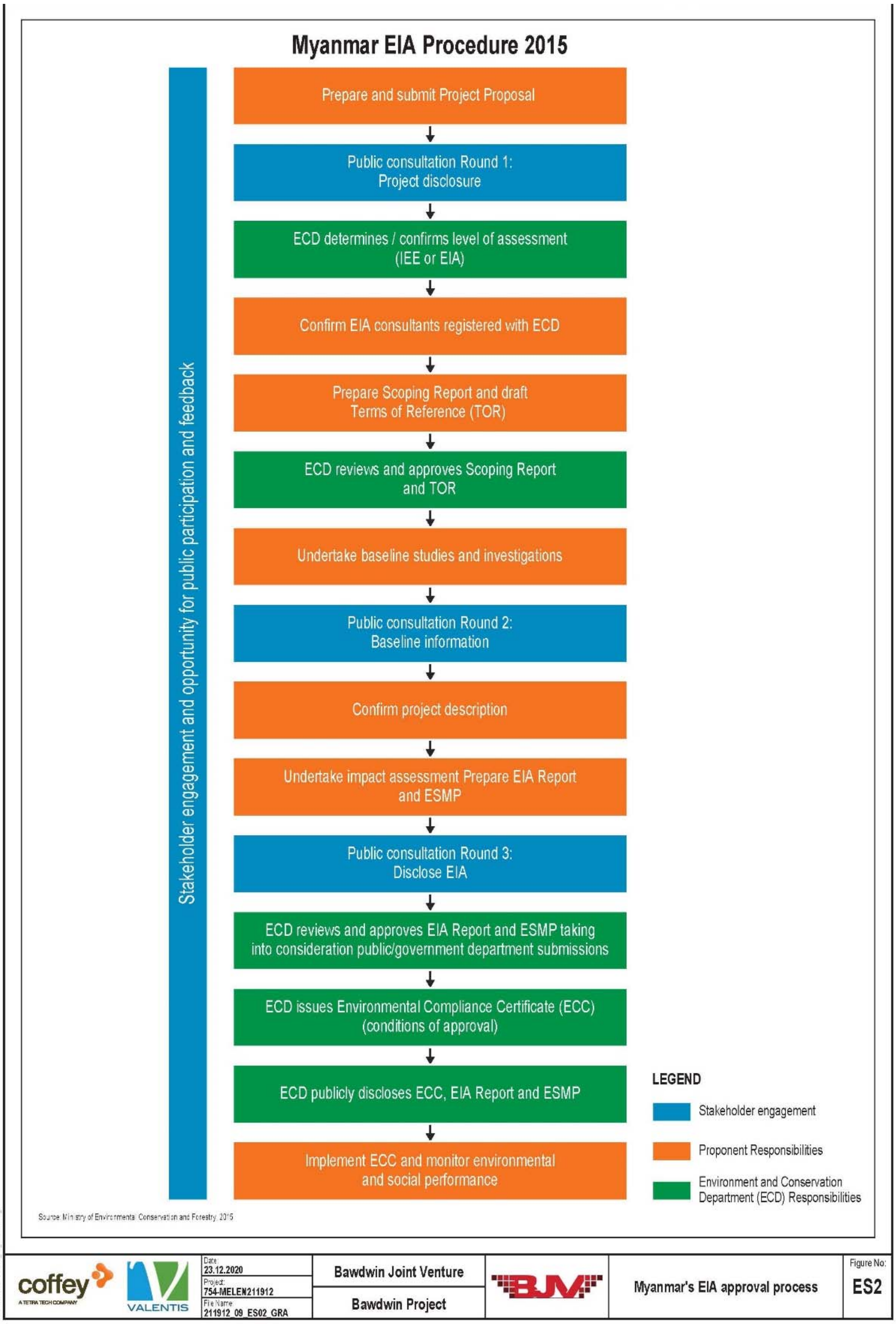


Figure ES.2 Myanmar's EIA approvals process

Project alternatives

The assessment of project alternatives has been progressively refined over the duration of scoping, pre-feasibility and feasibility studies between 2018 and 2020. Key constraints considered in the assessment of project alternatives included:

- Economic constraints that are driven by factors including the nature of the mineral deposits, project expenditure, and the need to extract and process the ore in a profitable manner.
- Physical constraints including the location of the mineral deposits, a lack of enabling infrastructure and the climatic, topographic and geotechnical constraints imposed by the landscape.
- Environmental constraints including environmental values and sensitivities focussing on water (surface water and groundwater), land (including biodiversity and soils) and air.
- Social constraints including economic, social, health and cultural heritage components, and the location of existing communities.

Project alternatives that have been assessed include:

- Expanding the existing open pit or developing an underground mine.
- Options for mineral processing including upgrading existing infrastructure or building new infrastructure.
- Options for the location and type of tailings storage facilities and waste rock dump.
- Where clean water is sourced from.
- The power supply including upgrading the existing hydropower station, connecting to the national grid or building a new power station.
- Site access and export routes including using the existing access road to Bawdwin or building a new access road from Namtu.

The option of not proceeding with the project (i.e., no project option) was also considered. Under this scenario:

- There would be no social and economic benefits that would come from the project, such as wages, royalties, training and work experience, community infrastructure, business development, and community development.
- There would be no health or environmental benefits that would occur from the project by attempting to address some of the impact of previous mine activities.
- The biophysical and social impacts described in this EIA associated with the project would not occur.

Project description

The Bawdwin mineral deposit is a world-class deposit in terms of its size and grade. Exploration conducted by WMM has resulted in an increase in the mineral resource estimate of the Bawdwin deposit and it now ranks among the largest polymetallic resources globally. The Bawdwin project has been defined through scoping, pre-feasibility and feasibility studies between 2018 and 2020. The ore reserve estimate on which the project is based was produced in June 2020, in accordance with the guidelines in the JORC Code (2012 Edition) and is shown in Table ES.1.

Table ES.1 Ore reserves estimate as at 15 June 2020

Classification	Tonnage (Mt)	Pb (%)	Ag (%)	Zn (%)
Proved	-	-	-	-
Probable	32.0	4.6	113	2.5
Total	**32.0**	**4.6**	**113**	**2.5**

The ore reserve is contained within an open pit containing 163.9 Mt of waste material resulting in a waste to ore (tonnes) strip ratio of 5.2:1. The total mass of rock to be removed from the open pit is 195.9 Mt.

Figure ES.3 shows both a plan view and oblique long section of the Bawdwin lead block model for the Shan, China and Meingtha lodes.

The project will produce two products from the process plant: lead-silver concentrate and a zinc concentrate. The forward outlook for both silver and lead is strong.

The Bawdwin project will lay strong foundations for future expansion enabling a long-life mining operation. Following the initial 13-year mine life, the project will target the un-mined mineral resources of the China, Shan and Meingtha Lodes. Broader mine expansion studies will continue in parallel with the construction and operation of the project.

As Myanmar pursues political and economic renewal, investment in the mining sector is anticipated to grow dramatically. At the national level there is increased appetite to kick-start development and investment in the minerals sector. It is anticipated that once Bawdwin is developed, this will result in a potential significant shift in GDP contribution from the mining industry.

WMM proposes to redevelop the existing Bawdwin mine into a larger, modern mining operation. The redevelopment will involve demolition of much of the existing infrastructure and construction of new infrastructure to support mining and processing activities.

Table ES.2 describes the key project components and the conceptual layout of the project is presented in Figure ES.4. A three-dimensional view of the project layout is shown in Figure ES.5.

The project schedule is dependent upon project financing and granting of all necessary project approvals including resettlement agreements with the residents of Bawdwin and Tiger Camp villages. The timeframe for redevelopment of the Bawdwin mine is set out in Figure ES.6 and is based on a 22-month design, construction, and commissioning timeframe.

A conceptual closure and rehabilitation plan has been prepared for the project. WMM has identified preliminary closure objectives and land uses. The primary goal for closure is to rehabilitate disturbed areas in a manner that, where possible, will support self-sustaining vegetation that is consistent with that of surrounding natural areas, limits post-closure contamination of the host environment and leaves a lasting positive legacy for impacted communities in the form of transferred skills and self-sustaining community development programs.

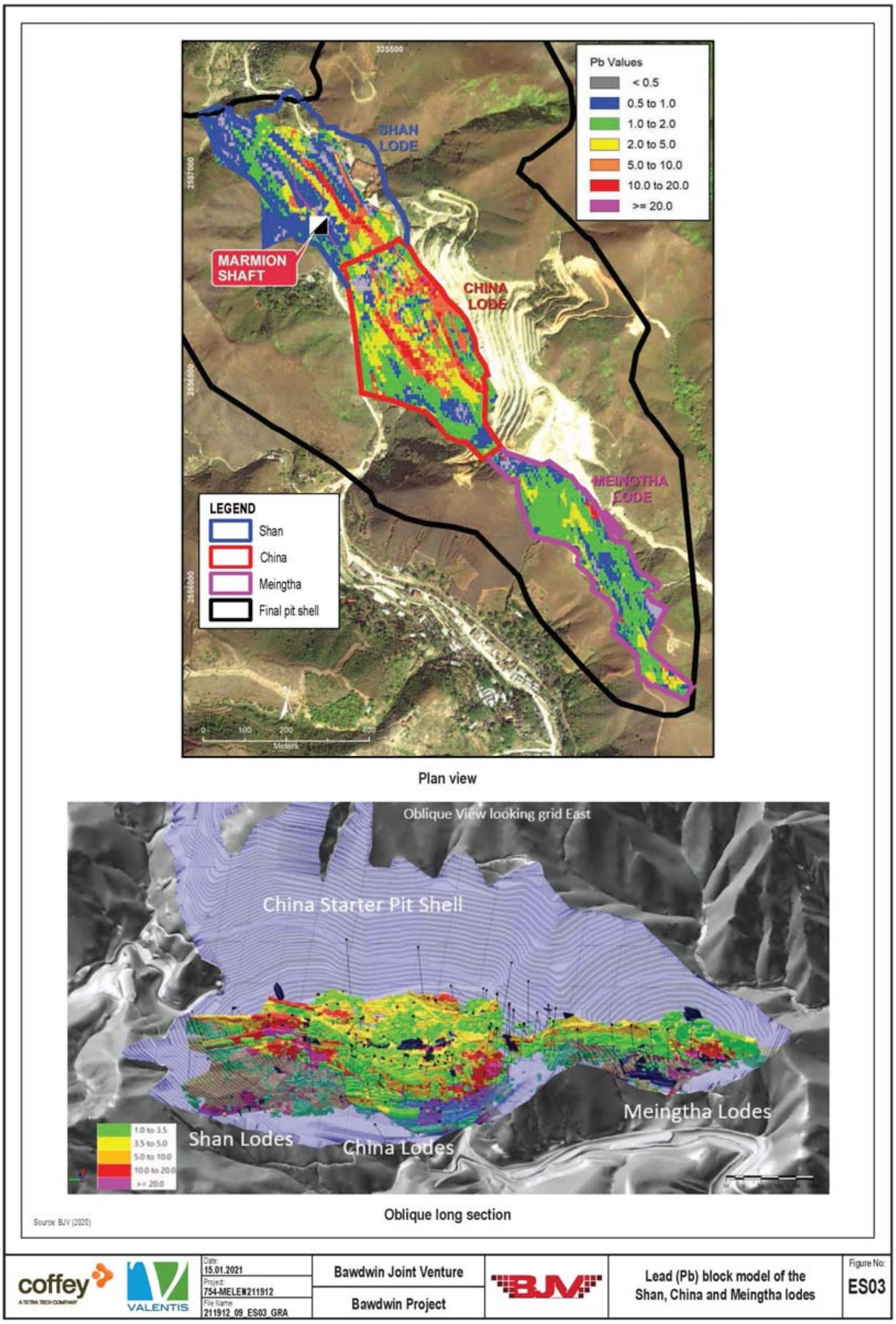


Figure ES.3 Lead (Pb) block model of the Shan, China and Meingtha lodes

Table ES.2 Key project components

Component	Description
Mining method	• Large-scale conventional open-pit mining. • Mining method will use drill rigs, excavators and/or front-end loaders and articulated haul trucks. • Ore and overburden will be loosened by blasting.
Open-pit dimensions	• The existing open pit will be expanded and deepened, growing in size from approximately 54.0 acres to at least 242.7 acres (21.9 hectares (ha) to 98.2 ha).
Construction timeframe	• The design, construction and commissioning timeframe is 22 months.
Mine life	• The planned expansion of the open pit will result in a 13-year mine life. • Exploration is proposed and has the potential to extend the life of the mine for up to 50 years.
Mine waste rock management	• 163.9 million tonne (Mt) of waste rock will be produced by the project. • Waste rock will be disposed in a waste rock dump to be constructed in the Wallah Valley and some will be used in the TSF construction. • The Wallah waste rock dump will be an engineered structure comprising benches and embankments. • Geochemical investigations indicate that the leachate or drainage from the waste rock material is likely to contain elevated levels of metals. Additionally, a very small percentage of waste rock may be acid forming. • The metalliferous drainage and management of potentially acid forming waste rock requires good management and design to reduce risks to the environment. • A series of three sediment basins will be constructed downstream of the waste rock dump to collect seepage and run off and allow water treatment prior to discharge if required.
Processing method	• A new process plant will be constructed in the Bawdwin concession. • Ore will be processed at a rate up to 3 Mt per annum (Mtpa). • Processing of the ore will involve crushing and grinding followed by separate lead-sliver and zinc flotation. • Several reagents (chemicals) will be used during the various stages of the mineral processing circuit. • The lead-silver and zinc concentrates will be thickened, filtered and stockpiled for loading into concentrate containers for export.

Component	Description
Tailing management	• 32.2 Mt of tailings will be produced as a waste product by the process plant. • Tailings will comprise fine silts, sands and clay and process water. • Tailings will be piped to one of three, cross valley, tailings storage facilities (TSFs). • The TSF sites are all located in the headwaters of the Nam Pangyun River, upstream of the open pit. • The total footprint of the three TSFs is approximately 308.9 acres. • The TSFs have been designed in accordance with international best practice guidelines and include decant and underdrainage systems to remove excess water, and collect seepage, respectively.
Concentrate production	• Approximately 193 ktpa of lead-silver concentrate. • Approximately 102 ktpa of zinc concentrate. • Concentrates will be loaded into covered 20 ft half height containers by the front end loaders. There will be an average of 27 containers per day in each direction will need to be moved by road transport.
Processing infrastructure	• Processing infrastructure will include construction of a new process plant and associated infrastructure including laboratory, reagents storage, water supply, workshop, warehouse and TSFs.
Water supply and management	• The project will require raw water for the process plant, mining services area (MSA) and accommodation camp and potable water supply. • The raw water requirements total 150.9 m^3/hr at steady state operations. • The project water supply will use a combination of stream flow from the Nam Pangyun and Nam La streams primarily in the wet season and storage of water in holding dams; and recycling decant water from the TSFs.
Export route and facilities	• Concentrate will be exported from Bawdwin via new private access roads to Namtu. From there trucks will travel to Lashio on public roads and then onwards for export to international markets. • A central warehouse and logistics hub for the project will be constructed in Lashio. Concentrate containers will be transported to the hub and then loaded onto trucks for onward transport.

Component	Description
Mine access	• The public Namtu-Manton Road currently provides access to Bawdwin, but will not provide the main access for the project. This road will be used to a limited extent during construction. • A new access road from Namtu to Tiger Camp is proposed to be constructed within the existing rail easement (referred to as Namtu-Tiger Camp access road). Access to this road will be provided to residents of Tiger Camp village and Bawdwin lower village, prior to their resettlement. • A new road from Tiger Camp to the process plant (referred to as plant access road) is proposed to provide site access. • Other new access roads will provide access to project components including the accommodation camp, TSFs and Nam La water harvesting facility. • A new double lane haul road will connect the open pit to the process plant and waste rock dump. • The project will generate additional heavy vehicle traffic. During steady state operations there will be between 60 and 90 journeys per day by concentrate transport trucks on the public road between Lashio and Namtu.
Accommodation	• An accommodation camp will be constructed for the project capable of accommodating approximately 1,400 people. • The accommodation camp will be used during construction and operation of the project. • The local workforce will reside in their homes and be transported to site daily.
Employment	• Up to 2,285 people during construction. • Up to 1,115 people during operations. • WMM will seek to maximise the proportion of available jobs that are allocated to members of local communities, through its Preferential Employment Policy. • WMM will develop and implement an employment and training plan to develop workforce readiness of locals.

Decommissioning will commence after mining operations have ceased and is expected to take two to three years. It will involve the removal of infrastructure, facilities, equipment and services, unless otherwise agreed with stakeholders. Disturbed areas will be stabilised and revegetated. It is planned that the open pit will be flooded to become a permanent pit lake. The waste rock dump and TSFs will be covered with soil and revegetated with grasses.

Further scientific studies are proposed to develop the detailed closure concepts and rehabilitation plans.

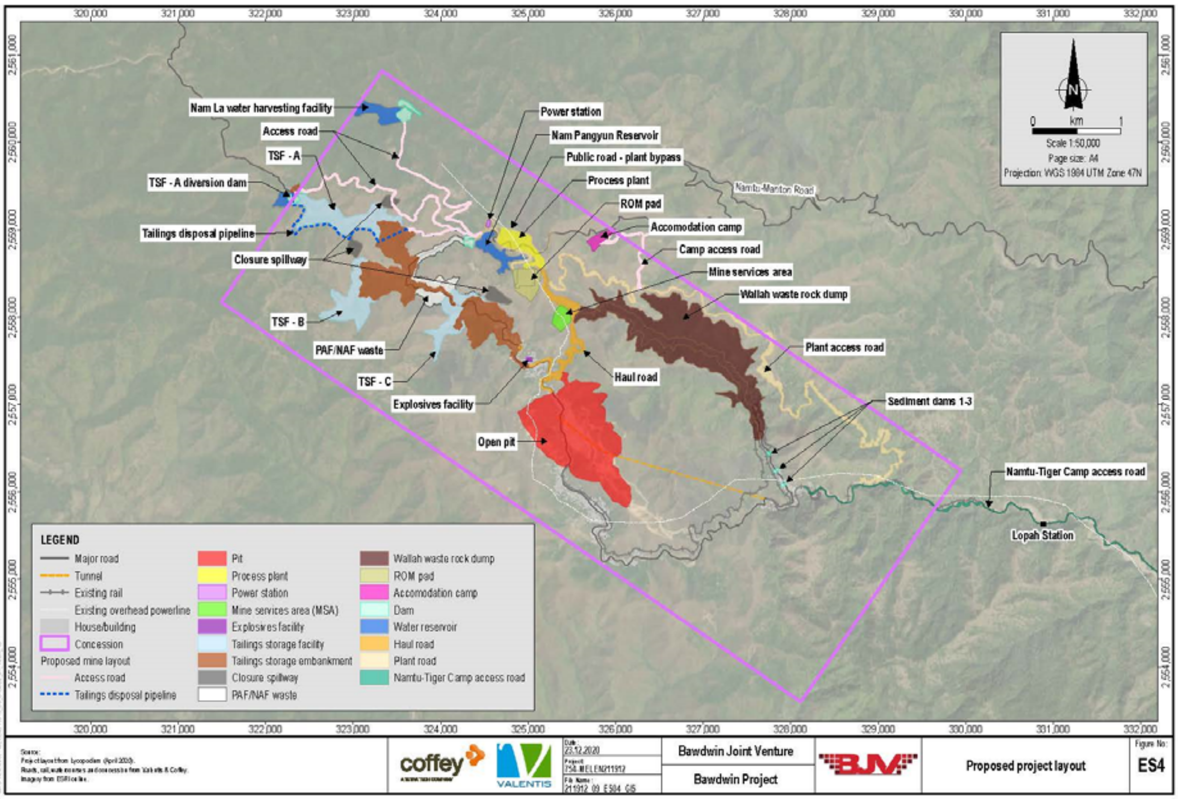


Figure ES.4 Proposed project layout

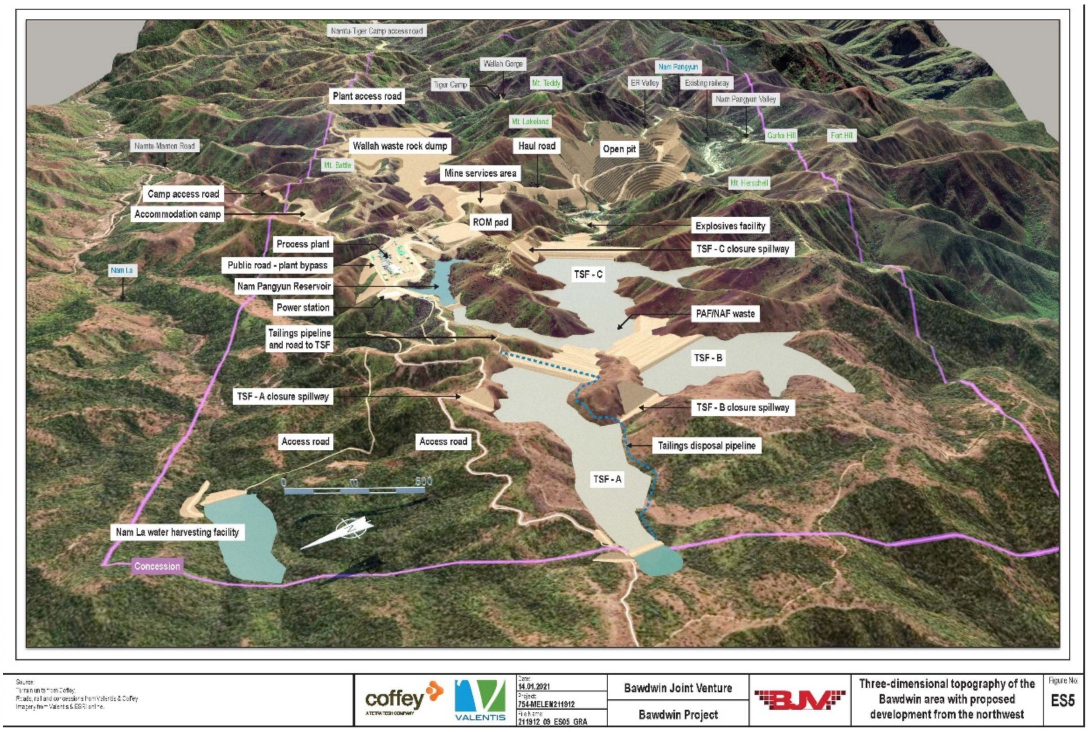


Figure ES.5 Three-dimensional topography of the Bawdwin area with proposed development from the Northwest

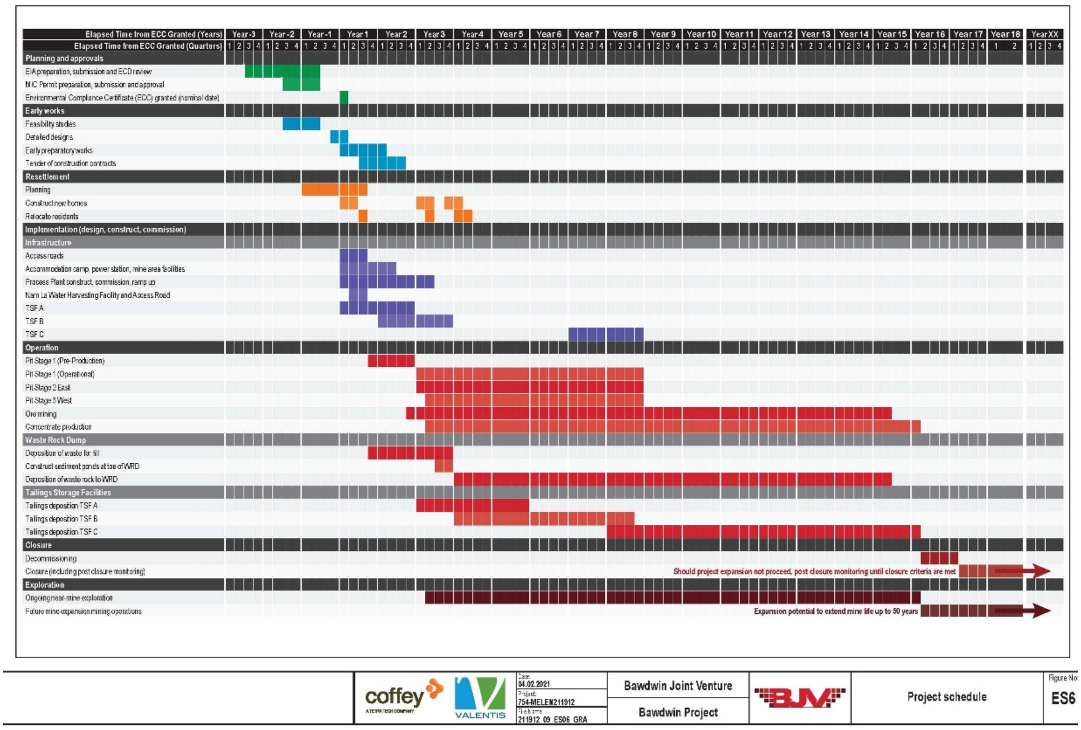


Figure ES.6 Project Schedule

Existing environment

The existing physical, biological, socio-economic and cultural environment of the project area and surrounds has been informed a program of data collection activities that has included both desktop and onsite investigations (baseline studies and surveys).

Physical existing environment

Geology, landform and soils existing environment

The majority of the project is situated in the steep and mountainous catchment of the Nam Pangyun stream, which includes the Nam Pangyun valley, ER valley, Wallah Gorge and associated tributaries. The majority of the terrain slopes are in excess of 20% with many areas sloping more than 30% (BJV, 2019). Some limited infrastructure elements of the project also occur in the neighbouring catchment to the northeast, which is called the Nam La catchment. In the northern and western corners of the study area there are areas of undulating hills and valleys that are less steep than the rest of the study area.

The soils present in the study area reflect the underlying geology of the region, primarily comprised of completely weathered tuff (rock made from volcanic ash) and sandstone material, as well as localised alluvial and colluvial deposits on valley floors. Soils in the Bawdwin area have elevated concentrations of metals, which can be attributed to both naturally occurring metals associated with the regional mineralogy, and legacy environmental issues from centuries of mining, ore processing and disposal of waste material. High concentrations of arsenic, lead and zinc were found around the open pit, downslope to the east, and in the Tiger Camp area.

Groundwater existing environment

Within the project area, groundwater is stored in two hydrogeological units: a fractured rock aquifer and a saprolite (weathered rock) aquifer. The saprolite aquifer is present in localised areas of the Bawdwin area, typically thicker on ridges and upper slopes, and absent on valley floors. Several springs in the area are surface expressions of the saprolite aquifer, discharging groundwater and feeding surface water features, and providing a source of potable water for communities.

Groundwater level monitoring indicated that groundwater levels range from less than 2 m below ground level to approximately 150 m below ground level, with levels typically within the fractured rock over much of the study area. Current on-going dewatering from the existing underground mine has lowered groundwater levels surrounding the existing mine pit.

Whilst naturally elevated concentrations of some metals are expected in groundwater at Bawdwin, extensive historical mining activities have led to groundwater contamination of salts and dissolved metals at elevated concentrations. Groundwater monitoring of water from the fractured rock aquifer identified elevated concentrations of total aluminium, antimony, arsenic, cadmium, iron, lead, manganese, nickel and zinc, all of which exceeded either aesthetic or health-based drinking water guidelines. The saprolite aquifer had concentrations of total and dissolved lead, total iron, total manganese and sulphate exceeding the adopted drinking water criteria.

Surface water existing environment

The primary watercourses in the study area are the Nam Pangyun and Nam La streams, which both discharge into the Myitnge River near Namtu. Surface water quality of these watercourses reflects the natural water quality and impacts from both current human usage of surrounding land and legacy environmental issues associated with extensive historic mining.

The Nam Pangyun flows through the Nam Pangyun valley, and is characterised by elevated levels of heavy metals, particularly downstream of the existing mine pit and in the lower catchment as a result of groundwater discharge from Tiger Tunnel. This contamination limits beneficial uses of the stream for downstream communities and has significantly degraded the watercourse and aquatic ecosystems. The Nam Pangyun rapidly responds to rainfall, causing sediment runoff and subsequent elevated total suspended solids (TSS) and turbidity.

The Nam La is characterised by low concentrations of most metals and evidence of waste/sewage. A weir has been constructed upstream of its confluence with Myitnge River, associated with the intake for the Nam La Flume. The flume is a gravity-fed channel which supports the supply of potable water for the northern districts of Namtu.

A summary of the baseline water quality monitoring is shown in Figure ES.7. Water quality of the Myitnge River reflects the discharge from the Nam Pangyun and Nam La streams and leaching and runoff contaminated from historical ore processing activities near Namtu, including smelting on the northern bank of the river, and ore concentration and tailings disposal on the southern bank. Metal concentrations are low upstream of Namtu, increasing downstream through Namtu and the confluence with the Nam La, with a significant increase in metal concentrations, TSS and turbidity around the confluence with the Nam Pangyun.

Meteorology existing environment

The climate of the Bawdwin region is monsoonal, with three main seasons: the cool, relatively dry northeast monsoon between late October and mid-February; the hot, dry inter-monsoonal season between mid-February and mid-May; and the rainy southwest monsoon between mid-May and late October. Average annual rainfall is 1,569 mm, with the heaviest rainfall usually occurring in the southwest monsoon.

In Bawdwin between 2000 and 2018, the lowest monthly mean temperatures were during the northeast monsoon season, with the monthly mean minimum lowest in December and January at 11°C degrees. The highest monthly mean temperatures were during the inter-monsoonal season and southwest monsoon season, with the monthly mean minimum highest from June to September at 22°C degrees, and the monthly mean maximum highest in April and May at 34°C degrees.

Static temperature inversions can occur where a cool layer of air develops below a warm air layer as a result of ground cooling at night combined with little air movement. These are common at Namtu where static atmospheric conditions occur, however anecdotally do not occur at Bawdwin due to the steep terrain and free air movement.

Wind patterns at Bawdwin are strongly influenced by the surrounding topography, with monitoring occurring between September 2019 and May 2020. South-southwesterly winds prevailed during this period, with wind speeds ranging from calm to a light breeze (0 m/s to 2.4 m/s). At Namtu, the annual prevailing wind direction is southerly, with the monsoon creates steady strong winds from December to April, and calm winds from June to September.

Air quality existing environment

Factors influencing air quality in the project area include roads (unsealed and sealed) around Bawdwin and Namtu, vehicle emissions, industrial activity, erosion of cleared areas, and vegetation burning. The quality of particulate matter may reflect legacy environmental issues associated with historical mining.

Monitoring of air quality during baseline studies determined air quality in the Bawdwin and Namtu airsheds was moderate to poor in terms of particulate matter (quality and quantity), with generally low concentrations of gaseous emissions (SO_2 and NO_2). Total suspended particles (TSP) and PM_{10} concentrations during 24-hour monitoring peaked in the morning and afternoon, likely associated with commuter traffic on unsealed roads. TSP was generally highest at Bawdwin and lowest at Tiger Camp, and also lower during the wet season. Dust deposition at all monitoring sites was above the adopted guideline value, except for one site near Bawdwin village.

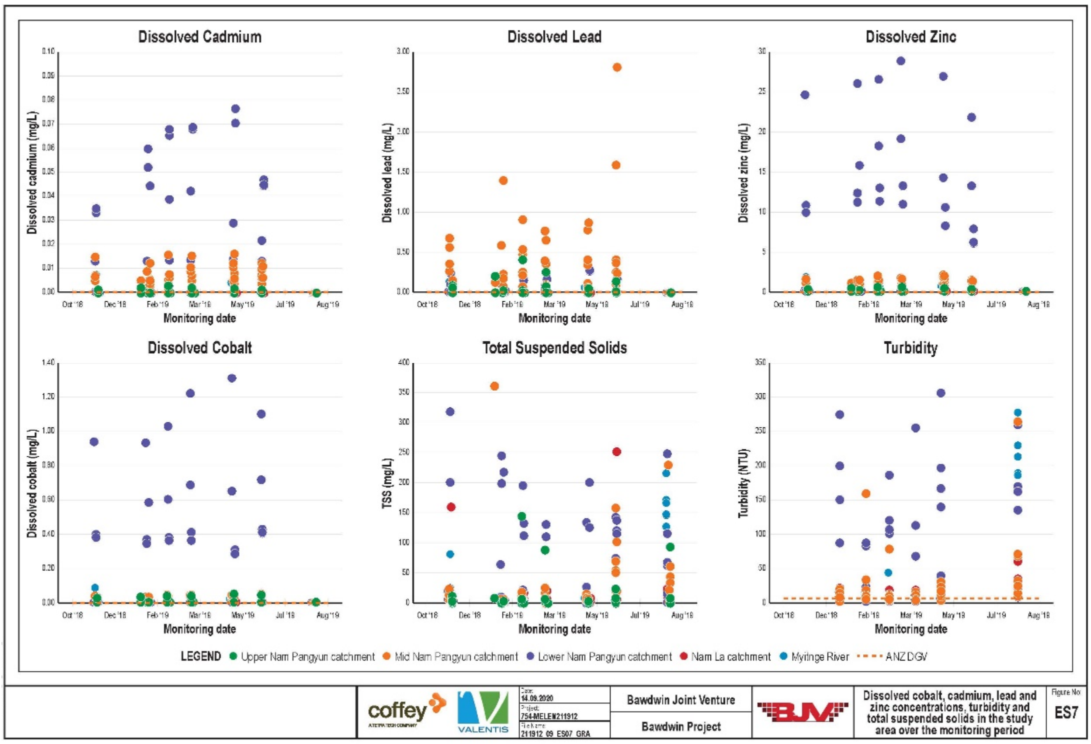


Figure ES.7 Dissolved cobalt, cadmium, lead and zinc concentrations, turbidity and total suspended solids in the study area over the monitoring period

The concentrations of metals in dust collected during 24-hour TSP and PM_{10} monitoring and from deposited dust had elevated concentrations of lead and chromium, with average values exceeding adopted guidelines at some locations in Bawdwin, Tiger Camp and Namtu. This may reflect the generation of dust from areas contaminated by historic mining activities.

Noise and vibration existing environment

Noise in the project area is typically associated with residential/village activities, vehicles and commercial activities. Monitoring of noise levels during baseline studies recorded the greatest average levels of noise were in the morning (between 5:00 am and 9:00 am), associated with normal village activities and traffic. The highest average noise levels were at the Bawdwin upper village, likely associated with normal village activities.

Noise levels at several sites in the project area were compared to the National Environmental Quality (Emission) Guidelines. These guidelines outline the maximum noise level permissible at the nearest sensitive residential, industrial or educational receptor, and nearest sensitive industrial or commercial receptor to a project. The L_{Aeq} (equivalent to the total sound energy measured over a given period of time) during the day at residential sites monitored in the project area were greater than the guideline level which should not be exceeded at the nearest sensitive receptor to a project. The measurements at commercial sites during the day and night were largely below the emission guidelines, however, can be classified as ‘moderate to loud’.

No baseline investigations of vibration have been conducted. However, the potential sources of significant vibration were anticipated to be minor and limited to heavy vehicle traffic, operation of limited plant for maintenance purposes, earthmoving to support exploration activities and drilling activities.

Biological existing environment

The biological environment in the project area has been heavily influenced and modified by deforestation, historical mining and processing activities, and agricultural activities and seasonal burning. The concession area primarily comprises grasslands and bamboo forest habitats, with sub-tropical mixed hill forest found in the northwestern extent of the concession area and beyond (Plates ES.7 to ES.9). The grassland and bamboo forests were classified as modified or degraded vegetation communities. Forest clearance dates back to the early Chinese mining years, with the grassland and bamboo forest representing regrowth and secondary forest. Areas of grassland and bamboo forest had relatively low flora and fauna diversity, with predominantly generalist, resilient and common species. The highest diversity of plant species was found in more intact sub-tropical mixed hill forest beyond the mine.

Two plant species of conservation significance were recorded in areas of sub-tropical mixed hill forest. These were *Cycas pectinata*, which is considered vulnerable on the IUCN Red List and Burmese black wood (*Dalbergia cultrate)*, which is considered Near Threatened. During baseline studies of terrestrial fauna, hunters reported four species of conservation significance as being historically present in the last decades in the region. This included one Critically Endangered species, the Chinese pangolin (*Manis pentadactyla*); one Endangered species, dhole (*Cuon alpinus)*; and two Vulnerable species, Asian black bear (*Ursust thibetanus*) and hog badger (*Arctonyx collaris*). However, the presence of these species in the project area, was assessed to be unlikely given the degraded habitats there. In 2020, the vulnerable king cobra (*Ophiophagus hannah*) was observed near the mine.

The aquatic ecosystems present in the project area are heavily influenced by the quality of the watercourses. The highly degraded and contaminated Nam Pangyun has a degraded ecosystem, with a depauperate community of generalist, adaptable and resilient macroinvertebrates and fish species recorded during biodiversity surveys. The Nam La has a higher quality aquatic habitat, with more intact vegetation along the stream and presence of species that are sensitive to water pollution and absent from the Nam Pangyun. The Myitnge River supports a range of aquatic plants and trees which line the river and provide habitat for aquatic fauna.

Plate ES.7 Bamboo forest

Plate ES.8 Grassland forest

Plate ES.9 Sub-tropical mixed hill forest

Cultural heritage existing environment

The cultural environment in Bawdwin is complex due to the long history of mining by Chinese, British and during the modern period. Mining at Bawdwin began in the early 15^{th} century. The tangible elements (sites, places, structures and artefacts) associated with this history have associated intangible cultural value, which can be aesthetic, historic, scientific, technological, social and spiritual. The cultural heritage features in the project area are shown in Figure ES.8.

During Chinese occupation and mining, a ring of hillforts and ridge defences lines were built on the ridges surrounding the mine. These were used to defend the mine, and potentially observe mine operations and settlements within the valley. Artefacts and evidence of Chinese occupation can also be found in the Nam Pangyun valley, along with Chinese workings and smelting furnaces. These are evidence of mining and smelting from this period and are valued for the insights they provide on early mineral exchange and mining in southeast Asia.

Cultural heritage features associated with the British mining period are predominantly mining infrastructure and buildings. The Marmion shaft and winding house, which are still operating, are an excellent and rare example of a complete British 20^{th} century winding plant, representing a key period at Bawdwin where the mine first became successful. The Namtu to Bawdwin railway and central Bawdwin and Tiger Camp precincts are key structures from the period, with the precincts including the mine office, Dead Chinaman tunnel, Bawdwin timberyard and Tiger Tunnel.

The area has several graveyards associated with various periods of occupation. Graveyards have bioarchaeological, social and spiritual value. Many are located in prominent positions of the landscape. There are also several religious sites which have social and spiritual significance and are valued by local communities.

Socio-economic existing environment

Bawdwin village tract has a population of 3,499 and is comprised of Bawdwin upper and lower villages and Tiger Camp. There are four wards in each of the Bawdwin villages, and two in Tiger Camp, with a total population of 3,499. Namtu town comprises Pang Hai Ward, Har Lin Village and Tha Ta La Ward, which is made up of seven wards and was established to accommodate people involved in mine operations at Bawdwin. The population of Tha Ta La wards and Har Lin village is 5,699. The organisational structure of Bawdwin is largely influenced by the operation of the Bawdwin mine (e.g., land tenure, house ownership etc).

The mining sector is highly important for livelihoods as it is a main source of employment and income for people in the Bawdwin and Namtu study areas, and provides an opportunity for subsidised housing. Namtu has greater access to alternative employment and income opportunities. The surrounding communities including the Hu Hsar, Hin Poke and Kyu Hsawt village tracts rely on agriculture, and have limited economic connectivity to Bawdwin. Residents of the Nam Pangyun valley rely on artisanal mining for income and livelihoods

There are 9 schools in Bawdwin and 11 in Namtu, with survey results indicate education levels in the Bawdwin and Namtu areas are higher than the average for Shan State. Less than 8% of community members in Bawdwin and Namtu surveyed reported having no education, as opposed to 45% in Shan State. The majority of community members in the Bawdwin and Namtu study areas are Bamar, and practice Buddhism. There are 12 religious facilities in

Bawdwin and 11 in Namtu, some of which also service the nearby Hu Hsar, Hin Poke and Kyu Hsawt village tracts.

Most houses in the Bawdwin and Namtu study areas are basic. Most households in the Bawdwin and Namtu study areas have ready access to water distribution systems. Water is treated by most households in Bawdwin and Namtu and sources may be substituted during periods of rain due to turbidity in the streams from which reticulated water is sourced. Houses in Namtu are generally larger than those in Bawdwin and have their own toilets. Toilets in Bawdwin are more commonly shared (public) and discharge to local rivers or streams. Waste/rubbish management facilities in Bawdwin and Namtu are lacking, and the populations dispose of most waste by uncontrolled dumping and burning. Transport in Bawdwin and Namtu is typically by motorcycle and walking, with narrow roads shared by vehicles and pedestrians.

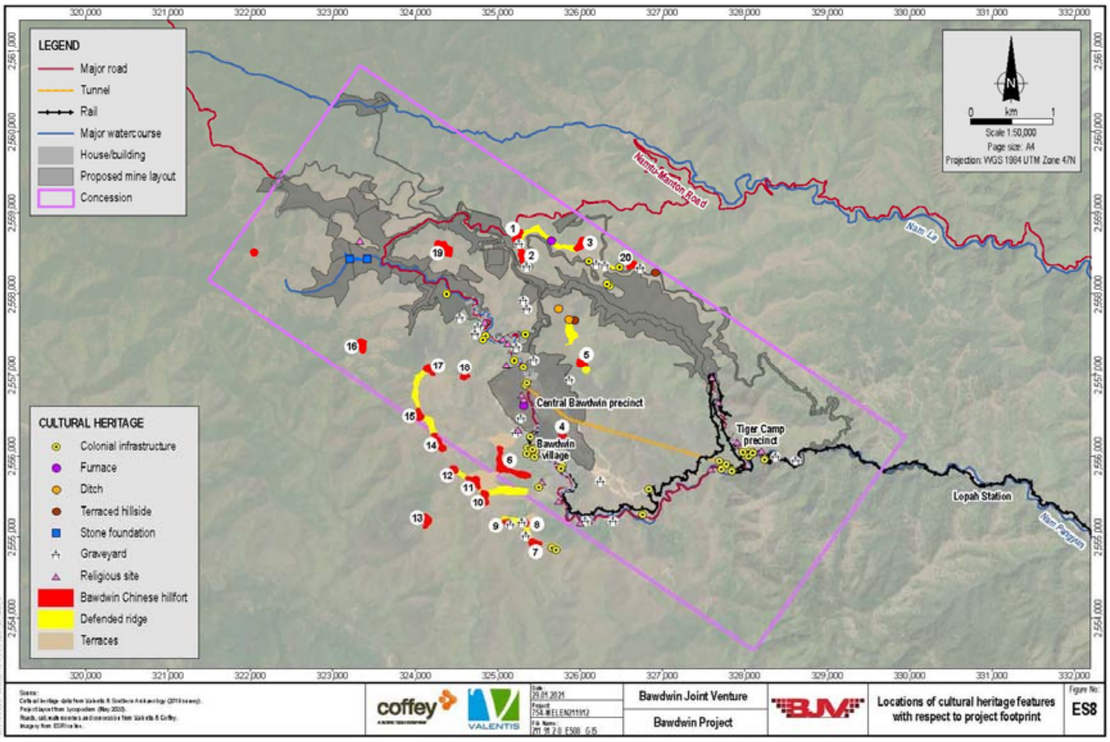


Figure ES.8 Locations of cultural heritage features with respect to project footprint

Community health existing environment

There are limited healthcare facilities in the Bawdwin and Namtu areas, with a small government hospital and a private clinic for mining employees (operated by WMM) in Bawdwin, a sub healthcare centre in Tiger Camp, and a hospital in Namtu. Lashio General Hospital, located approximately 50 km from Bawdwin, is the only tertiary public hospital in the region that delivers multi-specialty services. Despite the limited access to healthcare facilities and doctors, most survey respondents in the health baseline indicated they were in good health. Overall, the population of Bawdwin and Namtu seems to be in good health with low numbers of chronic disease, infectious disease and vector-borne disease

As a result of extensive historical mining and the poor waste management practices in place in Bawdwin and Namtu communities, there is a range of hazardous environmental health exposure pathways in the study area. These primarily relate to inhalation, ingestion or dermal contact with dust, metals (mainly lead) and bacteria (*E. coli).* The levels of lead measured in environmental media in Bawdwin indicates that residents are potentially exposed to elevated lead (and other metals) via multiple media and exposure pathways. There is a significantly high potential these exposures may pose a serious health risk to the population in this study area.

Separate to EIA health investigations, WMM undertook an occupational health investigation of the blood lead levels in current workers at Bawdwin between April and June 2020. The investigation was completed for a sample of local employees and also a sample of recently engaged contract personnel who were not residents locally and were therefore considered a control group. All of the permanent workers had blood lead levels over the level of 10 µg/dL where adverse effects are expected, compared with 48% of the contract workers. Over 65% of permanent workers measured blood lead levels greater than 40 µg/dL, and over 18% measured levels at 65 µg/dL. As 65 µg/dL is the maximum level measurable by the LeadCare ll instrument, some of these workers may have blood lead levels exceeding this.

Impact assessment

Approach to impact assessment

The impact assessment method used in the EIA is a ‘significance assessment’. This is a values-based approach that assesses the potential significance of impacts by considering the sensitivity of values to change, and the magnitude of change that they are predicted to experience as a result of project-related activities. This framework is consistent with current international environmental and social impact assessments for resource development projects, and reflects the approach described in Environmental Impact Assessment Guidelines for the Mining Sector in Myanmar.

Assessment of potential impacts is based on specialist judgement and technical assessment supported by baseline field data, experience of other mining projects in similar environments, stakeholder feedback and scientific literature. The EIA describes the rationale, justification and any limitations and uncertainties of the assessment. The assessment of the significance of impacts involves the following:

- Consideration of the sensitivity of defined environmental or social values or receptors, which may be affected by the project. Sensitivity was defined by assessing the importance of each value or receptor, its vulnerability to change, and its resilience or ability to recover.
- Consideration of potential, credible effects associated with all phases of the project, mechanisms and pathways that may lead to these effects, and the resulting impacts in the context of the existing conditions.
- Development of management measures, where the measures described are technically and economically feasible within the context of the project and reflect WMM’s commitments.
- Assessing the magnitude of change the environmental or social value or receptor experiences as a result of the project following implementation of proposed management measures.
- Assessing the significance of the residual impact. The residual impact is the impact that is predicted to occur following successful implementation of avoidance and management measures that address that impact.

Impacts can either be positive (beneficial) or negative. The impact magnitude (very low, low, medium, high or very high) was determined considering the amount and type of change based on the following aspects:

- Spatial extent or the scale of the effect or impact.
- Severity or intensity, which considers the scale or degree of change from the existing conditions as a result of the impact; severity can also be considered in terms of the intensity of the impact.
- Duration or frequency, which considers the timescale or frequency of the impact, i.e., if it is temporary, short-term or long-term.

The significance (very low, low, moderate, high or major) of residual impacts was rated using a matrix approach, by multiplying the sensitivity of the value or aspect and the magnitude of the impact to that value or aspect. The matrix of residual impact significance is shown in **Error! Reference source not found.**.

Table Error! No text of specified style in document.**.1 Matrix of residual impact significance**

Magnitude of Impact		Sensitivity of Receptor				
		Very low	**Low**	**Medium**	**High**	**Very High**
Positive	**Very high**	Moderate	High	Major	Major	Major
	High	Low	Moderate	High	Major	Major
	Medium	Low	Low	Moderate	High	High
	Low	Very low	Low	Low	Moderate	Moderate
	Very low	Very low	Very low	Very low	Low	Moderate
Negative	**Very low**	Very low	Very low	Very low	Low	Moderate
	Low	Very low	Low	Low	Moderate	Moderate
	Medium	Low	Low	Moderate	High	High
	High	Low	Moderate	High	Major	Major
	Very high	Moderate	High	Major	Major	Major

The uncertainty associated with the significance assessment is noted for each impact. The level of uncertainty relates to the available information, level of assumptions, certainty of predictions and confidence in the accuracy of the inputs that produce the significance rating.

Benefits

Positive impacts of the Bawdwin project include employment and training; opportunities to supply goods and services to the project; generation of economic activity across the local region; reduced exposure to environmental hazards; and improved living conditions for the Bawdwin concession communities that are resettled.

The project will directly benefit the Myanmar economy in a number of ways. These include:

- Direct financial benefits including royalties and dead rent paid to the Union of Myanmar (dead rent is the amount that has to be paid by the lessee to the lessor whether or not he has derived benefit from the asset).
- Corporate income taxes paid to the Union of Myanmar by WMM
- Indirect taxes paid to the Union of Myanmar including, commercial tax; withholding tax; customs duties and personal income tax.
- An additional profit share tax as governed by the amended Production Sharing Contract or agreement.

- Contributions to national mineral export revenue, total export revenue and gross domestic product.

The project may result in local and regional economic stimulus associated with the procurement of goods and materials and employment opportunities. Local businesses (existing and new) will be supported through preferential procurement policies for local goods and services. Other goods and materials will be procured from within Shan State and elsewhere in Myanmar, where practicable. This will aim to support, as far as practicable, the establishment of local businesses that are sustainable in the longer term. Additionally, there will be strategic community-level investments by WMM in services, infrastructure, local business and livelihood development.

The project workforce will include up to 2,285 people during construction and up to 1,115 people during operations. WMM will seek to maximise the proportion of for members of local communities, through its Preferential Employment Policy. The project will contribute to the training, employment and capacity of both local and Myanmar workers, benefitting the economy and providing workers with an income.

There is an opportunity for the project to improve community health in the Bawdwin communities by resettling communities away from areas currently impacted by legacy environmental issues to lower risk locations. Reduced exposure to environmental hazards after resettlement is predicted to be a major significance positive impact to the community health of Bawdwin concession communities. Resettlement may also provide additional benefits in the form of improved access to employment opportunities in Namtu, essential services and resources (clean water, electricity, sanitation) and housing conditions.

Predicted impacts

A summary of the key impacts of the Bawdwin project presented by relevant environmental and social aspect is provided below.

Landform and soil impacts

The construction and operation of the project will involve significant changes to the landforms and movement of large volumes of soil and mine waste materials within the Bawdwin concession.

The open pit, TSFs and Wallah waste rock dump will represent large, permanent landform features. The TSFs and waste rock dump will be designed for long-term stability and reduced erosion potential. The existing pit void will be expanded and become a pit lake post-closure of the operations. The changes to landforms are shown in Figure ES.9.

Soil excavation, stockpiling and handling measures will include covering exposed soils from weathering, measures for correct segregation and reinstatement of soil and subsoil profile, and measures to reduce surface compaction. Of particular importance will be limiting side-casting of soil during construction, progressive rehabilitation of land and reinstating the soil profile to promote successful revegetation and land stability.

Key measures to reduce mixing of contaminated soils include identifying areas of contaminated soil and avoiding using these soils for rehabilitation, burying soils of lower level contamination deeper in the soil profile below the soil root zone and capped with uncontaminated soil, and treating and/or disposing highly contaminated soils.

The key impacts (those with a high significance or above) to landform and soils will be:

- Changes to landform due to formation and operation of the open pit, construction of the tailings storage facilities (TSFs) and waste rock dump – a high significance impact for the pit void across all terrain units and high to moderate significance impact for the TSFs and waste rock dump depending on the terrain unit.
- Reduced capacity to support ecosystems and beneficial land uses due to loss of topsoil due to increased erosion or poor soil management – a high significance impact for the steep mountain terrain land unit.

Areas of uncertainty relating to the assessment of impact of landform and soils include details of construction methods and detailed designs, closure designs, material balances for rehabilitation and closure, and extent of existing contamination from historic mining activities.

Groundwater impacts

The project will interact with groundwater in a number of ways: there will be facilities placed over existing springs where groundwater currently discharges; there will be extraction of groundwater through pit dewatering (both via in pit sumps and the existing pumping via Tiger Tunnel); and there will be increased inputs to groundwater from seepage from water storages, TSFs, the waste rock dump and the open pit (post closure when it becomes a pit lake). Seepage is likely to contain elevated metals and sulphate, and seepage from the TSF may have residual processing reagents. The seepage has the potential to reduce the quality of groundwater in the local area.

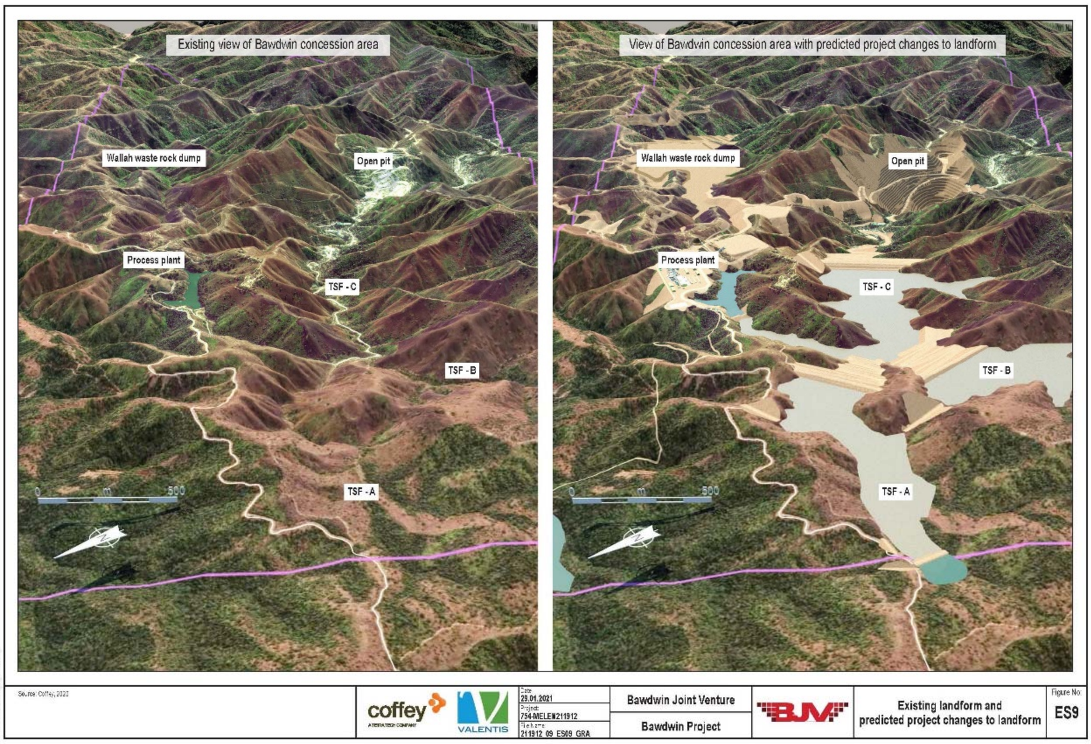


Figure ES.9 Existing landform and predicted project changes to landform

Design and management measures relating to groundwater include the design, construction and operation of the TSFs and Wallah waste dump to minimise seepage of poor water quality. The facilities will have underdrainage installed to minimise seepage and enable water collection, re-use and treatment prior to discharge. Other key mitigation and management measures include the resettlement of the Bawdwin and Tiger Camp communities that currently use groundwater fed water sources, lining of TSF embankment zones, water management on facilities and closure designs and strategies for the TSFs, waste rock dump and open pit to minimise potential for seepage of poor quality water.

The key impacts (those with a high significance or above) to groundwater will be:

- Loss of capability to support aquatic ecosystems and beneficial uses due to direct loss of springs from placement of project facilities over springs – a high significance impact that will affect 6 of the 16 known springs on the Bawdwin concession.
- Contamination of groundwater in the saprolite and fractured rock aquifers due to seepage from the TSFs – a major significance impact for the saprolite aquifers of the Nam Pangyun and Nam La and also the springs; a high significance impact for the fractured rock aquifers of the Nam Pangyun and Nam La.
- Contamination of groundwater in the saprolite and fractured rock aquifers in the Nam Pangyun catchment due to seepage from the waste rock dump – a major significance impact for the saprolite aquifer and a moderate to high significance impact for the fractured rock aquifer. Contaminated groundwater is expected to report to surface water features down gradient in the Wallah Valley.

Areas of uncertainty relating to the assessment of impacts to groundwater include the absence of groundwater modelling, predicted quality and rate of seepage, absence of geochemical modelling, the behaviour of groundwater flow (e.g. changes in flow, groundwater mounding) and the existing and predicted water quality of the fractured rock aquifer.

Surface water impacts

The majority of the direct project interactions with surface water will occur in the Nam Pangyun catchment, however there are also interactions that affect the Nam La catchment. The Nam Pangyun and Nam La are both tributaries to the Myitnge River.

The project will cause direct physical disturbance to watercourses by construction of project infrastructure construction of roads, watercourse crossings, river diversions and dams resulting in direct loss of surface water features, stream erosion and sediment deposition and aggradation. Changes to surface water flow will occur as a result of stream diversions, water abstraction, dewatering and landform and drainage changes, and may include changes to flood risk. Changes to water quality will occur as a result of runoff from disturbed areas, discharge of project effluents and dewatering water, discharge of groundwater and surface water from the waste rock dump and TSFs which is predicted to become enriched with metals, particularly lead and surface water will also be high in suspended sediments. The bed sediment quality in downstream surface waters may also change due to mobilisation of sediments and contaminated soils containing high metals concentrations.

Key design and management measures that will be used to minimise impacts to surface water include using: sediment dams to reduce the level of suspended sediments in surface water runoff prior to discharge; underdrainage systems in the TSFs and waste rock dump to capture the bulk of the seepage and allow this water to be treated prior to discharge; and treating mine dewatering water prior to discharge. WMM intend to treat all effluent streams to the Myanmar effluent standard.

Water abstraction from the Nam Pangyun, which will be partly offset by the discharge of groundwater from the pit dewatering system. To minimise potential impact of reduced flows on downstream users including Namtu, water will be extracted from the Nam La primarily during the wet season when flows are high, with the water being stored for use during the dry season. WMM will also ensure compensatory flows are released to ensure sufficient water is provided to Namtu and that water abstraction does not cause material impacts to downstream users.

To minimise construction impacts WMM will conduct the bulk of earthworks during the dry season, minimise the volume of water coming into contact with disturbed mine areas, and implement erosion and sediment control measures.

The key impacts (those with a high significance or above) to surface water will be:

- Physical disturbance of habitat due to direct removal of instream and riparian habitat affecting the ability to support ecosystems and beneficial uses – a high significance impact for the upper Nam Pangyun catchment which has higher quality water and aquatic habitat than the mid and lower sections of the catchment. This includes a 3 km section of the Nam Pangyun that will be converted to an underdrain and will result in permanent loss of instream and riparian habitat.

- Changes to surface water flow due to water abstraction during operations impacting the ability to support ecosystems and beneficial uses – a high significance impact for the upper section of the Nam La during dry periods throughout operations.
- Altered flood risk from project infrastructure – a potential high significance impact for the Nam La and an area that requires further investigation since flood modelling has not been undertaken.
- Reduced water quality due to contamination from project sources around the mine and runoff from the TSFs impacting the ability to support ecosystems and beneficial uses – a high significance impact for the upper Nam Pangyun.
- Reduced water quality due to increased TSS, turbidity and possibly metals concentrations impacting the ability to support ecosystems and beneficial uses – a high significance impact for the Nam La which will receive runoff from TSF A and B once they are closed.

Areas of uncertainty relating to the assessment of impacts to surface water include the lack of quantitative prediction and modelling of downstream water quality and flow changes, lack of sediment transport and deposition modelling, uncertainty surrounding water balance modelling and flood risk.

Air quality impacts and greenhouse gas emissions

Sources of impacts to air quality include dust emissions and deposition, and gaseous emissions. Dust emissions can result in airborne particulate matter and dust deposition. While there has not been modelling to quantify the likely severity and extent of impacts to air quality and to enable comparison with regulatory compliance, it is predicted that there will be an increase in airborne dust in some areas within and surrounding the project.

Most dust deposition during operations will occur in proximity to the open pit, stockpiles, waste rock dump, major construction areas, and to a lesser extent along haul roads. Sources of dust during operations will mainly be from mining, drilling, blasting in the open pit, movement of ore and waste rock and potentially the tailings as they dry.

The main gaseous emissions from the project will be in the form of sulphur dioxide and nitrogen dioxide from the power station and from vehicles. The emitted concentrations of these gases from the power station are predicted to be below the Myanmar criteria discharge limits for power stations, with the exception of nitrogen. In addition, there will be exhaust emissions from project vehicles and trucks that may reduce the air quality along roads used by these vehicles, including the export route.

Annual emissions of GHG (Scope 1 emissions) from project construction, operation and decommissioning are estimated to be on average 133.50 kt CO2-e / annum, generating a total of 2,269.50 kt CO2-e over the life of the project. Most of the GHG emissions will occur during the mine's operational period (13 years). The power station is expected to comprise approximately 66% of the total project emissions across all project phases. The second highest emissions contribution will come from vehicles, these will make up 33% of project related emissions. Explosives and waste will each comprise 0.3% of total emissions.

The key receptor groups considered in the assessment of air quality impacts are shown in Figure ES.10, ES.11 and ES.12.

A key measure to avoid air quality impacts to human receptors will be the resettlement of communities that are located in proximity to the project area where the greatest potential impacts to air quality will occur. The various receptors will be resettled at different times depending on their location with respect to project activities. The military base is not scheduled for resettlement at this stage, however resettlement will be decided in consultation with the army. The Bawdwin military base is the only receptor that will not be moved by the proponent and may remain on the Bawdwin concession area.

Other design and management measures to minimise impacts to air quality include use of modern and well maintained plant, vehicles and equipment, use of dust suppression measures (e.g., spraying unsealed roads with water), measures to limit dust generation including revegetation and rehabilitation measures and erosion and sediment control measures.

The key impacts (those with a high significance or above) to air quality will be:

- Reduced air quality due to increased airborne particulate matter and increased dust deposition during construction – a high significance impact for the Bawdwin upper village airshed (prior to their resettlement after 7 to 9 months) and for the Tiger Camp village airshed; and a major significance impact for the Military base and Bawdwin lower village airshed.
- Reduced air quality due to increased airborne particulate matter and increased dust deposition during operations – a major significance impact for the Military base and Bawdwin lower village airshed (prior to their resettlement 30 to 32 months after commencement of construction).
- Reduced air quality due to increased airborne particulate matter and increased dust deposition during active closure activities – a high significance impact for the Military base.
- Reduced air quality due to gaseous pollutants during operation of power station– a major significance impact for the Military base which will be located around 400 m from the source.

Areas of uncertainty relating to the assessment of impacts to air quality include the lack of predictive modelling of gas and dust emissions and deposition and uncertainty on how metal concentrations vary with dust particle size.

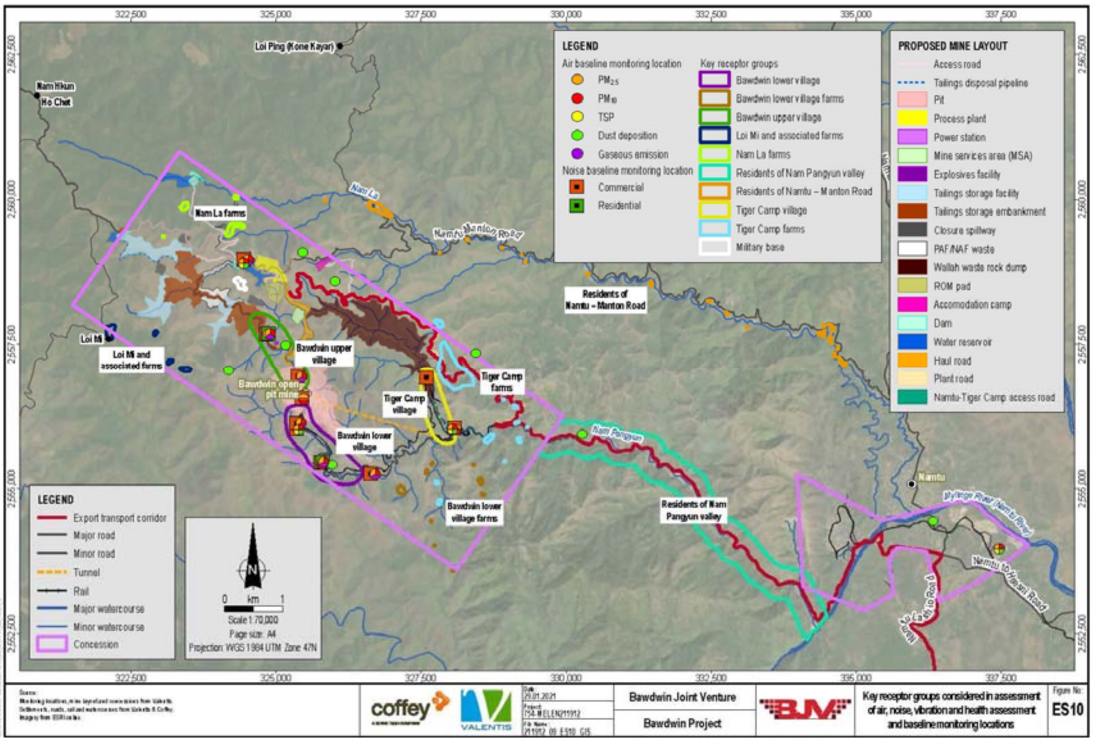


Figure ES.10 Key receptor groups considered in assessment of air, noise, vibration and health assessment and baseline monitoring locations

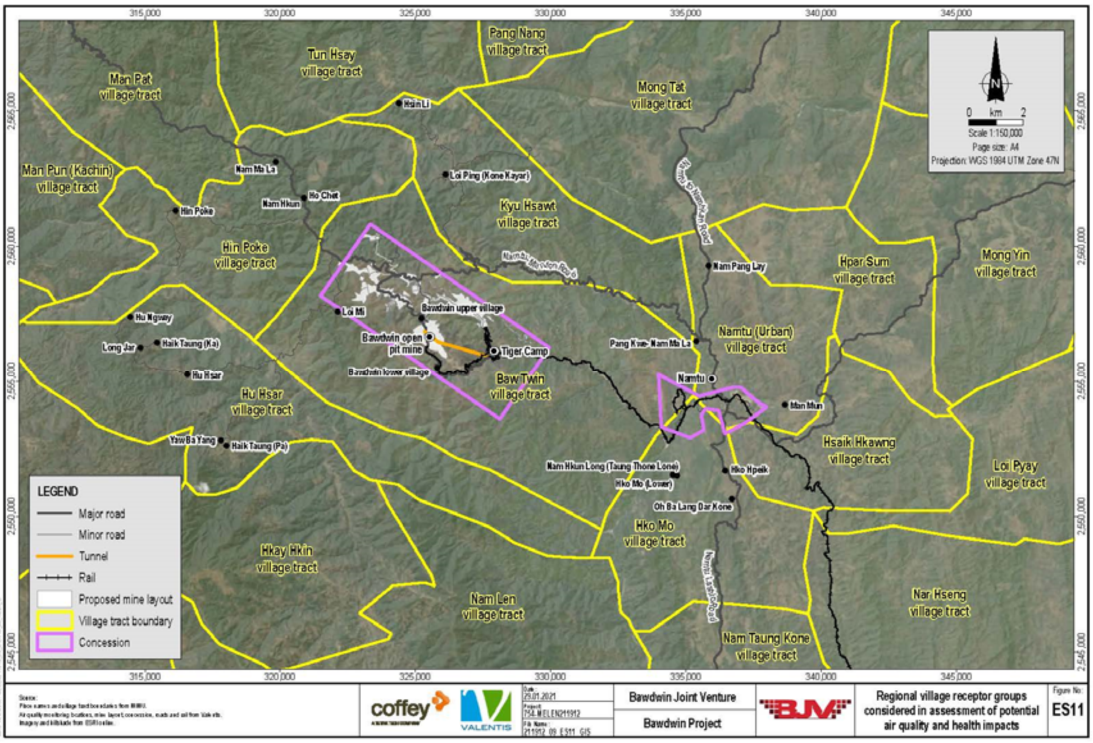


Figure ES.11 Regional village receptor groups considered in assessment of potential air quality and health impacts

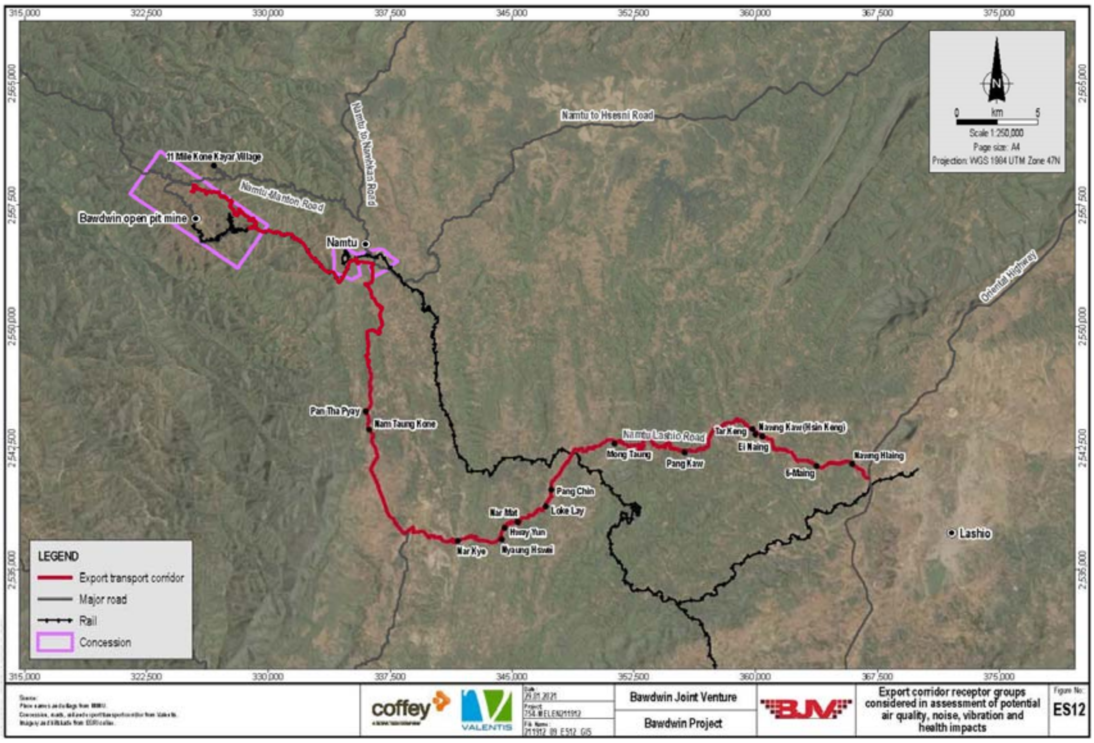


Figure ES.12 Export corridor receptor groups considered in assessment of potential air quality, noise, vibration and health impacts

Noise and vibration impacts

Project activities will result in noise and vibration emissions. However, with community resettlement from the highest intensity noise areas, the potential for severe impacts to health and amenity will be limited. The key receptor groups considered in the assessment of noise and vibration quality impacts are shown in Figure ES.10 and ES.12.

The primary impact avoidance measure will be the resettlement of communities that are located in proximity to the project area. Additional management measures will be implemented to limit the adverse impacts associated with noise and vibration including use of good practice blast management procedures.

The key noise and vibration impacts (those with a high significance or above) will be:

- Increased noise and vibration levels due to construction of process plant, power station, TSF-B and TSB-C embankments and haul road – a high significance impact for the Military base.
- Increased noise and vibration levels due to construction of roads and facilities and construction-related traffic - a high significance impact to the Nam La farms receptor (prior to their relocation after 7 to 9 months after commencement of the project).
- Increased noise and vibration levels due to mining activity – a high significance impact for the Bawdwin lower village (prior to their resettlement 30 to 32 months after commencement of construction).

Areas of uncertainty relating to the assessment of noise impacts include the lack of noise emission predictions and modelling of vibration emissions.

Biodiversity impacts

Impacts to biodiversity vales include loss or degradation of habitat and reduced abundance and/or diversity of flora and fauna species. The project will result in the removal of vegetation to expand the existing mine pit and construct infrastructure, including the TSFs, waste rock dump, water reservoir and roads. Most of the habitat removed will be modified grassland and bamboo, which is a low sensitivity vegetation type owing to it supporting common and generalist species.

Impacts to flora and fauna may occur due to habitat loss and degradation, accidental collision with project vehicles and machinery, introduction and spread of pests and weeds, and disturbance to fauna from project noise and dust. While there are a number of threatened flora and fauna that occur regionally the project area is not predicted to support key populations and therefore impacts to these species are not predicted.

Impacts to aquatic ecosystems in the Nam Pangyun are predicted to be low given the existing high levels of existing sedimentation and contamination in that catchment from hundreds of years of mining. Sedimentation and changes to flow in the Nam La represent more significant impacts compared to those to the Nam Pangyun, given its higher ecological importance.

Design and management measures to minimise biodiversity impacts include minimising clearance, erosion and sediment control, progressive rehabilitation and revegetation and measures to maintain flows (particularly during dry periods) for the Nam La.

The key biological impact (with a high significance or above) will be:

- Habitat loss and degradation due to vegetation clearance, contamination and introduction of invasive species - a high significance impact for the sub-tropical mixed hill forest habitat, which has a higher diversity of flora and fauna compared to other vegetation types in the project area. Approximately 12 ha of this habitat will be lost.

Areas of uncertainty relating to the assessment of biological impacts include limitations in the baseline survey data due to security-related access constraints, water quality and water quantity impacts, and mine closure and rehabilitation details.

Cultural heritage impacts

As a result of continuous human occupancy over six centuries, the Bawdwin area has a rich and complex history associated with mining activity. Much of the cultural heritage value of Bawdwin relates to the historical mining operations in addition to sites of importance to residents such as religious sites and grave sites.

The construction of the project would see the mining legacy of the Bawdwin deposits continued in the modern era, but as a consequence will impact some of the existing infrastructure and construction of new infrastructure at Bawdwin to support mining and processing activities. This will fundamentally alter the existing historical mining context, but provides an opportunity to document, research and conserve aspects of the past operations.

Sources of potential impact to cultural heritage include: disturbance or loss through project construction; restriction of access; and modification of the surrounding landscape character.

Proposed management measures are aimed to minimising impacts to known cultural heritage sites, and where avoidance is not possible putting in measures to comprehensively document and preserve key items to highlight and display the history of the Bawdwin mine into the future.

To manage impacts to cultural heritage features, a cultural heritage management plan will be implemented for the retrieval, dismantling and storage of features. The cultural heritage management plan will include measures for preservation of key components of the features in a dedicated mining museum. For graves and other sensitive archaeological features, a process for the inspection, exhumation, archiving and relocation will be established with qualified archaeologists, regulators, the community and appropriate religious and/or community leaders. It is expected that those graveyards that have strong cultural ties or active community use with the local community will be re-established/relocated as part of the community resettlement plan. Known graveyards and religious sites may be lost from their current locations, however these will probably be relocated rather than destroyed.

The cultural heritage management plan will also outline procedures for ensuring that the project personnel are made aware of the cultural heritage values and the importance of complying with the management measures. This will involve a combination of measures such as incorporating requirements into contracts, workforce induction, cultural awareness training, workforce training, education and awareness, compliance audits and monitoring. Cultural heritage features that are relocated or stored will have appropriate management plans in place to ensure that they have the necessary levels of safeguard and care and maintenance. Sites that are relocated within the Bawdwin concession will have appropriate 'no-go' zones established around the features.

The key impacts (with a high significance or above) to cultural heritage will be:

- Direct loss of sites and values due to earthworks and mining – a major significance impact for the known Chinese era mining and smelting evidence sites, Chinese stone bridge foundation and Chinese bazaar buildings and larger/rarer artefacts and evidence of Chinese occupation; a high significance impact for graveyards, any unknown Chinese era smelting evidence and the smaller, widespread artefacts and evidence of Chinese occupation. Figure ES.8 shows the locations of cultural heritage features with respect to Project footprint.
- Loss due to sites or objects being decommissioned and removed from project footprint – a major significance impact for the Colonial-period infrastructure (Marmion shaft and winding house) and the Namtu to Bawdwin railway.
- Disturbance (rather than loss) of sites and values due to earthworks and mining – a high significance impact for larger/rarer artefacts and evidence of Chinese occupation.
- Reduced heritage values due to modification of surrounding landscape – a high significance impact for Chinese hillforts and defended ridges, and those graveyards located on prominent ridges and crests.

Areas of uncertainty relating to the assessment of cultural heritage impacts include the location of possible subsurface heritage features and artefacts (only a surface inspection has been conducted), exact age and value of some cultural heritage features, community feedback on particular management measures and significance of some items.

Social impacts

The project has the potential to impact a range of social and socio-economic aspects at differing spatial scales. To assess social impacts three key aspects were defined as well as relevant supporting values. These covered:

- Local economies, livelihoods and land use.
- Living conditions, social cohesion and security.
- Access to health, education and other services.

Social impact areas have been broadly defined through consideration of: community location (including watershed boundaries; village tract boundaries; and proximity to the project's footprint; lease boundaries and logistics support corridors); and the type of project activity that may occur in proximity to villages.

Six social impact zone were defined. These are shown on Figures ES.13 and ES.14, and include:

- Zone 1 – Bawdwin communities consisting of upper and lower Bawdwin villages and Tiger Camp (and Nam La village and scattered hamlets and houses within the south and eastern portions of the Bawdwin concession but outside of the village settlements).
- Zone 2 – villages in village tracts adjoining the Bawdwin concession area (and the Loi Mi village and associated farms that use land within the Bawdwin concession).
- Zone 3 – Namtu Town.

- Zone 4 – the corridor along the Nam Pangyun valley that includes scattered farming hamlets and periodic presence of artisanal miners.
- Zone 5 – villages along the road between Namtu and Lashio that will be used by the project.
- Zone 6 – Lashio.

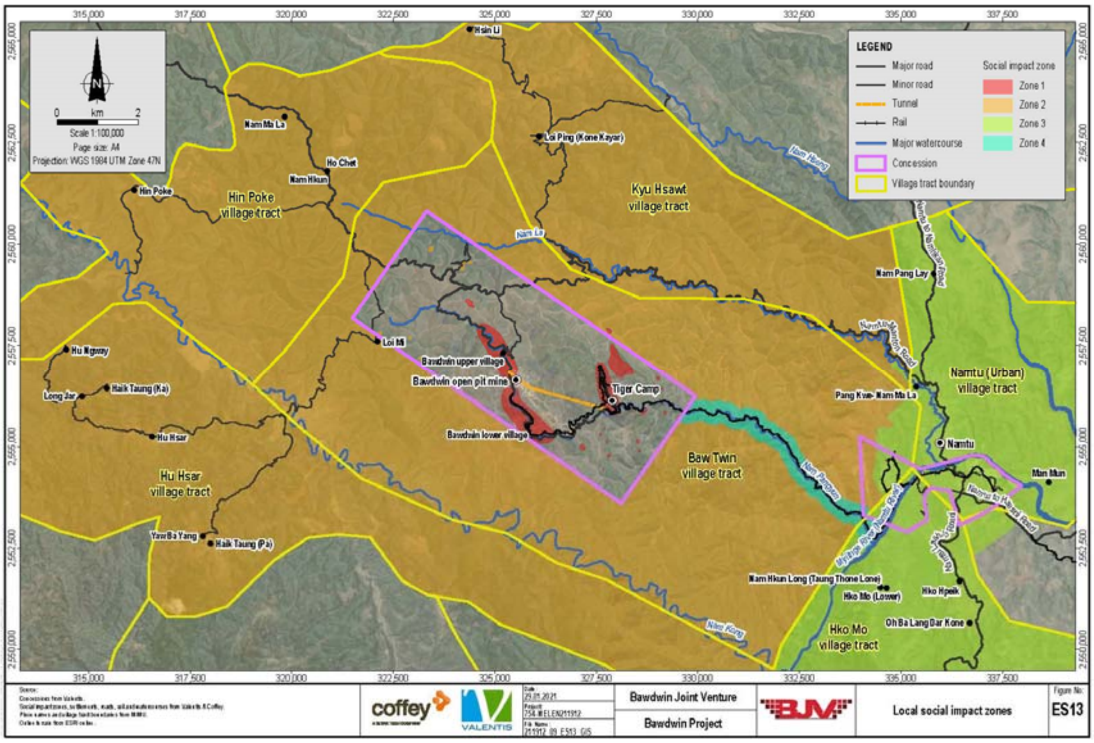


Figure ES.13 Local social impact zones

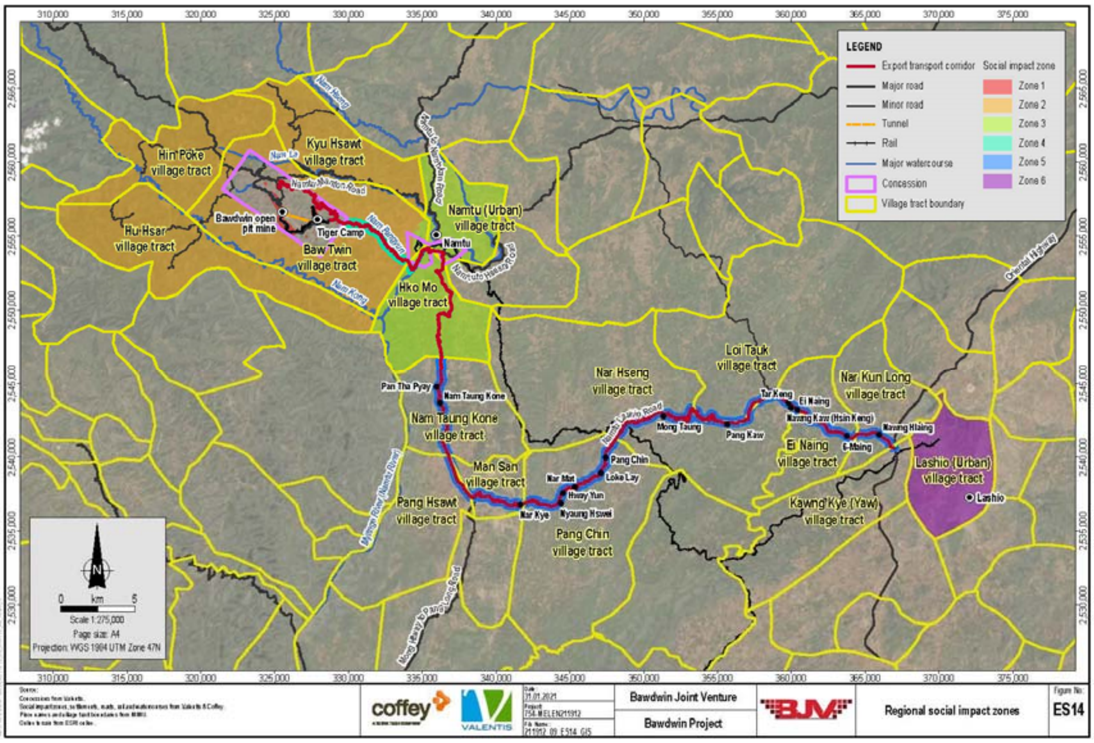


Figure ES.14 Regional social impact zones

The Bawdwin project has a substantially larger footprint than the historical Bawdwin mining operation. The total footprint area is approximately 470 hectares (ha). Although the Bawdwin project is still contained in the Bawdwin concession, it will result in more land being directly and indirectly disturbed by the mining operations than has occurred in previous mining periods. This will require resettlement of the existing communities within the Bawdwin concession.

The project will also result in increased use of some public infrastructure (e.g., roads) and creation of new infrastructure to support the projects. Socio-economic impacts associated with large mining projects can be broad ranging, relating to employment opportunities, supply of goods and services to the project, increased immigration to the project area, changes to social cohesion and changed amenity for communities (e.g., visual, air, noise etc.)

WMM will implement social management plans aimed at maximising project benefits and minimising potential negative impacts. Resettlement of the Bawdwin concession communities is both a social impact and also a mitigation and management measure to minimise the exposure of the community to environmental hazards and risks associated with the development of the mine. WMM has committed to providing the same or improved access to education, health services and religious institutions at the new resettlement village and there is likely to be improved access to markets, shops and other services if the communities are resettled to near Namtu.

The key impacts (with a high significance or above) to social aspects will be:

- Mining related employment opportunities - a major positive significant impact for the concession villages (Zone 1).
- Loss of access to land/resources for livelihood purposes – a high significance impact for the Bawdwin farm communities (Zone 1b), Loi Mi community (Zone 1c) which will lose access to productive agricultural land and scavenging sites,
- Adverse physical living conditions as a result of project construction activities – a high significance impact for the Tiger Camp Village and surrounding rural farms, Bawdwin Lower Village and surrounding farms prior to resettlement.
- Improved physical living conditions for resettled Bawdwin communities – a major positive significant impact for the Bawdwin communities (Zone 1) following resettlement.
- Altered social cohesion and a loss or reduction of social identity as a result of the resettlement for the project – a high significance impact for resettled Bawdwin concession communities (Zone 1).
- Impaired access to religious institutions and support for resident villages surrounding the Bawdwin concession from closure of places of worship – a high significance impact for surrounding villages to the concession (Zone 2).

Areas of uncertainty relating to the assessment of social impacts include resettlement planning (including location and potential livelihood restoration), the socioeconomic environment of some receptor groups, perceptions of communities to visual changes, the potential extent of in-migration, and lack of modelling to support air quality, noise and vibration impacts.

Health impacts

Project-related activities may directly, indirectly, and even cumulatively change community exposures to environment-based health risks, such as exposure to hazardous materials or conditions and traffic accidents like the socio-economic, health impacts differ depending on the people's location as well as the type of exposure pathway. The key receptor groups considered in the assessment of health impacts are shown in Figure ES.10 to ES.12.

Based on available data evaluation of metals in soil, water, air and food, there are multiple pathways by which Bawdwin and Namtu communities are currently exposed to health hazards. While community interviews of health indicators, anthropometric measurements, and non-invasive clinical examinations did not demonstrate any clear relationships between exposure of contaminants such as lead known to be present in both study areas, blood sampling of employees for occupational health testing showed that they all had high concentrations of lead in their blood.

The project construction will generate a number of health exposure pathways or exacerbate the current conditions by increasing dust, exposing soils, and reducing the quality of water. These have the potential to further expose these communities to hazardous conditions for their health. In addition, having the presence of a large workforce has the potential to introduce and spread disease.

Prior to resettlement Bawdwin lower and Tiger Camp villages and the nearby surrounding residences will continue to be exposed to emissions of dust containing metals such as lead. Depending on the location of residences these have the potential to be inhaled or ingested. This is likely to increase existing already high levels of lead within people's bodies. Additionally, several of these groups use surface water and groundwater resources which may become impacted.

Resettlement of communities from the Bawdwin area will result in people being moved away from hazardous areas, where soils and waters are contaminated with high concentrations of heavy metals such as lead. With resettlement of the Bawdwin communities and the construction of a new villages with essential services including clean water and modern sanitation systems, the project is expected to reduce exposure to environmental hazards and have a positive effect on the health of these resettled communities. Resettlement of villages will also lower risks to community safety during operations, including for example, removal from areas of impact from blasting.

The key impacts (with a high significance or above) to health will be:

- Exposure to environmental hazards (contaminated dust and water) as a result of the project –impact to Bawdwin upper village (prior to resettlement during the construction period) and Tiger camp village and Tiger Camp farms (not located along plant access road) (prior to resettlement) and residents of the Nam Pangyun valley; and a major significant impact to Bawdwin lower village during construction and operations (prior to resettlement) and to the military base during construction and operations.
- Reduced exposure to environmental hazards (contaminated dust and water) as a result of the project once communities are resettled – a high significance positive impact for Bawdwin lower village farms, Tiger Camp farms (not located along plant access road) and Nam La farms; a major significance positive impact for Bawdwin upper village, Bawdwin lower village and Tiger Camp village.

- Changes in sanitation and access to clean, non-contaminated water - a moderate to high significance positive impact for the communities within the Bawdwin concession area.

Areas of uncertainty relating to the assessment of social impacts include community blood lead levels, environmental baseline data for some receptor groups (e.g., Nam Pangyun valley along rail corridor), resettlement location and baseline contaminant exposure levels and uncertainties related to other aspects that impact on health (e.g., air quality, noise and vibration, surface water and groundwater).

Assessment of hazard and risk

In addition to the potential impacts caused by the planned or known events associated with the project, there is the potential for impacts to occur due to unplanned events which are unlikely or very unlikely to occur. These unplanned events include natural hazards and disasters and industrial mining hazards, and can have consequences that may impact the success of the project and increase the magnitude of project impact on the surrounding environment.

Natural hazards

Natural events may cause an environmental or safety incident at the mine such as infrastructure failure, which in turn can have environmental and social impacts. Earthquakes, landslides, storms and/or floods have the potential to damage project facilities, potentially resulting in failure of the TSFs, waste rock dump, water storage dams and open pit wall, or resulting in uncontrolled release of contaminated materials into the environment, posing a risk to the environment and human health.

The project lies within an area of moderate seismic activity within the Bawdwin Fault Zone and is therefore at risk of being affected by earthquakes. Landslides may occur as a result of sustained heavy rainfall, earthquakes and slope instability. Climate change has the potential to exacerbate certain natural hazards, including storms, flooding and droughts, and precipitation and temperature are both predicted to increase in Myanmar over coming decades.

Drought may reduce availability of water for the project, which requires 150.0 m^3/hr or 2.8 M m^3 at steady state operations. Collected in wet season and used year-round. Abnormally dry wet seasons may not provide sufficient water. Abstraction of water from the Nam La during dry periods may reduce flows and reduce the amount of water available for communities and putting pressure on water resources.

Hazards

Additional hazards assessed in the hazard and risk assessment include:

- Mining industrial hazards (e.g., vehicles accidents, failure of TSFs, pit wall failure and fires).
- Occupational and community health and safety hazards.
- Civil unrest and conflict were assessed.
- Failure of the TSFs or waste rock dump are key risks associated with the project and have the potential to cause contamination which may impact people and/or the environment downstream, should they eventuate.

Management measures and design controls to reduce the likelihood and/or minimise the consequences of the event include designing infrastructure with consideration of the probable maximum food (PMF), probable maximum precipitation (PMP), maximum credible earthquake (MCE), relevant standards and modelling results where possible.

No events are assessed as having major risk. The consequences of events assessed as being high risk are:

- Potential fatalities and/or severe injuries (unlikely) due to vehicle accidents; TSF failure; fire and/or explosions; electrical failures, equipment malfunction and mechanical failure; building failure; blasting and fly rock; falls from heights; and civil unrest and conflict.
- Major effects to environment and nearby communities due to fire and/or explosions.

Cumulative impacts

The cumulative impact assessment considers potential impacts of other operating, approved or proposed developments within the area of influence of this project and assesses the potential combined impacts from these projects and the Bawdwin project on key environmental, social, health and cultural values.

The location of projects that could contribute to cumulative impacts are shown in Figure ES.15. These projects include mineral projects, exploration projects, electricity and power projects and highway and railway projects.

Landforms and soil

At a broader landscape scale, all of the mining and exploration projects will probably to locally impact landforms and soil in the region due ground disturbance and erosion. The construction activities associated with the electricity and power projects as well as the railway and road projects will probably impact landforms and soils. The number of mining and exploration projects represent a further (cumulative) threat to landforms and soil quality in Northern Shan State.

Air quality

Material impacts of the Bawdwin project are limited to the airsheds in proximity to mine area and minimal cumulative impacts may occur due to oxide mining, which will conclude at or very shortly after the commencement of mining by the Bawdwin project. Some cumulative air quality impacts may occur due to dust generation from construction of the Bawdwin project, alongside oxide mining. All other identified projects do not fall within the Bawdwin project area of influence relevant to air quality, however, are expected to have cumulative impacts to air quality (along with the Bawdwin project) in Northern Shan State, albeit in separate airsheds apart from the projects mentioned above at Bawdwin and Namtu.

Surface water

Several projects are located along or may discharge to the Myitnge River, including zinc production from slag in Namtu by Myanmar Apex Mining Company Limited (operational) and the processing of oxide ore at the existing 32-Mile concentrator plant by WMM (in development). Collectively, these projects may impact the water quality and beneficial uses of Myitnge River.

The Namtu (Hsipaw) Dam Project by NCEH (proposed) and Upper Yeywa Dam for Hydro Power headed by the MEPE (in construction) may impact hydrological regimes, flood risks and cause inundation as well as construction related impacts to water quality. While these impacts will potentially affect the same river (Myitnge), the impacts will probably occur in separate areas of the Myitnge to the area of influence of the Bawdwin project.

Groundwater

The Bawdwin project’s primary impacts to groundwater will stem from contamination of groundwater within Nam Pangyun catchment and potentially the Nam La catchments due to seepage from the TSFs and Wallah waste rock dump which is likely to contain elevated metals and sulphate, and residual processing reagents (in the case of TSF seepage). There may be some groundwater-related cumulative impacts if exploration projects proceed to large scale mining and development. However, these range from around 16 km to 365 km from the Bawdwin project, and are therefore not likely to impact the saprolite or fractured rock aquifers within the Nam Pangyun and Nam La catchments.

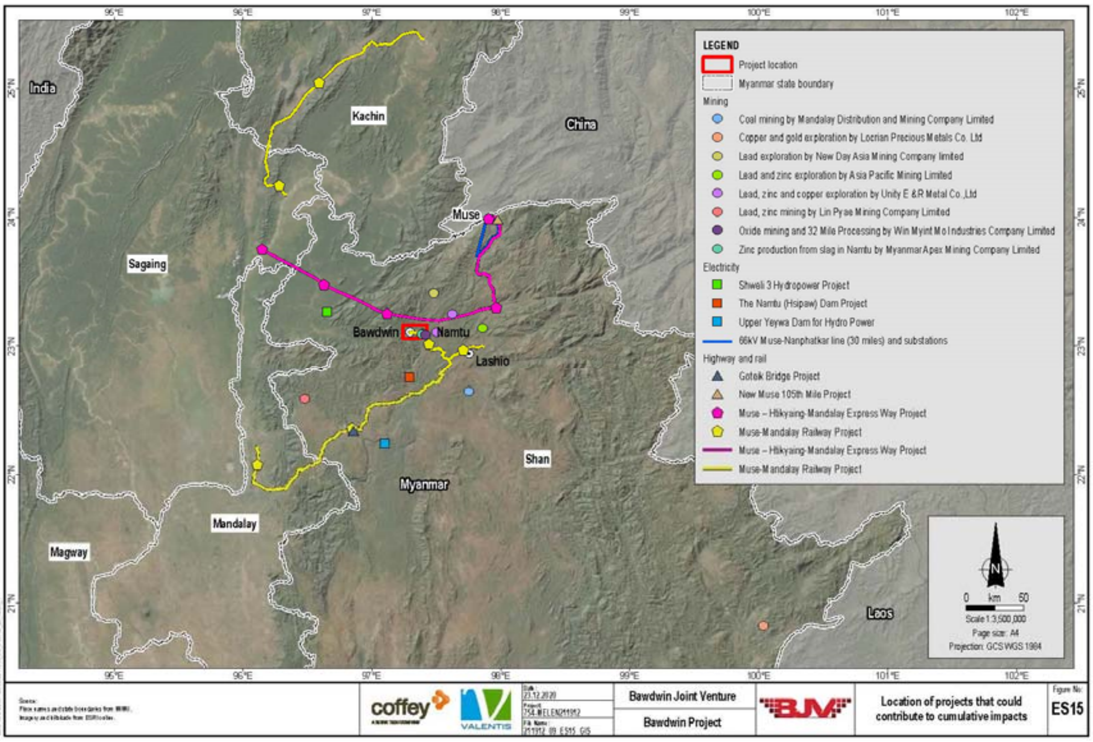


Figure ES.15 Location of projects that could contribute to cumulative impacts

Biological

Material impacts to the biological environment due to the Bawdwin project identified by the EIA were limited to habitat loss and degradation of the sub-tropical mixed hill forest habitat. All of the other proposed projects are expected to impact the biological environment to some extent, resulting in cumulative impacts at a broader landscape scale. The impacts will depend on the exact location of projects and their impacts on vegetation, habitats and flora and fauna.

Cultural heritage

Given most of the significance and uniqueness of cultural heritage at the Bawdwin mine is related to the history of the mine itself, it is not expected that there will be any cumulative impacts to cultural heritage features within the Bawdwin concession and along the existing railway corridor related to the other proposed projects. It is noted that the Muse-Mandalay Railway Project is still in early stage of feasibility and information on its alignment is uncertain.

Noise and vibration

Material noise and vibration impacts from the Bawdwin project are limited to the receptor groups residing within the Bawdwin concession, who may experience cumulative impact during the temporal overlap between oxide mining and construction of the Bawdwin project. Given the location of the other proposed projects, cumulative impacts related to noise and vibration are not expected.

Socio-economic

Impacts from the Bawdwin Project will overlap with the oxide mining within the Bawdwin concession which is expected to reduce amenity and increase traffic and road use during the Bawdwin project construction period.

Projects that are located in Namtu may lead to cumulative socio-economic impacts with the Bawdwin project. Particularly, if the Bawdwin concession villages are resettled to a location near Namtu, including impacts to convenience and liveability associated with potential in-migration from all projects and altered social cohesion. There may also be positive cumulative impacts of all the projects associated with increased local employment and procurement.

Human health

Cumulative human health impacts may result during the temporal overlap between operation of the oxide mining project and construction of the Bawdwin project from inhalation, ingestion or dermal contact of dust emissions with elevated metals. Following resettlement, the communities will face significantly lower exposures from the Bawdwin project. However, if resettled to a location near Namtu they may be impacted by reduced air quality resulting from the processing projects in the area including oxide ore processing by WMM (proposed) and zinc processing from slag by Myanmar Apex Mining Company Limited (operational).

Public participation

A Public Participation Plan has been prepared by WMM to guide consultation and disclosure of project information, feedback and disclosure for the project EIA.

Identification of stakeholders

Stakeholder identification is the process of determining who the project stakeholders and interested parties are, the particular interests held by those groups, and the influence they may have on the project. A stakeholder identification process has been undertaken and continually reviewed and updated.

Categories of stakeholders and project affected persons (PAP) identified include:

- Communities.
- Community leaders.
- Religious groups.
- Ethnic groups.
- Vulnerable groups.
- Government.
- Non-government organisations.
- Existing workforce.
- Ethnic armed organisations.
- Railway corridor communities.
- Export route communities.
- Contractors, suppliers and service providers.
- Media.
- Owners and investors.

Consultation methods

Tailored stakeholder communication and consultation methods were used to engage with each stakeholder group based on their interest and understanding of the project, how they may be affected by the project and their language and literacy skills. Consultation activities including seeking views and input and general project awareness.

The methods used to seek views and input included:

- Three rounds of formal public consultation with PAPs and stakeholders.
- Informal, ad hoc community meetings and updates with Bawdwin, Namtu and Tiger Camp communities and members of WMM management.
- Stakeholder meetings and one-on-one briefings.

- Community information centres in Bawdwin and Tiger Camp villages.
- Liaison officer in communities.
- Community newsletters and publications, including presentations, newsletters and fact sheets.
- EIA baseline surveys, including the socio-economic survey, community meetings and engagement with surrounding villages.
- Workforce presentations and meetings.
- The methods used for general project awareness included:
- Project videos.
- WMM website.
- Myanmar Metals ASX announcements.
- Media interviews.
- Community development projects.

Formal public consultation

Consultation meetings as part of the first round of public participation were held with a cross section of project-affected persons and other stakeholders including Union, Shan and Township Governments and NGOs. The meetings took place in January and February 2019. This first round of public participation intended to disclose project and provide high level information on the Project Proposal.

The second round of public consultation was made challenging by the outbreak of the COVID19 pandemic. The second formal round of public consultation was organized in close collaboration with the Namtu General Administration Department and adhered to COVID19 prevention protocols. This round was held with a cross section of project-affected persons and other stakeholders including local communities, Union, State and Township Governments, NGOs and the military. Separate meetings were held with female community members via meetings organised by the Women's Affairs Federation. Stakeholders were given the opportunity to raise their concerns, suggestions and recommendations.

During each of the meetings in round one and two, a presentation was provided which was followed by questions and answers. Plates ES.10, ES.11 and ES.12 show meetings with Bawdwin and Namtu community members and the Monks Association.

The third round of consultation was made challenging by the significant spread of the COVID19 virus and the lockdown placed on Yangon residents by the Ministry of Health and Sports. To enable the consultation to continue, a process of digital consultation was established in accordance with ECD's notification relating to consultation guidelines during Covid19. A series of videos were created to provide updated project information to the communities and distributed via memory stick widely in Bawdwin and Namtu and through the WMM website to other stakeholders. Questions from the community were communicated via household leaders to the EIA consultant and answered by WMM.

Results of consultation

Round 1

Key areas of interest and issues raised in the first round of consultation included:

- Project development, infrastructure requirements, layout and planning, including queries regarding waste management, maintenance and current stage of the study.
- Resettlement and compensation.
- Local development and improvement of living standards, education, health, infrastructure and economy.
- Employment.
- Public consultation importance, accessibility (availability in multiple languages) and inclusion of minorities.
- Benefits to the local community and Myanmar, and importance of the project to regional development.
- Mine closure.
- Project proponent background and ownership structure.
- Transparency and disclosure.

Round 2

Key areas of interest and issues raised in the second round of consultation included:

- Resettlement, including location, internally displaced persons, compensation, accountability, provision of burial grounds, and accessibility to services, community infrastructure and land.
- Peace, security and Ethnic Armed Organisations (EAO).
- Public consultation including importance, inclusion of minorities, understanding local community needs and incorporation of consultation findings in EIA.
- Transparency and disclosure
- Employment, in-migration, skills/training and livelihoods
- Project development, existing contamination, alternatives, scoping, timing, infrastructure requirements, layout and planning, including queries regarding waste and water management, future mining plans and Free, Prior and Informed Consent of the community
- Health impacts
- Local businesses and regional development
- Preservation of cultural heritage and destruction of buildings in accordance with religious belief and practice.

- Access to education and health services for surrounding communities.
- Ensure clear understanding of Government expectations for environmental /community funds management.

Round 3

<<To come once communication of EIA has been completed. It was not possible to complete the third round of public consultation due to COVID-19 restrictions and civil unrest related to the political situation in Myanmar. The third round of public consultation was commenced, however the component which addressed impact assessment findings was not able to be delivered due to reasons outlined above. >>

Plate ES.10 Bawdwin community meeting

Plate ES.11 Namtu community meeting

Plate ES.12 Monks Association meeting

Environmental and social management framework

Environmental and social management framework

The environmental and social management framework (ESMF) provides the project with a system for designating roles/responsibilities, management measures and performance outcomes so that legislative, stakeholder and good practice requirements are addressed in the environmental and social management plan (ESMP) and to allow ongoing monitoring of performance so that improvements are made where identified. The framework is implemented through the overarching ESMP (Attachment 4).

The ESMF is applicable to all project phases: pre-construction (planning and approvals); construction (implementation); operations (mining and production); decommissioning and closure; and post-closure. The ESMF guides the implementation of environmental, social and cultural management through integrating WMM policies and procedures with Myanmar legislation, guidelines and standards as well as adopted international guidelines and standards. The ESMF and ESMP align with WMM policies and procedures regarding the environment, communities and cultural heritage.

Environmental and social management plan

The ESMP (see Attachment 4) outlines the integrated management, monitoring, auditing and reporting processes and requirements for specific environmental, social and cultural aspects during all phases of the project. This ESMP includes the following components:

- Project phases.
- The policy and regulatory framework for the management of environmental, social, health and cultural heritage.
- Responsibilities of personnel implementing the ESMP.
- A summary of the impacts and hazards associated with the project and mitigation measures.
- Overall budget for implementation of the ESMP.
- The monitoring and reporting regime that will be implemented.
- Sub-plans to address specific mitigation and management requirements for different environmental, social, health and cultural heritage aspects.

Figure ES.16 provides an overview of the environmental and social management framework and associated management plans.

The approach taken towards environmental and social management will involve monitoring, auditing, recording and reporting results of monitoring and compliance with commitments and regulatory obligations. This will be undertaken to measure impacts and verify the predictions made in this EIA, determine the effectiveness of management measures and demonstrate compliance with permits and regulations.

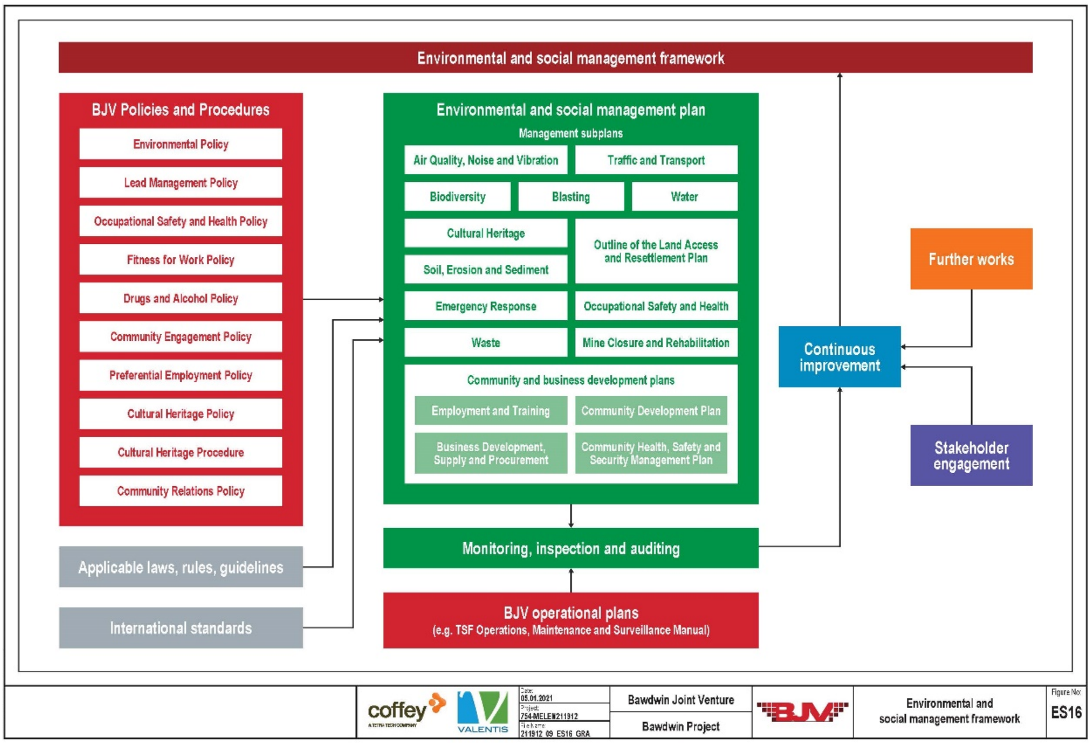


Figure ES.16 Environmental and social management framework

အစီရင်ခံစာအကျဉ်းချုပ်

နိဒါန်း

ဝင်းမြင့်မိုရ်စက်မှုလုပ်ငန်းကုမ္ပဏီလီမိတက်သည် မြန်မာနိုင်ငံ ရှမ်းပြည်နယ်မြောက်ပိုင်းရှိ ငွေ၊ ခဲ၊ သွပ် ထွက်ရှိသည့် နှစ်ပေါင်း ၆၀၀ သက်တမ်းရှိသော ဘော်တွင်းသတ္တုတွင်း (ဘော်တွင်းစီမံကိန်း)ကို ပြန်လည်ဖွံ့ဖြိုးအောင် ဆောင်ရွက်နိုင်ရန် အဆိုပြုထားပါသည်။ ဘော်တွင်းစီမံကိန်း၏ တည်နေရာမှာ မြန်မာနိုင်ငံမြို့တော်၏ အရှေ့မြောက် ၃၈၅ ကီလိုမီတာခန့်တွင် တည်ရှိပြီး နမ္မတူမြို့၏ အရှေ့ဘက် ၁၁ ကီလိုမီတာ အကွာအဝေးခန့်နှင့် ရှမ်းပြည်နယ်၏ မြို့ကြီးတစ်ခုအပါအဝင်ဖြစ်သော လားရှိုးမြို့၏ အရှေ့ဘက် ၄၀ ကီလိုမီတာခန့်အကွာအဝေးတွင် တည်ရှိပါသည်။ တည်နေရာပြမြေပုံအား (ES-1) ၌ ဖော်ပြထားပါသည်။

လက်ရှိအချိန်ကာလ၌ ဘော်တွင်းသတ္တုတွင်းကြီးသည် ဟင်းလင်းပွင့် တူးဖော်ထားမှု တစ်ခု၊ မြေအောက်သတ္တု တူးဖော်နေခြင်းနှင့် သတ္တုသန့်စင်ခြင်းဆိုင်ရာ အခြေခံအဆောက်အအုံများရှိသည်။ ဘော်တွင်းစီမံကိန်းတွင် ယခင် တူးဖော်ခဲ့သည့် ဟင်းလင်းပွင့် သတ္တုတွင်းအား တိုးချဲ့ကာ ဆက်လက် တူးဖော်ခြင်း၊ သတ္တုသန့်စင်ခြင်းလုပ်ငန်းစဉ် အသစ်အတွက် အထောက်အကူပြု အခြေခံ အဆောက်အအုံများ တည်ဆောက်ခြင်းတို့ ပါဝင်သည်။ စီမံကိန်းလုပ်ငန်းသည် ၁၃ နှစ်ကြာခန့် တူးဖော်နိုင်မည်ဖြစ်ပြီး ငွေ၊ ခဲ၊ သွပ် ပါဝင်သော သတ္တုများအား တစ်နှစ်လျှင် သတ္တုသန့်စင်နိုင်မှု ခန့်မှန်းခြေ တန်ချိန်ပေါင်း ၃.၀ သန်းခန့် ထုတ်လုပ်မည် ဖြစ်ပါသည်။ ထို့အပြင် သတ္တုတွင်းအား ဆက်လက်တိုးချဲ့နိုင်မည့် အလားအလာရှိပြီး သတ္တုတွင်း သက်တမ်းနှစ်ပေါင်း ၅၀ ခန့်အထိ ထုတ်လုပ်သွားနိုင်မည်ဖြစ်သည်။ ဘော်တွင်းသတ္တုတွင်း၌ ခဲ၊ ငွေ နှင့် သွပ် သတ္တုသယံဇာတ အရင်းအမြစ် တန်ချိန် ၁၀၀ သန်းခန့်ရှိနိုင်မည်ဟု ခန့်မှန်းထားပါသည်။

ဝင်းမြင့်မိုရ်စက်မှုလုပ်ငန်းကုမ္ပဏီလီမိတက်သည် ပတ်ဝန်းကျင်ထိန်းသိမ်းရေးဥပဒေ (၂၀၁၂) ခုနှစ် အရ ထုတ်ပြန်ထားသော ပတ်ဝန်းကျင်ထိခိုက်မှု ဆန်းစစ်ခြင်းဆိုင်ရာ လုပ်ထုံးလုပ်နည်းနှင့်အညီ ပတ်ဝန်းကျင်ထိခိုက်မှု ဆန်းစစ်ခြင်းဆောင်ရွက်နိုင်ရန် Coffeey Myanmar Limited နှင့် Valentis Services Limted (Coffeey & Valentis) တို့အား အပ်နှံခဲ့ပါသည်။ Coffeey & Valentis တို့သည် ဘော်တွင်းစီမံကိန်းအတွက် ပတ်ဝန်းကျင်ထိခိုက်မှု ဆန်းစစ်ခြင်း အစီရင်ခံစာ မူကြမ်းအား ပြင်ဆင်ခဲ့သော်လည်း လက်ရှိအရပ်ရပ်သော အခြေအနေများအရ အစီရင်ခံစာ ပြင်ဆင်ခြင်း လုပ်ငန်းစဉ်အား ဆက်လက်ဆောင်ရွက်နိုင်ခြင်း မရှိခဲ့ပါ။ ထို့ကြောင့် ဝင်းမြင့်မိုရ် စက်မှုလုပ်ငန်း ကုမ္ပဏီလီမိတက်သည် အီးဂတ်ပတ်ဝန်းကျင်ဆိုင်ရာ ဝန်ဆောင်မှု လုပ်ငန်းအား ဘော်တွင်း စီမံကိန်းအတွက် ပတ်ဝန်းကျင်ထိခိုက်မှု ဆန်းစစ်ခြင်းအစီရင်ခံစာကို ပြန်လည် ပြင်ဆင်ခြင်း လုပ်ငန်းစဉ်များ ဆက်လက်ဆောင်ရွက်နိုင်ရန် မေလ၊ ၂၀၂၃ ခုနှစ်တွင် ဆက်သွယ်ခဲ့ပါသည်။ ထို့နောက် အီးဂတ်ပတ်ဝန်းကျင်ဆိုင်ရာဝန်ဆောင်မှုလုပ်ငန်းသည် ၂၀၂၃ ခုနှစ်၊ ဇွန်လ၊ ၁ ရက်နေ့တွင် အစီရင်ခံစာပြင်ဆင်ခြင်းလုပ်ငန်းစဉ်များကို စတင်လေ့လာမှုများ ပြုလုပ်ခဲ့ပါသည်။

နောက်ခံအကြောင်းအရာ

ဘော်တွင်း သတ္တုတွင်းသည် သတ္တုတူးဖော်ခြင်းများ စတင်ခဲ့သည့် ၁၅ ရာစုမှစ၍ ကမ္ဘာပေါ်တွင် နှစ်အကြာဆုံးနှင့် အရေးပါဆုံးသော အခြေခံသတ္တုများ ထုတ်လုပ်သော သတ္တုတွင်းကြီးတစ်ခု ဖြစ်ပါသည်။ ဘော်တွင်းသတ္တုတွင်း၏ နောက်ခံသမိုင်းအကြောင်းအရာကို အဆင့် (၅) ဆင့် ခွဲခြားနိုင်ပါသည်။

- ရှေးဟောင်းသုတေသန မှတ်တမ်းများအရ ဖြစ်နိုင်ခြေရှိသော သတ္တုရိုင်းများကို အစောဆုံး ရှာဖွေတွေ့ရှိခြင်းဟု ဆိုနိုင်သည်။
- တရုတ်နိုင်ငံ၏ သတ္တုတွင်းလုပ်ငန်းတစ်ခုသည် ဘော်တွင်း သတ္တုတွင်း၌ ၁၄၁၂ ခုနှစ်မှ စတင်၍ ၁၈၆၈ ခုနှစ် အထိ လုပ်ကိုင်ဆောင်ရွက်ခဲ့သည်။ ဤအဆင့်တွင် ER ချိုင့်ဝှမ်းနှင့် နန့်ပန်ယွန်းတို့၌ ငွေသတ္တုအမျိုးအစားကိုသာ တူးဖော်ခဲ့ပါသည်။ သတ္တုရိုင်းများကို လုပ်ငန်းတည်ရှိရာ နေရာ၌ပင် အရည်ကျိုပြီး ခဲသတ္တုကြွယ်ဝသော စွန့်ပစ်အစိုင်အခဲများကို နန့်ပန်ယွန်း ချိုင့်ဝှမ်း၌ပင် စုပုံထားရှိခဲ့ပါသည်။ Plates ES 1နှင့် ES-2 တို့တွင် ဘော်တွင်း ဧရိယာအတွင်း တရုတ်နိုင်ငံ၏ သတ္တုတွင်းလုပ်ငန်းတစ်ခု ဆောင်ရွက်ခဲ့သည့် အထောက်အထားကို တွေ့နိုင်သည်။
- ကချင်ပြည်နယ်နှင့် ရှမ်းပြည်နယ်ရှိ ဒေသခံများ၏ အကန့်အသတ်ဖြင့် အသေးစား လုပ်ကိုင်သော သတ္တုလုပ်ငန်းများကို ၁၈၆၈ ခုနှစ်မှ ၁၉၀၁ ခုနှစ်အထိ တွေ့ရသည်။
- ၁၉၀၁ ခုနှစ်၊ ဗြိတိသျှ ကိုလိုနီခေတ်နှင့် ကိုလိုနီခေတ် လွန်ကာလမှ ၁၉၆၂ ခုနှစ် အများပြည်သူပိုင်အဖြစ် မသိမ်းဆည်းခင်ကာလ အထိ၊ ၁၉ ရာစု အစောပိုင်းနှစ်များတွင် ခဲဓာတ်ကြွယ်ဝသော ချေးချေး (ဘော်ကျောက်) များကို ပြန်လည်သန့်စင်ခြင်း လုပ်ငန်းများကို စတင်ခဲ့ပြီး ဟင်းလင်းဖွင့် တူးဖော်ခြင်းနှင့် မြေအောက်တူးဖော်ခြင်း လုပ်ငန်းများကို ဆောင်ရွက်ခဲ့သည်။ ၁၉၂၈ ခုနှစ်၊ ၁၉၃၈ ခုနှစ် ကာလများသည် သတ္တုတွင်းလုပ်ငန်း၏ ထုတ်လုပ်နိုင်မှု အတည်ငြိမ်ဆုံးနှင့် ထုတ်လုပ်နိုင်မှု အကောင်းဆုံး နှစ်ကာလများဖြစ်ခဲ့ပြီး အမြင့်ဆုံး ထုတ်လုပ်နိုင်မှုမှာ ခန့်မှန်းခြေအားဖြင့် တစ်နှစ်လျှင် သတ္တုရိုင်းပမာဏ တန်ချိန် ၅ သိန်းအထိ အများဆုံးထုတ်လုပ်နိုင်ခဲ့သည်။ Plate အမှတ် (ES-3) တွင် ခန့်မှန်းမှု အားဖြင့် ဗြိတိသျှလူမျိုးများနှင့် တရုတ်လူမျိုးများ လုပ်ငန်းများဆောင်ရွက်နေသည်ကို ဖော်ပြထားသည်။

- သတ္တုတွင်းလုပ်ငန်းကို ၁၉၆၂ ခုနှစ်မှ ၂၀၀၉ ခုနှစ်အထိ အများပြည်သူပိုင်အဖြစ် သိမ်းဆည်းခဲ့သည့် ကာလဖြစ်သည်။ အသေးစား သတ္တုတူးဖော်မှုလုပ်ငန်းများကို ဆက်လက်လုပ်ကိုင်ခဲ့သော်လည်း ၂၀၀၉ ခုနှစ်တွင် ပိတ်သိမ်းခဲ့သည်။

ဝင်းမြင့်မိုရ်စက်မှုလုပ်ငန်းကုမ္ပဏီလီမိတက်သည် သယံဇာတနှင့် သဘာဝပတ်ဝန်းကျင် ထိန်းသိမ်းရေး ဝန်ကြီးဌာနအောက်ရှိ အစိုးရသတ္တုတွင်းလုပ်ငန်း၊ အမှတ် (၁) သတ္တုတွင်းလုပ်ငန်း (ME-1)နှင့် ထုတ်လုပ်မှုအပေါ် ခွဲဝေသည့် စနစ်ဖြင့် ၂၀၀၉ ခုနှစ်၊ ဒီဇင်ဘာလ ၃၁ ရက်နေ့တွင် သဘောတူ စာချုပ်ချုပ်ဆိုထားခဲ့ပြီး ထိုစဉ်ကတည်းကပင် ထုတ်လုပ်မှုအပေါ် ခွဲဝေသည့် စနစ်ဖြင့် ခွင့်ပြုမိန့်နှင့် စာချုပ်ပါ စည်းကမ်းများအတိုင်း သတ္တုတွင်းနှင့် သတ္တုသန့်စင်ခြင်းဆိုင်ရာ အထောက်အကူပြု ပစ္စည်းများအား ပြုပြင်ထိန်းသိမ်းစောင့်ရှောက်သည့် လုပ်ငန်းများကို ပြန်လည်ဆောင်ရွက်ခဲ့သည်။

၂၀၂၀ ပြည့်နှစ် နှောင်းပိုင်းတွင် ဝင်းမြင့်မိုရ် စက်မှုလုပ်ငန်း ကုမ္ပဏီလီမိတက်သည် ယခင် ဟင်းလင်းပွင့် သတ္တုတွင်းရှိ အောက်ဆိုဒ်သတ္တုရိုင်းများ ထုတ်လုပ်နေသည့် အသေးစား သတ္တုတွင်း လုပ်ငန်းများအတွက် အထောက်အကူပြုစေရန် ယာဉ်ယန္တရားများဖြင့် သယ်ယူပို့ဆောင်နိုင်မည့် လမ်းတစ်ခုကို ဖောက်လုပ်ပေးခဲ့သည်။

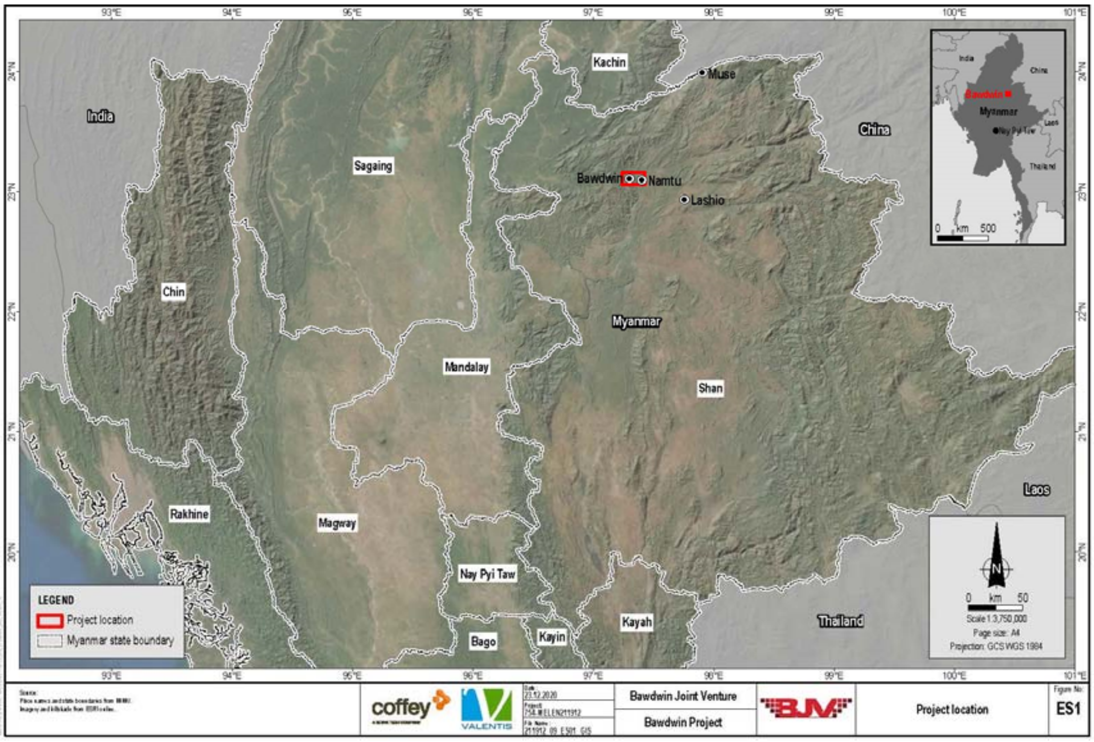


Figure ES.1 Project location

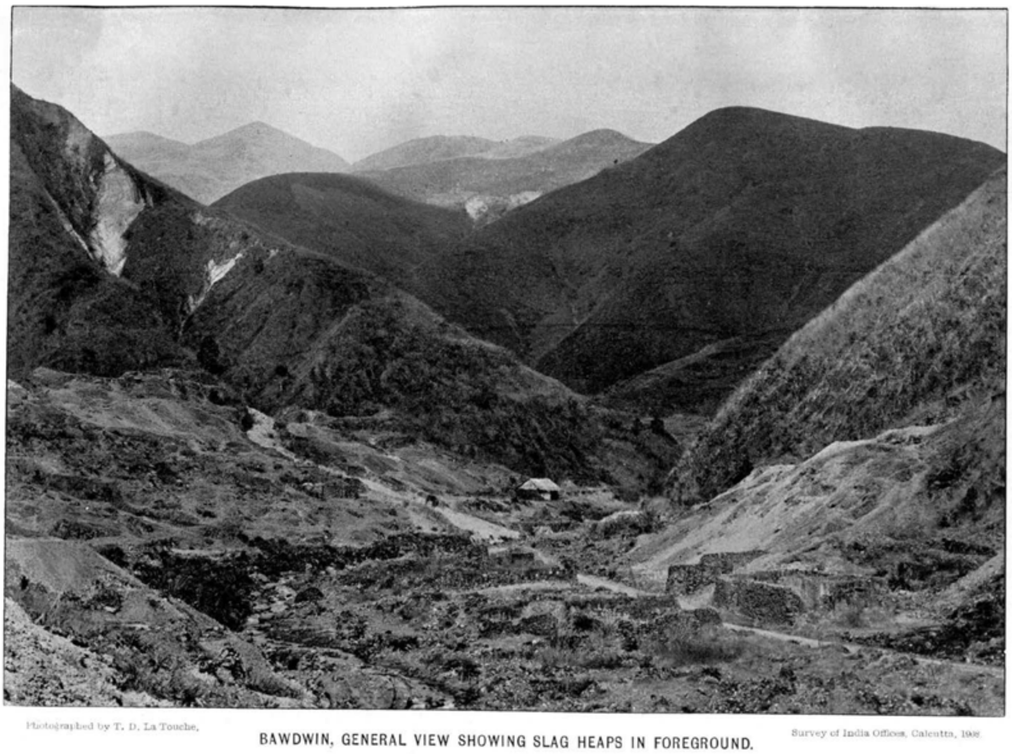


Plate ES.1 Nam Pangyun valley at Bawdwin in 1907 with ruins of Chinese stone huts in the right foreground and slag heaps along the valley sides

Plate ES.2 Chinese underground workings in Goldhole Valley

Plate ES.3 Probable British drive in Goldhole Valley, immediately adjacent to Chinese workings

ဝင်းမြင့်မိုရ် စက်မှုလုပ်ငန်း ကုမ္ပဏီလီမိတက်သည် အောက်ဆိုဒ်သတ္တုရိုင်းများ တူးဖော်ခြင်းနှင့် ကြိတ်ခွဲခြင်းတို့ကို ၂၀၂၁ ခုနှစ်၊ နှစ်လယ်ပိုင်းတွင် စတင်ဆောင်ရွက်နိုင်ရန် ရည်မှန်းထားပြီး ဘော်တွင်းစီမံကိန်းအတွက် သတ္တုရိုင်းများကို စတင်တူးဖော်ချိန်အထိ လုပ်ကိုင်သွားမည်ဖြစ်သည်။ အတည်ပြုရရှိထားပြီးသည့် ခွင့်ပြုမိန့် လိုင်စင်များအတိုင်း အောက်ဆိုဒ်သတ္တုရိုင်းများကို တူးဖော်ထုတ်လုပ်လျက်ရှိပြီး ယင်းဆောင်ရွက်မှုသည် ဤပတ်ဝန်းကျင်ထိခိုက်မှု ဆန်းစစ်ခြင်း၏ နယ်ပယ်အတိုင်းအတာနှင့် သက်ဆိုင်ခြင်းမရှိသည်ဟု ဆိုနိုင်သည်။

ES.4 မှ ES.6 အထိ၌ မြေမျက်နှာသွင်ပြင် အနိမ့်အမြင့်၊ နမ့်ပန်ယွန်းချိုင့်ဝှမ်း၊ ဟင်းလင်းပွင့်သတ္တုတွင်းနှင့် သမိုင်းတွင်ကျန်သည့် အထောက်အကူပြုအဆောက်အအုံများအပါအဝင် ဘော်တွင်းသတ္တုတွင်း၏ လက်ရှိပတ်ဝန်းကျင် အခြေအနေများကို ဖော်ပြထားသည်။

စီမံကိန်းအဆိုပြုသူ

ဤစီမံကိန်းအဆိုပြုသူသည် ဝင်းမြင့်မိုရ် စက်မှုလုပ်ငန်း ကုမ္ပဏီလီမိတက်ဖြစ်ပြီး သယံဇာတနှင့် သဘာဝပတ်ဝန်းကျင် ထိန်းသိမ်းရေးဝန်ကြီးဌာန၊ အမှတ် (၁) သတ္တုတွင်းလုပ်ငန်းနှင့် ဘော်တွင်း သတ္တုတွင်းရှိ ခဲ၊ ငွေနှင့် သွပ်များ ထုတ်လုပ်ခြင်းလုပ်ငန်းအတွက် ထုတ်လုပ်မှုအပေါ် ခွဲဝေသည့်စနစ်ဖြင့် စာချုပ်ချုပ်ဆိုထားပြီး ခွင့်ပြုမိန့်ကိုလည်း ရရှိထားပြီးဖြစ်သည်။ ယင်းစာချုပ်ကို ၂၀၀၉ ခုနှစ်၊ ဒီဇင်ဘာလတွင် စတင်ချုပ်ဆိုခဲ့ခြင်းဖြစ်ပါသည်။ ဝင်းမြင့်မိုရ် စက်မှုလုပ်ငန်း

ကုမ္ပဏီလီမိတက်သည် မြန်မာနိုင်ငံရှိ အခြေခံအဆောက်အအုံများဆိုင်ရာ စီမံကိန်းများကို အဓိကထား ရင်းနှီးမြှုပ်နှံနေသည့် အဖွဲ့တစ်ခုဖြစ်သော အမျိုးသား အခြေခံအဆောက်အအုံဆိုင်ရာ ဟိုးဒင်း ကုမ္ပဏီလီမိတက် (National Infrastructure Holdings Company Limited) ၏ ကုမ္ပဏီခွဲ တစ်ခုဖြစ်ပြီး လက်ရှိတွင် စုစုပေါင်း ဝန်ထမ်း ၄,၀၀၀ ကျော် ခန့်အပ်ထားနိုင်ခဲ့ပြီဖြစ်သည်။

Plate ES.4 Steep terrain near Bawdwin

Plate ES.5 Nam Pangyun valley facing Bawdwin upper village and the open pit

Plate ES.6 Marmion Shaft headframe and winding house

မူဝါဒ၊ စည်းမျဉ်းဥပဒေများနှင့် အဖွဲ့အစည်းဆိုင်ရာ မူဘောင်များ

သတ္တုတူးဖော်ခြင်း လုပ်ငန်းကဏ္ဍကို အခြေခံအားဖြင့် သယံဇာတနှင့် သဘာဝပတ်ဝန်းကျင် ထိန်းသိမ်းရေး ဝန်ကြီးဌာန၏ သတ္တုတွင်းဦးစီးဌာန၊ ဘူမိဗေဒလေ့လာရေးနှင့် ဓာတ်သတ္တုရှာဖွေရေး ဦးစီးဌာနများမှတဆင့် နိုင်ငံတော်ပိုင် သတ္တုတွင်းလုပ်ငန်း (၄) ခုဖြင့် ကြီးကြပ်စီမံဆောင်ရွက်ပြီး ဤစီမံကိန်းအတွက် အဓိက ပူးပေါင်းဆောင်ရွက်ရသော နိုင်ငံတော်ပိုင်လုပ်ငန်းမှာ အမှတ် (၁) သတ္တုတွင်းလုပ်ငန်း ဖြစ်ပါသည်။
ဘော်တွင်းသတ္တုတွင်း၌ လုပ်ငန်းများဆောင်ရွက်ခွင့်နှင့် ဓာတ်သတ္တုထုတ်လုပ်ခွင့်များကို အမှတ် (၁) သတ္တုတွင်းလုပ်ငန်းနှင့် ဝင်းမြင့်မိုရ်စက်မှုလုပ်ငန်း ကုမ္ပဏီလီမိတက်တို့အကြား ထုတ်လုပ်မှုအပေါ် ခွဲဝေသည့် စာချုပ်စနစ်ဖြင့် လက်ရှိတွင် တရားဝင် ဆောင်ရွက်နေခြင်း ဖြစ်ပါသည်။ ဘော်တွင်း သတ္တုတွင်းအား ပြန်လည် အကောင်အထည်ဖော် ဆောင်ရွက်ခြင်းတွင် အကျိုးအမြတ်ရရှိစေမည့် စီးပွားရေးတစ်ခု ဖြစ်စေရန် အကြီးစားထုတ်လုပ်မှု ခွင့်ပြုမိန့် သက်တမ်းတိုးမြှင့်ခြင်း၊ သတ္တုတွင်းတူးဖော်မှု သက်တမ်း (၁၃) နှစ် ကာလအတွင်း ခေတ်မီနည်းပညာများအတွက် ရင်းနှီးမြှုပ်နှံခြင်းနှင့် မြေအောက်တူးဖော်ခြင်းလုပ်ငန်းဖြင့် စီးပွားဖြစ် ဆောင်ရွက်နိုင်ပါက နှစ်ပေါင်း ၅၀ အထိ တူးဖော်ခွင့် ရရှိရန်လိုအပ်ပါသည်။
မြန်မာနိုင်ငံ ရင်းနှီးမြှုပ်နှံမှုဥပဒေ (၂၀၁၆) ခုနှစ်အရ အကြီးစား ဓာတ်သတ္တုထုတ်လုပ်ခြင်း အဆိုပြုစီမံကိန်းများ အပါအဝင် အဓိက နှင့်/ သို့မဟုတ် အရေးပါသော စီမံကိန်းလုပ်ငန်းများသည် မြန်မာနိုင်ငံ ရင်းနှီးမြှုပ်နှံမှုကော်မရှင် (MIC) နှင့် အခြားသက်ဆိုင်သည့် အစိုးရဌာနများ၏ ကြိုတင်ခွင့်ပြုချက်ရရှိရန်လိုအပ်မည် ဖြစ်သည်။ ယင်းတွင် နိုင်ငံခြားသားရင်းနှီးမြှုပ်နှံသည့် ထုတ်လုပ်မှုစီမံကိန်းများ၏ မြန်မာနိုင်ငံရင်းနှီးမြှုပ်နှံမှု ကော်မရှင် အတည်ပြုချက်၊ အဆိုပြုစီမံကိန်း၏ ဘဏ္ဍာရေး၊ နည်းပညာနှင့် ထုတ်လုပ်မှုဆိုင်ရာ မျှော်မှန်းချက်များပါဝင်သော လျှောက်လွှာများလည်း ပါဝင်သည်။ ဘော်တွင်းသတ္တုတွင်း၏ အရွယ်အစားနှင့် အရေးပါမှုတို့ကြောင့် နိုင်ငံခြားသား ရင်းနှီးမြှုပ်နှံမှုဖြင့် ဆောင်ရွက်ရာတွင် မြန်မာနိုင်ငံရင်းနှီးမြှုပ်နှံမှု ကော်မရှင်၏ ခွင့်ပြုမိန့် ရရှိရန် လိုအပ်မည်ဖြစ်သည်။ ဤခွင့်ပြုမိန့်တွင် စီမံကိန်းလုပ်ငန်းတစ်ခုအတွက် စီမံကိန်းဆိုင်ရာ အဓိက လိုအပ်ချက်များနှင့် မည်သည့် စီမံကိန်းအမျိုးအစားအတွက်မဆို သတ်မှတ်ထားသည့် အာမခံမှုကို ရင်းနှီးမြှုပ်နှံသူတစ်ဦးမှ ရရှိမည်ဖြစ်သည်။

ဝင်းမြင့်မိုရ် စက်မှုလုပ်ငန်းကုမ္ပဏီလီမိတက်၏ ဖြစ်မြောက်နိုင်စွမ်းအရ လေ့လာထားရှိသော အရင်းအမြစ်ဆိုင်ရာ သတ်မှတ်ချက်ကို အခြေခံ၍ ထုတ်လုပ်မှုအပေါ် ခွဲဝေသည့် စာချုပ်ပါ အချက်အလက်များနှင့် ခွဲဝေရရှိနိုင်ခွင့်များကို ချိန်ညှိ၊ တိုးမြှင့်ခြင်းများ ဆောင်ရွက်နိုင်ရန် ဆွေးနွေးညှိနှိုင်းမှုများ ဆောင်ရွက်လျက်ရှိသည်။

စီမံကိန်းလုပ်ငန်းသည် အောက်ဖော်ပြပါ ဥပဒေများအပါအဝင် စီမံကိန်းနှင့် သက်ဆိုင်သည့် ဥပဒေ၊ နည်းဥပဒေများနှင့် စည်းမျဉ်းစည်းကမ်းများအတိုင်း ဆောင်ရွက်သွားမည်ဖြစ်သည် -

- မြန်မာ့ သတ္တုတွင်း ဥပဒေ (၁၉၉၄)
- ပတ်ဝန်းကျင်ထိန်းသိမ်းရေးဥပဒေ (၂၀၁၂)
- ပတ်ဝန်းကျင်ထိန်းသိမ်းရေးနည်းဥပဒေများ (၂၀၁၄)
- အမျိုးသားပတ်ဝန်းကျင်ဆိုင်ရာ အရည်အသွေး (ထုတ်လွှတ်မှု) လမ်းညွှန်ချက်များ (၂၀၁၅)
- ပတ်ဝန်းကျင်ထိခိုက်မှုဆန်းစစ်ခြင်းဆိုင်ရာ လုပ်ထုံးလုပ်နည်း (၂၀၁၅)

ထပ်မံလုပ်အပ်မည့် အတည်ပြုခွင့်များအတွက် ကဏ္ဍပေါင်းစုံမှ ဥပဒေ၊ နည်းဥပဒေများလည်း ဤစီမံကိန်းမှ လိုက်နာ ဆောင်ရွက်ရမည်ဖြစ်သည်။

ပတ်ဝန်းကျင်ထိခိုက်မှုဆန်းစစ်ခြင်းအတွက် လိုအပ်ချက်များကို ပတ်ဝန်းကျင်ထိန်းသိမ်းရေးဥပဒေနှင့် နည်းဥပဒေများတွင် ချမှတ်ထားသည်။ ထိခိုက်သက်ရောက်မှုရှိနိုင်သော ဖွံ့ဖြိုးတိုးတက်ရေး စီမံကိန်းများအတွက် ပတ်ဝန်းကျင်ထိခိုက်မှုဆန်းစစ်ခြင်းလုပ်ငန်းစဉ်များ အထောက်အကူ ပြုစေနိုင်ရန် ပတ်ဝန်းကျင်ထိခိုက်မှုဆန်းစစ်ခြင်းဆိုင်ရာ လုပ်ထုံးလုပ်နည်းအား ပတ်ဝန်းကျင်ထိန်းသိမ်းရေး ဥပဒေ၊ ပုဒ်မ ၄၂၊ ပုဒ်မခွဲ (ခ) အရ ၂၀၁၅ ခုနှစ်တွင် ထုတ်ပြန်ခဲ့သည်။

ပတ်ဝန်းကျင်ထိခိုက်မှုဆန်းစစ်ခြင်းဆိုင်ရာ လုပ်ထုံးလုပ်နည်းများတွင် ဖွံ့ဖြိုးတိုးတက်မှု အတိုင်းအတာ၊ သဘောသဘာဝတို့အပေါ် အခြေခံ၍ ဆန်းစစ်မှုပြုလုပ်ရန် လိုအပ်သည့် အဆင့်များကို ထုတ်နုတ်ဖော်ပြထားသည်။ အသစ်ဆောင်ရွက်မည့် စီမံကိန်းလုပ်ငန်းများအားလုံးနှင့် ထပ်မံတိုးချဲ့မည့် စီမံကိန်းလုပ်ငန်းများသည် ထိခိုက်သက်ရောက်မှုရှိစေနိုင်သောကြောင့် ပတ်ဝန်းကျင်ထိခိုက်မှုဆန်းစစ်ခြင်း အစီရင်ခံစာကို တင်သွင်းရန် လိုအပ်ပြီး အတည်ပြုချက်ရရှိထားသည့် စီမံကိန်းတစ်ခုအတွက် သတ်မှတ်ထားသော စည်းမျဉ်းစည်းကမ်းများပါဝင်သော ပတ်ဝန်းကျင် ထိန်းသိမ်းရေးဆိုင်ရာ လိုက်နာဆောင်ရွက်မှု သက်သေခံလက်မှတ် (ECC) ၏ ပုံစံဖြင့် အတည်ပြုချက် ရရှိမည်ဖြစ်သည်။

ပတ်ဝန်းကျင်ထိခိုက်မှုဆန်းစစ်ခြင်းဆိုင်ရာ လုပ်ထုံးလုပ်နည်း (၂၀၁၅) ၏ အပိုဒ် (၂၃) ၌ ပတ်ဝန်းကျင်နှင့် လူမှုရေးဆိုင်ရာ အတည်ပြုချက်လုပ်ငန်းစဉ်များအတွက် စိစစ်ခြင်းအဆင့်များကို ဖော်ပြထားပါသည်။ အဆိုပါ ဖော်ပြချက်များတွင် အဓိကအားဖြင့် -

- စီမံကိန်းအဆိုပြုသူသည် စီမံကိန်းအဆိုပြုလွှာအပြည့်အစုံကို ပဏာမ စိစစ်ရန် သယံဇာတနှင့် သဘာဝ ပတ်ဝန်းကျင်ထိန်းသိမ်းရေးဝန်ကြီးဌာန သို့ တင်သွင်းရမည်ဖြစ်သည်။ ဘော်တွင်း စီမံကိန်းအတွက် စီမံကိန်း အဆိုပြုလွှာအပြည့်အစုံကို ဝင်းမြင့်မိုရ်၊ စက်မှုလုပ်ငန်း ကုမ္ပဏီလီမိတက်မှ အမှတ် (၁) သတ္တုတွင်း လုပ်ငန်းသို့ ၂၀၁၈ ခုနှစ်၊ အောက်တိုဘာလတွင်

တင်သွင်းခဲ့ပြီး ပတ်ဝန်းကျင်ထိန်းသိမ်းရေး ဦးစီးဌာနမှ ပြန်လည် ပြင်ဆင်ရန်ပေးပို့ခဲ့သည့် သဘောထားမှတ်ချက်များကို ၂၀၁၉ ခုနှစ် မတ်လတွင် ပြန်လည်ပြင်ဆင်ပြီး တင်သွင်းခဲ့ပါသည်။

- သယံဇာတနှင့် သဘာဝပတ်ဝန်းကျင်ထိန်းသိမ်းရေးဝန်ကြီးဌာန (စီမံကိန်းလုပ်ငန်းနှင့် သက်ဆိုင်သည့် အာဏာပိုင်များ) သည် စီမံကိန်းအဆိုပြုလွှာအား စိစစ်ခြင်းနှင့် ပတ်ဝန်းကျင် ထိခိုက်မှုဆန်းစစ်ခြင်းဆိုင်ရာ လုပ်ထုံး လုပ်နည်း၊ နောက်ဆက်တွဲ (က) နှင့်အညီ ရင်းနှီးမြှုပ်နှံမှု စီမံကိန်းအမျိုးအစားများအလိုက် ပတ်ဝန်းကျင် ထိခိုက်မှု ဆန်းစစ်ခြင်းဆောင်ရွက်ရန် လိုအပ်သည့် စီမံကိန်းအမျိုးအစားများကို သတ်မှတ်ခြင်းတို့ကို ဆောင်ရွက် နိုင်သည်။
- ဝန်ကြီးဌာနသည် စီမံကိန်းအမျိုးအစား အပေါ်မူတည်၍ ပတ်ဝန်းကျင်ထိခိုက်မှုဆန်းစစ်ခြင်း ပြုလုပ်ရန် လိုအပ်သည့် စီမံကိန်းအမျိုးအစား သို့မဟုတ် ကနဦးပတ်ဝန်းကျင်ဆန်းစစ်ခြင်း ပြုလုပ်ရန် လိုအပ်သည့် စီမံကိန်း အမျိုးအစား သို့မဟုတ် မည်သည့် ဆန်းစစ်ခြင်းမှ ပြုလုပ်ရန် မလိုအပ်သည့် စီမံကိန်းအမျိုးအစားများ ကို ရွေးချယ်သတ်မှတ်နိုင်သည်။ မေလ၊ ၂၀၁၉ ခုနှစ်တွင် ပတ်ဝန်းကျင်ထိခိုက်မှုဆန်းစစ်ခြင်း ပြုလုပ်ရန် လိုအပ်သည့် စီမံကိန်း အမျိုး အစားများကို ဦးဆောင်ညွှန်ကြားရေးမှူး ကိုယ်စား အထွေထွေမန်နေဂျာမှ ရွေးချယ်မှု ပြုလုပ်ခဲ့သည်။
- စီမံကိန်းအဆိုပြုသူသည် ပတ်ဝန်းကျင်ထိခိုက်မှုဆန်းစစ်ခြင်းလုပ်ငန်းစဉ်များ ဆောင်ရွက်ရန် (ပတ်ဝန်းကျင် ထိန်းသိမ်းရေးဦးစီးဌာနမှ အတည်ပြုထားသည့် တတိယအဖွဲ့အစည်းများ) ပတ်ဝန်းကျင်ဆိုင်ရာ အကြံပေး များ၏ အသေးစိတ် အကြောင်းအရာဖော်ပြချက်များကို တင်သွင်းရမည်ဖြစ်သည်။ အဆိုပြု စီမံကိန်းအတွက် ပတ်ဝန်းကျင်ထိခိုက်မှုဆန်းစစ်ခြင်း ဆောင်ရွက်မည့် Coffey & Valentis သည် ညွှန်ကြားရေးမှူးချုပ် (သယံဇာတနှင့် သဘာဝပတ်ဝန်းကျင်ထိန်းသိမ်းရေးဝန်ကြီးဌာန) ကိုယ်စား ညွှန်ကြားရေးမှူးမှ တတိယအဖွဲ့အစည်းအဖြစ် ဩဂုတ်လ၊ ၂၀၁၉ ခုနှစ်တွင် အတည်ပြုပေးပြီးဖြစ်သည်။
- Coffey & Valentis သည် ဘော်တွင်းစီမံကိန်းအတွက် ပတ်ဝန်းကျင်ထိခိုက်မှုဆန်းစစ်ခြင်း၏ နယ်ပယ်အတိုင်း အတာသတ်မှတ်ခြင်း အစီရင်ခံစာအား စတင်ပြင်ဆင်ခဲ့သော်လည်း လက်ရှိ အခြေအနေများကြောင့် အစီရင်ခံစာအား ဆက်လက်ဆောင်ရွက်နိုင်ခြင်းမရှိပါ။ ထို့ကြောင့် စီမံကိန်းအဆိုပြုသူသည် ပတ်ဝန်းကျင်ထိခိုက်မှု ဆန်းစစ်ခြင်း အစီရင်ခံစာအား ဆက်လက် ဆောင်ရွက်နိုင်ရန် အခြားတတိယအဖွဲ့အစည်းအား ရွေးချယ်ခြင်းဆိုင်ရာ ပုံစံကို တင်သွင်းခဲ့ ပါသည်။ အဆိုပြု စီမံကိန်းလုပ်ငန်းအတွက် ပတ်ဝန်းကျင်ဆိုင်ရာ အကြံပေးပုဂ္ဂိုလ် သို့မဟုတ်

အဖွဲ့အစည်းအဖြစ် ဆောင်ရွက်ရန် အီးဂတ် ပတ်ဝန်းကျင်ဆိုင်ရာ ဝန်ဆောင်မှုအား ညွှန်ကြားရေးမှူးချုပ် (သယံဇာတနှင့် သဘာဝပတ်ဝန်းကျင်ထိန်းသိမ်းရေးဝန်ကြီးဌာန) ကိုယ်စား ညွှန်ကြားရေးမှူးမှ ၁၉ - ၀၅ - ၂၀၂၃ ခုနှစ်တွင် အတည်ပြုပေးခဲ့ပါသည်။

- ပတ်ဝန်းကျင်ထိခိုက်မှုဆန်းစစ်ခြင်းဆောင်ရွက်ရန် လိုအပ်သည့် စီမံကိန်းအမျိုးအစားများအတွက် အတည်ပြုခြင်း ဆိုင်ရာ ခြုံငုံ သိရှိနိုင်မည့် လုပ်ငန်းစဉ်များကို ES-2 တွင် ဖော်ပြထားပါသည်။
- ပတ်ဝန်းကျင်ထိခိုက်မှုဆန်းစစ်ခြင်းဆိုင်ရာ လုပ်ထုံးလုပ်နည်း၊ အပိုဒ် ၆၂ မှ ၆၃ အထိ ပတ်ဝန်းကျင်ထိခိုက်မှု ဆန်းစစ်ခြင်းနှင့် ပတ်ဝန်းကျင်စီမံခန့်ခွဲမှုအစီအစဉ်များတွင် ပါဝင်ရမည့် အကြောင်းအရာများကို ဖော်ပြထား သည်။ ဤ အစီရင်ခံစာတွင် မြန်မာနိုင်ငံ သတ္တုတွင်း လုပ်ငန်းများအတွက် ပတ်ဝန်းကျင်ထိခိုက်မှု ဆန်းစစ်ခြင်း ဆိုင်ရာ လမ်းညွှန်ချက် (၂၀၁၈) မူကြမ်းပါ ထည့်သွင်းဖော်ပြရမည့် အချက်များနှင့် နိုင်ငံတကာတွင် ဆောင်ရွက်လျက်ရှိသည့် ပတ်ဝန်းကျင်ထိခိုက်မှု ဆန်းစစ်ခြင်း၊ ပတ်ဝန်းကျင်နှင့်လူမှုရေးဆိုင်ရာ စီမံခန့်ခွဲမှုအစီအစဉ်များ၏ အကြောင်းအရာများနှင့် စံချိန်စံညွှန်းများကို ထည့်သွင်း စဉ်းစား၍ ဖော်ပြထားသည်။

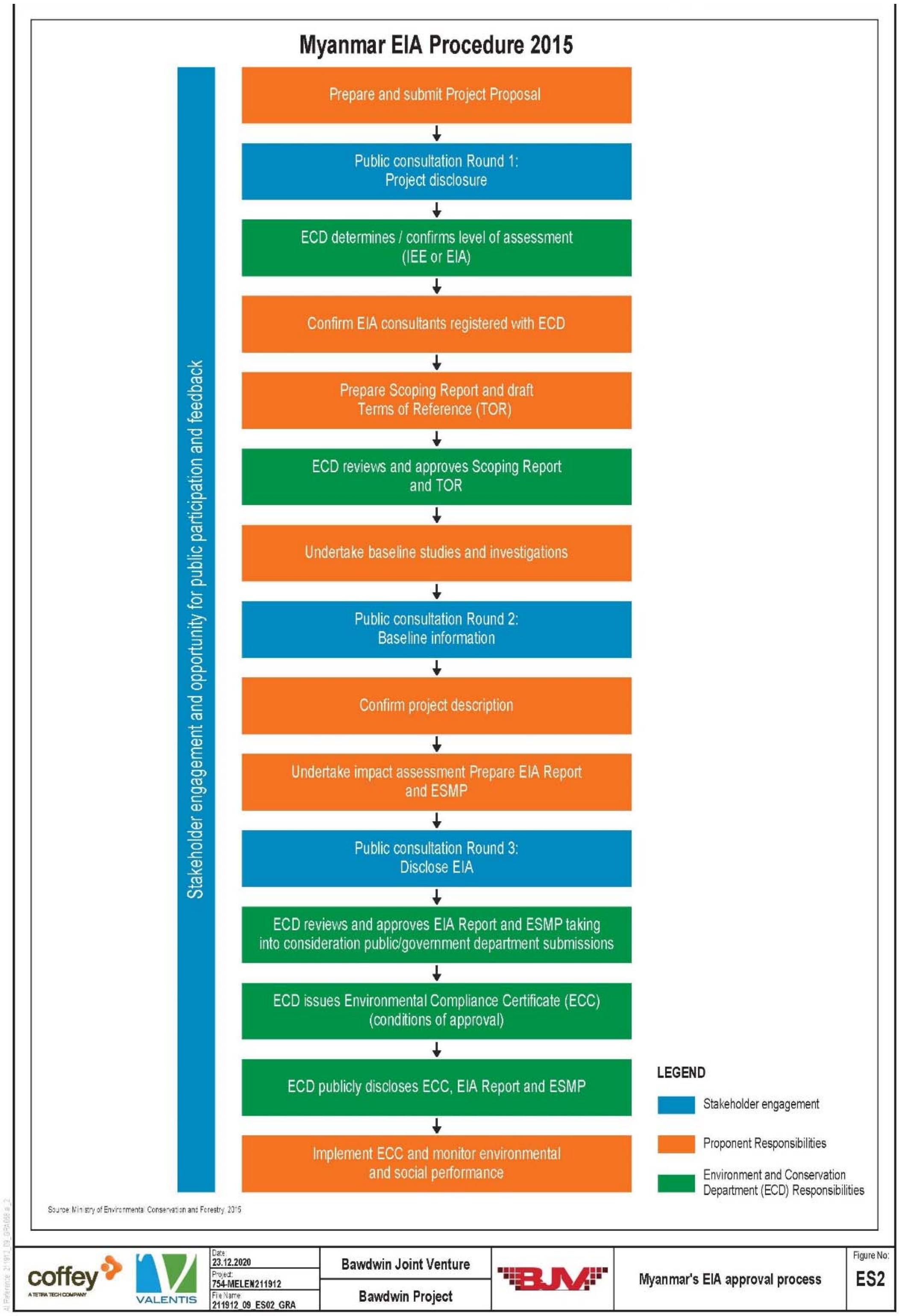


Figure ES.2 Myanmar's EIA approvals process

အခြားဆောင်ရွက်နိုင်သော နည်းလမ်းများ

စီမံကိန်းလုပ်ငန်းနှင့်စပ်လျဥ်း၍ အခြားဆောင်ရွက်နိုင်သော နည်းလမ်းများကို နယ်ပယ်အတိုင်းအတာ သတ်မှတ်ခြင်း၊ အကြို ဖြစ်နိုင်ခြေများကို လေ့လာဆန်းစစ်ခြင်း၊ ဖြစ်နိုင်ခြေများကို လေ့လာဆန်းစစ်ခြင်းများ ဆောင်ရွက်ခဲ့သည့် ၂၀၁၈ ခုနှစ်မှ ၂၀၂၀ ပြည့်နှစ်အထိ အဆင့်ဆင့် ပြန်လည်သုံးသပ် ပြင်ဆင်ထားပါသည်။ စီမံကိန်းလုပ်ငန်းနှင့်စပ်လျဉ်း၍ အခြားဆောင်ရွက်နိုင်သော နည်းလမ်းများအပေါ် အကဲဖြတ်ခြင်းအား အောက်ဖော်ပြပါ အဓိကအချက်များကို ထည့်သွင်း၍ စဉ်းစားခဲ့ပါသည် -

- သတ္တုသိုက်များ၏ သဘောသဘာဝ၊ စီမံကိန်းမှ ကျခံနိုင်မည့် အသုံးစရိတ်၊ သတ္တုရိုင်းများမှ အကျိုးအမြတ်ဖြစ်ထွန်းစေရန် ထုတ်လုပ် သန့်စင်နိုင်မှု အစရှိသည့် စီးပွားဖြစ်ထွန်းမှုဆိုင်ရာ ကန့်သတ်ချက်များကို ထည့်သွင်းစဉ်းစားခြင်း၊
- သတ္တုသိုက်များ၏ တည်နေရာ သို့မဟုတ် တည်ရှိမှု၊ အခြေခံအဆောက်အအုံများ လုံလောက်မှု အပါအဝင် ရုပ်ဝတ္ထုပိုင်းဆိုင်ရာ ကန့်သတ်ချက်များ၊ ရာသီဥတု၊ မြေယာရှုခင်းနှင့် မြေမျက်နှာသွင်ပြင်အပါအဝင် ပထဝီဝင်ဆိုင်ရာ ကန့်သတ်ချက်များကို ထည့်သွင်းစဉ်းစားခြင်း၊
- ပတ်ဝန်းကျင်ဆိုင်ရာ အရည်အသွေးများနှင့် အလေးထားရမည့် ရေထုအရည်အသွေး (မြေပေါ်ရေ အရည်အသွေးနှင့် မြေအောက်ရေ အရည်အသွေး)၊ မြေယာ (ဇီဝမျိုးစုံမျိုးကွဲများနှင့် မြေဆီလွှာများ အပါအဝင်) နှင့် လေအရည်အသွေးများကို ထည့်သွင်းစဉ်းစားခြင်း၊
- စီးပွားရေး၊ လူမှုရေး၊ ကျန်းမာရေးနှင့် ယဉ်ကျေးမှု အမွေအနှစ် အစိတ်အပိုင်းများနှင့် အနီးဝန်းကျင်ရှိ လူမှုအသိုက်အဝန်းများ၏ တည်ရှိမှုများအပါအဝင် လူမှုရေးဆိုင်ရာ ကန့်သတ်ချက်များကို ထည့်သွင်း စဉ်းစားခြင်း၊

စီမံကိန်းမှ အခြားဆောင်ရွက်နိုင်သော နည်းလမ်းများအား အကဲဖြတ်ဆန်းစစ်ရာတွင် -

- လက်ရှိ ဟင်းလင်းပွင့် တူးဖော်မှုအား တိုးချဲ့ခြင်း သို့မဟုတ် မြေအောက်သတ္တုတူးဖော်မှု ဆောင်ရွက်ခြင်း၊
- လက်ရှိ အခြေခံ အဆောက်အအုံများကို အဆင့်မြှင့် ပြုပြင်ခြင်း သို့မဟုတ် အဆောက်အအုံအသစ်များ တည်ဆောက်ခြင်းများအပါအဝင် သတ္တုသန့်စင်ပြုပြင်ခြင်း လုပ်ငန်းစဉ်များအတွက် ရွေးချယ်ခြင်း၊
- ရေကောင်းရေသန့်ရရှိနိုင်မည့် အရင်းအမြစ်၊

- ဓာတ်အားလျှပ်စစ် အလုံအလောက်ရရှိစေနိုင်ရန် လက်ရှိလည်ပတ်နေသည့် ရေအား လျှပ်စစ်အား အဆင့်မြှင့်တင်ခြင်း၊ မဟာဓာတ်အားလိုင်းဖြင့် သွယ်တန်းခြင်း သို့မဟုတ် ဓာတ်အားလျှပ်စစ် အသစ်တပ်ဆင်ခြင်းတို့ကို ရွေးချယ်ဆောင်ရွက်ခြင်း၊
- ဘော်တွင်းသို့ သွားရောက်နိုင်ရန် လက်ရှိ ဖောက်လုပ်ထားပြီးသား လမ်းများ၊ ပတ်လမ်းများကို အသုံးပြုခြင်း သို့မဟုတ် နမ္မတူမှ သွားရောက်နိုင်မည့် လမ်းအသစ်အား ဖောက်လုပ်ခြင်း၊

စီမံကိန်းလုပ်ငန်းအား ဆက်လက်လုပ်ကိုင်ခြင်း မရှိသည့် ရွေးချယ်မှု (ဥပမာ - စီမံကိန်း ဆောင်ရွက်မှု မရှိခြင်း) တို့ကိုလည်း ထည့်သွင်းစဉ်းစားခဲ့သည်။ ယင်းတွင် -

- စီမံကိန်းလုပ်ငန်းဆောင်ရွက်ခြင်း မရှိပါက စီမံကိန်းမှ ရရှိလာမည့် လုပ်ခလစာ၊ လေ့ကျင့်သင်ကြားပေးမှုများ၊ လုပ်ငန်းခွင် အတွေ့အကြုံ၊ လူထုအခြေပြု အခြေခံအဆောက်အအုံ၊ စီးပွားရေးနှင့် လူမှုအသိုက်အဝန်း ဖွံ့ဖြိုးမှုများကဲ့သို့ လူမှု စီးပွားရေးဆိုင်ရာ အကျိုးအမြတ်များလည်း ရရှိနိုင်မည် မဟုတ်ပါ။
- စီမံကိန်းလုပ်ငန်းဆောင်ရွက်ခြင်း မရှိပါက ယခင်က ဆောင်ရွက်ခဲ့သည့် သတ္တုတွင်း လုပ်ငန်းများကြောင့် ပတ်ဝန်းကျင် သို့မဟုတ် ကျန်းမာရေးတို့အပေါ် ဖြစ်ပေါ်ခဲ့သော သက်ရောက်မှုများကို လျှော့ချဆောင်ရွက်နိုင်မည့် နည်းလမ်းများလည်း ရရှိနိုင်မည် မဟုတ်ပါ။
- ဤပတ်ဝန်းကျင်ထိခိုက်မှုဆန်းစစ်ခြင်း အစီရင်ခံစာတွင် ဖော်ပြထားသည့် စီမံကိန်းနှင့် စပ်လျဉ်းသည့် ဇီဝ ရုပ်ပိုင်းဆိုင်ရာ လူမှုရေးဆိုင်ရာ သက်ရောက်မှုများလည်း ရှိမည် မဟုတ်ပါ။

စီမံကိန်းအကြောင်းအရာဖော်ပြချက်

ဘော်တွင်းသတ္တုတွင်းသည် ၎င်း၏အရည်အသွေးနှင့် အရွယ်အစားအရ ကမ္ဘာ့အဆင့် သတ္တုတွင်း တစ်တွင်း ဖြစ်ပါသည်။ ဝင်းမြင့်မိုရ်မှ ဆောင်ရွက်နေသော ရှာဖွေတူးဖော်ခြင်းရလဒ်အရ ခန့်မှန်းသတ္တုအရင်းအမြစ်များတွင် တိုးတက်လာသည့် ရလာဒ်များ ရရှိခဲ့ပြီး ယခုအခါ တစ်ကမ္ဘာလုံးဆိုင်ရာ အကြီးဆုံးသတ္တုအရင်းအမြစ်များထဲများတွင် စာရင်းဝင်နေပါသည်။ ဘော်တွင်းစီမံကိန်းအတွက် ၂၀၁၈ ခုနှစ်နှင့် ၂၀၂၀ ခုနှစ်ကြားထဲတွင် နယ်ပယ်အတိုင်းအတာသတ်မှတ်ခြင်း၊ ကြိုတင်ဖြစ်နိုင်ချေနှင့် ဖြစ်နိုင်ချေများ လေ့လာခြင်းများကို ဆောင်ရွက်ခဲ့ပါသည်။ JORC Code (2012 Edition) ထဲရှိ လမ်းညွှန်းချက်များနှင့် အညီ ဇွန်လ ၂၀၂၀ပြည့်နှစ်တွင် စီမံကိန်းအပေါ် အခြေခံ၍ တွက်ချက်ထားသော အရံသတ္တုရိုင်းများကို ထုတ်လုပ်ခဲ့ပြီး ဇယား ES.1 တွင်ဖော်ပြထားပါသည်။

၂၀၂၀ ပြည့်နှစ်၊ ဇွန်လ ၁၅ ရက်နေ့ရှိ အရံသတ္တုရိုင်းတွက်ချက်မှုပြဇယား ES.1

အမျိုးစားခွဲခြားခြင်း	တန်ချိန် (သန်းပေါင်း)	ခဲ(ရာခိုင်နှုန်း)	ငွေ(ရာခိုင်နှုန်း)	သွပ်(ရာခိုင်နှုန်း)
လက်တွေ့တွက်ချက်မှု	-	-	-	-
ဖြစ်နိုင်ချေတွက်ချက်မှု	၃၂.၀	၄.၆	၁၁၃	၂.၅
စုစုပေါင်း	၃၂.၀	၄.၆	၁၁၃	၂.၅

ဟင်းလင်းပွင့်တူးဖော်ခြင်းအတွင်း စွန့်ပစ်ပစ္စည်းများ၏ ၁၆၃.၉ သန်းတန်တွင် စွန့်ပစ်စ္စည်းများမှ သန့်စင်ရရှိသော သတ္တုရိုင်း အချိုး ၅.၂း၁ ရှိသော အရံသတ္တုရိုင်းကို ရရှိပါသည်။ ဟင်းလင်းပွင့်တူးဖော်ခြင်းမှ ဖယ်ရှားရသော ကျောက်၏ စုစုပေါင်းအလေးချိန်သည် တန်ချိန် သန်းပေါင်း ၁၉၅.၉ ရှိပါသည်။

ပုံES.3သည် ရှမ်း၊ တရုတ်နှင့် Meingtha lodes အတွက် ဘော်တွင်းသတ္တုတွင်း၏ အပေါ်မှ မြင်ရသော အနေအထားနှင့် အလျားလိုက်ဖြတ်၍ မြင်ရသော အနေအထားနှစ်ခုလုံးကို ပြထားပါသည်။.

စီမံကိန်းသည် ခဲနှင့်ငွေ ပါဝင်သည့် ထုတ်ကုန်နှင့် သွပ် ပါဝင်သည့် ထုတ်ကုန် နှစ်မျိုးကို လည်ပတ်နေသည့် စက်ရုံမှ ထုတ်လုပ်ပါမည်။ ငွေနှင့်ခဲအတွက် ရှေ့ဆက်ထုတ်လုပ်နိုင်သည့် အလားအလာသည် ပိုမိုကောင်းမွန်ပါသည်။

ဘော်တွင်းသတ္တုတွင်းစီမံကိန်းသည် အနာဂတ်တွင် ကျယ်ပြန့်စွာ ရေရှည် သတ္တုဖော်လည်ပတ်နိုင်ရေးအတွက် ခိုင်မာသော အခြေခံအုတ်မြစ်များ ချမှတ်ထားပါမည်။ အောက်ဖော်ပြပါ ကနဦး ၁၃နှစ် သတ္တုတွင်း သက်တမ်းတွင် တရုတ်၊ ရှမ်း နှင့် Meingtha Lodes များ၏ မတူးဖော်ရသေးသော သတ္တုအရင်းအမြစ်များကို ဦးစားပေးတူးဖော်ပါမည်။ မိုင်းနယ်နိမိတ်ချဲ့ထွင်တူးဖော်လေ့လာခြင်းကို

စီမံကိန်း၏ ဆောက်လုပ်ချိန်နှင့် လည်ပတ်ချိန်များတွင် တပြိုင်နက်ဆက်လက် လုပ်ဆောင်သွားပါမည်။

မြန်မာနိုင်ငံ၏ နိုင်ငံရေးနှင့် စီးပွားအသစ် ပြန်လည်ထူထောင်ရေးများကြောင့် သတ္တုတူးဖော်ရေး အခန်းကဏ္ဍတွင် ရင်းနှီးမြုပ်နှံမှုအနေဖြင့် ချက်ချင်းသိသိသာသာ တိုးတက်လာရန် မျှော်လင့်ထားပါသည်။ နိုင်ငံတော်အဆင့်တွင် သတ္တုတူးဖော်ရေးအခန်း ကဏ္ဍအနေဖြင့် ဖွံ့ဖြိုးတိုးတက်မှုနှင့် ရင်းနှီးမြှုပ်နှံမှုတို့သည် တဟုန်ထိုးတိုးတက်လာပါသည်။ ဘော်တွင်းသတ္တုတွင်းတိုးတက်လာသည့်နှင့် တစ်ပြိုင်နက် သတ္တုတူးဖော်ခြင်းနယ်ပယ်မှ GDP ပူးပေါင်းပါဝင်မှုတွင် အလားအလာရှိသော သိသာထင်ရှားသည့် အပြောင်းအလဲများ ရှိလာလိမ့်မည်ဟု မျှော်မှန်းရပါသည်။

ဝင်းမြင့်မိုရ်သည် အခုလက်ရှိဘော်တွင်းမိုင်းတွင်းကို ပို၍ကြီးမားပြီး ခေတ်မီသော မိုင်းတွင်းလုပ်ငန်းအဖြစ် ပြန်လည်ဖွံ့ဖြိုးလာစေရန် ရည်ရွယ်ထားပါသည်။ ပြန်လည်ဖွံ့ဖြိုးရေးလုပ်ငန်းတွင် အခုလက်ရှိ အခြေခံအဆောက်အဦများကို ဖြိုဖျက်ခြင်း၊ မိုင်းတွင်းတူးဖော်ခြင်းနှင့် လုပ်ဆောင်နေဆဲ လုပ်ငန်းများကို အထောက်အပံ့ဖြစ်စေရန် အခြေခံအဆောက်အအုံအသစ်များကို တည်ဆောက်ခြင်းများ ပါဝင်ပါမည်။

ဇယား ES.2 သည် စီမံကိန်းတွင် ပါဝင်သော အစိတ်အပိုင်းအချက်အလက်များကို ဖော်ပြထားပြီး စီမံကိန်း၏ နေရာချထားမှုပုံစံကို ပုံ ES.4 တွင် တင်ပြထားပါသည်။ စီမံကိန်း အပြင်အဆင်၏ သုံးဘက်မြင် မြင်ကွင်းကို ပုံ ES.5 တွင် ဖော်ပြထားပါသည်။

စီမံကိန်းကာလသည် ဘော်တွင်းနှင့် ကျားစခန်းကျေးရွာရှိ နေထိုင်သူများ အတွက် ပြန်လည်နေရာချထားခြင်းဆိုင်ရာ သဘောတူညီချက်များအပါအဝင် လိုအပ်သည့် စီမံကိန်းဆိုင်ရာ ခွင့်ပြုချက်များကို ရယူလျှောက်ထားခြင်းနှင့် စီမံကိန်း၏ ဘဏ္ဍာငွေတို့အပေါ်တွင် မူတည်ပါသည်။ ဘော်တွင်း သတ္တုတွင်း၏ ပြန်လည်ဖွံ့ဖြိုးရေးအတွက် အချိန်ကာလသတ်မှတ်ချက်ကို ပုံ ES. 6 တွင် သတ်မှတ်ဖော်ပြထားပြီး ၂၂လကြာ ဒီဇိုင်းပုံစံ၊ ဆောက်လုပ်ခြင်းနှင့် အစီအစဉ်ပေါ်တွင် အခြေခံထားပါသည်။

စီမံကိန်းအတွက် ပိတ်သိမ်းခြင်းနှင့် ပြန်လည်နေရာချထားခြင်း အစီအစဉ်များကို ပြင်ဆင်ထားပါသည်။ ဝင်းမြင့်မိုရ်သည် ပဏာမ ပိတ်သိမ်းခြင်းအတွက် ရည်ရွယ်ချက်များနှင့် မြေအသုံးချမှုများကို ဖော်ထုတ်ခဲ့ပါသည်။ လုပ်ငန်းပိတ်သိမ်းခြင်း၏ မူလရည်ရွယ်ချက်သည် ပိတ်သိမ်းပြီးနောက် စီမံကိန်းရှိ ပတ်ဝန်းကျင်၏ ညစ်ညမ်းမှုများကို ကန့်သတ်ခြင်း၊ သဘာဝပတ်ဝန်းကျင်ဧရိယာနှင့် လိုက်လျောညီထွေမှုရှိသည့် သဘာဝနည်းလမ်းအားဖြင့် ရှင်သန်နိုင်သော အပင်များ ထောက်ပံ့ခြင်း၊ အကျိုးသက်ရောက်မှုရှိသော ရပ်ရွာအတွက် လက်ဆင့်ကမ်းလွှဲပြောင်းခြင်း ပုံစံဖြင့် ကျန်ရှိနေသော ကောင်းမွန်သည့် အမွေအနှစ်များနှင့် ကိုယ်ထူကိုယ်ထနည်းအားဖြင့် ရပ်တည်နိုင်သော ရပ်ရွာဖွံ့ဖြိုးတိုးတက်ရေးအတွက် အစီအစဉ်များ ထားရှိပေးခြင်း အစရှိသည့် ဖြစ်နိုင်ချေရှိသော နည်းလမ်းကို ထိခိုက်ပျက်စီးသွားသည့် ဧရိယာများတွင် ပြန်လည်နေရာချထားရန် ဖြစ်ပါသည်။

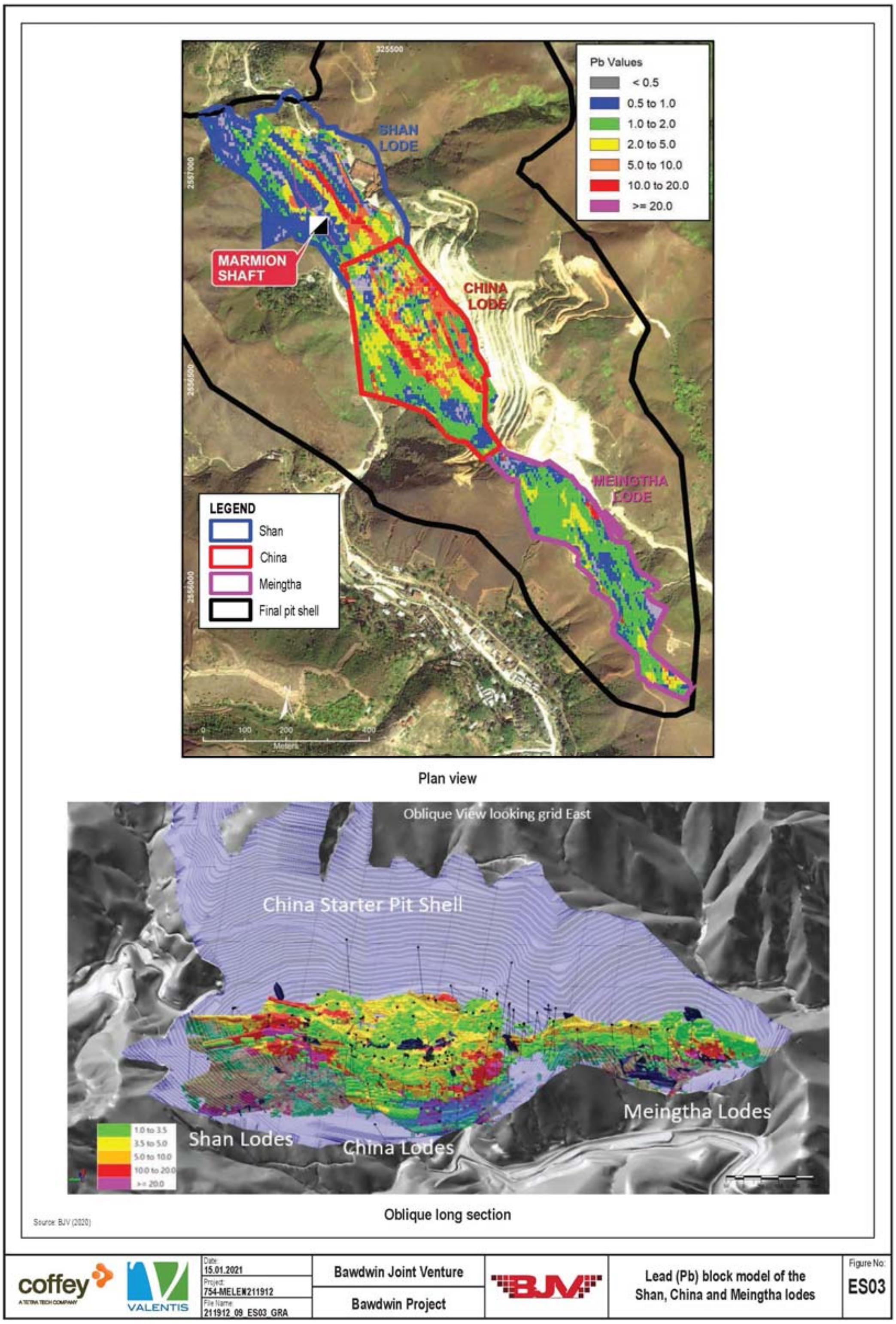


Figure ES.3 Lead (Pb) block model of the Shan, China and Meingtha lodes

ဇယား ES.2 စီမံကိန်းအစိတ်အပိုင်းအချက်အလက်များ

အစိတ်အပိုင်း	ဖော်ပြချက်
သတ္တုတူးဖော်ရေးနည်းလမ်း	• သမားရိုးကျအကြီးစား မြေပေါ်ဟင်းလင်းပွင့်မိုင်းတူးဖော်ခြင်း • သတ္တုတူးဖော်ရေးနည်းလမ်းတွင် မြေသယ်ကားများ၊ ဘူဒိုဇာများ၊ ဆောက်လုပ်ရေးလုပ်ငန်းတွင်သုံးသော ကိရိယာများနှင့် တူးစင်များကို အသုံးပြုပါမည် • သတ္တုရိုင်းနှင့် ဝန်ပိုများကို ဖောက်ခွဲခြင်းနည်းဖြင့် လျော့ချပါမည်
ဟင်းလင်းပွင့်တူးဖော်ခြင်း အတိုင်းအတာများ	• အခုလက်ရှိ မြေပေါ်ဟင်းလင်းပွင့် တူးဖော်ထားသော မိုင်းကို အနက်နှင့် အကျယ်ကို ခန့်မှန်းချေ ၅၄.၀ ဧကမှ အနည်း ဆုံး ၂၄၂.၇ ဧကအထိ (၂၁.၉ ဟက်တာမှ ၉၈.၂ ဟက်တာ) အထိ တိုးချဲ့ သွားပါမည်
ဆောက်လုပ်ရေးအချိန်ကာလ	• ဒီဇိုင်းပုံစံရေးဆွဲခြင်း၊ ဆောက်လုပ်ခြင်းနှင့် တာဝန် ပေးအပ်ခြင်း အချိန်ကာလမှာ ၂၂ လ ဖြစ်ပါသည်။
မိုင်းသက်တမ်း	• စီစဉ်ရေးဆွဲချဲ့ထွင်ထားသော သတ္တု မြေပေါ် ဟင်းလင်းပွင့် တူးဖော်ခြင်း၏ သက်တမ်းမှာ ၁၃ နှစ်ဖြစ် ပါသည်။ • စူးစမ်းရှာဖွေခြင်းကို အဆိုပြုတင်သွင်းထားပြီး မိုင်းတွင်း သက်တမ်းကို နှစ် ၅၀ အထိ တိုးရန် အလားအလာရှိပါ သည်။

အစိတ်အပိုင်း	ဖော်ပြချက်
မိုင်းတွင်း စွန့်ပစ် ကျောက်တုံးများ စီမံခန့်ခွဲခြင်း	• ၁၆၃.၉ သန်း တန်ချိန်ရှိသော စွန့်ပစ်ကျောက်ခဲများကို စီမံကိန်းမှ ထွက်ရှိပါသည် • စွန့်ပစ် ကျောက်ခဲများကို ဝေါလက်ချိုင့်ဝှမ်းတွင် တည် ဆောက်မည့် စွန့်ပစ်ကျောက်ခဲစုပုံနေရာတွင် စွန့်ပစ်မည်ဖြစ်ပြီး အချို့ကို TSF တည်ဆောက်ရန် အသုံးပြုသွားမည် ဖြစ်ပါသည်။ • ဝေါလက်စွန့်ပစ်ကျောက်ခဲစုပုံထားရာနေရာကို Benches များ၊ မြေထိန်းနံရံများ ပါဝင်သည့် ပုံစံဖြင့် တည် ဆောက်ပါမည်။ • ဘူမိဓာတုစုံစမ်းစစ်ဆေးခြင်းသည် စွန့်ပစ်ပစ္စည်းများ (သို့) ရေနုတ်မြောင်းမှ စွန့်ပစ်အစိုင်အခဲပစ္စည်းများတွင် အဆင့်မြင့်မားသော သတ္တုများ ပါဝင်နိုင်ချေများသည်ကို ဖော်ညွှန်းပါသည်။ ထို့အပြင် အနည်းငယ်သော စွန့်ပစ်ကျောက်များတွင် အက်ဆစ်ဓါတ်ပေါ်ပေါက်နိုင်ချေရှိပါသည်။ • စွန့်ပစ်ကျောက်ခဲများစုဖွဲ့ခြင်းမှ ဖြစ်နိုင်ချေရှိသော အက်စစ်များ စီမံခန့်ခွဲခြင်းနှင့် သံသတ္တုပါဝင်မှုများအတွက် ပတ်ဝန်းကျင်ကို အန္တရာယ်ဖြစ်စေနိုင်မှုကို လျှော့ကျစေသည့် ဒီဇိုင်းများနှင့် ကောင်းမွန်သော စီမံခန့်ခွဲခြင်းတို့အား လိုအပ်ပါသည်။ • စိမ့်ထွက်လာသော အနည်များနှင့် စီးဆင်းလာသော အနည်များကို စုဆောင်းရန်နှင့် လိုအပ်လျှင် ရေသန့်စင်ခြင်းကို ကြိုတင်ပြုလုပ်နိုင်ရန်အတွက် စွန့်ပစ်ကျောက်ခဲပုံ၏ အောက်ခြေဘက်တွင် အနည်အနှစ် နှန်းစစ်ကန်သုံးခုကို အတွဲလိုက် ဆောက်လုပ်ထားပါမည်။

အစိတ်အပိုင်း	ဖော်ပြချက်
ဆင့်တက်ပြုပြင်ခြင်း	• စက်ရုံအသစ်ကို ဘော်တွင်းသတ္တုတွင်း ဧရိယာထဲတွင် ဆောက်လုပ်သွားပါမည် • သတ္တုရိုင်းကို တစ်နှစ်လျှင် ၃ မက်ထရစ်တန်နှုန်းအထိ တိုးမြှင့်ထုတ်လုပ်ပါမည် • သတ္တုရိုင်းထုတ်လုပ်ခြင်းတွင် ကြိတ်ခွဲကြိတ်ခြေခြင်းများနှင့် ခဲ-ငွေ နှင့် သွပ် တို့အား ခွဲခြားခြင်းတို့ ပါဝင်ပါသည်။ • များစွာသော ဓာတ်ပြုပစ္စည်း (ဓာတုပစ္စည်း) များကို ဓာတ်သတ္တုထုတ်လုပ် ခြင်းလုပ်ငန်းစဉ်အတွင်း အသုံးပြုပါမည်။ • ခွဲခြားထားသော ခဲ - ငွေ နှင့် သွပ်သတ္တုများကို အခဲအဖြစ် ပြုလုပ်ကာ စစ်ထုတ်ပြီးနောက် သိုလှောင်ထားပြီး ပြည်ပသို့ တင်ပို့ရန် အတွက် ကွန်တိန်နာများအပေါ် တင်ပို့ခြင်းများကို ပြုလုပ်ပါမည်

အစိတ်အပိုင်း	ဖော်ပြချက်
အကြွင်းအကျန်များကို စီမံခန့်ခွဲခြင်း	• ၃၂.၂ မက်ထရစ်တန်ရှိသော သတ္တုအကြွင်းအကျန်များကို လည်ပတ်နေသည့်စက်ရုံမှ စွန့်ပစ်ထုတ်ကုန်အနေဖြင့် ထွက်ရှိမည် ဖြစ်ပါသည်။ • သတ္တုအကြွင်းအကျန်များတွင် နုန်းများ၊ သဲများ၊ ရွံ့များနှင့် လုပ်ငန်းသုံးရေများ ပါဝင်ပါမည်။ • အကြွင်းအကျန်များအား တောင်ကြားချိုင့်ဝှမ်းရှိ Tailings Storage Facilities သုံးခုအနက် တစ်ခုစီသို့ ပိုက်လိုင်းဖြင့် ပို့ဆောင် ပါမည်။ • Tailings Storage Facilities အားလုံးသည် ဟင်းလင်းပွင့်သတ္တုတူးဖော်ခြင်းအပေါ်ပိုင်းတွင် တည်ရှိသည့် နန့်ပန်ကျွန်း မြစ်ဖျားပိုင်းတွင် တည်ရှိပါသည်။ • အကြွင်းအကျန်သိုလှောင်ရုံသုံးခု၏ ယေဘုယျ အကျယ်အဝန်းသည် ၃၀၈.၉ ဧက ရှိပါသည်။ • Tailings Storage Facilitiesများကို နိုင်ငံတကာ အကောင်းဆုံး လမ်းညွှန် ချက်များ အညီ ရေပိုများကိုဖယ်ရှားရန်နှင့် စိမ့်ထွက်လာ ရေများကို အသီးသီးစုဆောင်းရန် ရေမြောင်းစနစ်များ ပါဝင်သည့် ဒီဇိုင်း များပြုလုပ်ထားပါသည်။
သတ္တုသန့်စင်ထုတ်လုပ်ခြင်း	• ခဲ ငွေ အနည်အနှစ်၏ ၁၉၃ ktpa နီးပါး • သွပ် အနည်အနှစ်၏ ၁၀၂ ktpa နီးပါး • အနည်အနှစ်များကို ဘူဒိုဇာဖြင့် သိုလှောင်ရုံ၏အမြင့် တဝက် ပေ၂၀ အထိ ဖုံးလွှမ်းသွား သည်အထိ ဖြည့်တင်း ပါမည်။
အခြေခံအဆောက်အဦများ စီမံဆောင်ရွက်ခြင်း	• အခြေခံအဆောက်အဦများစီမံဆောင်ရွက်ခြင်းတွင် စက်ရုံအသစ်တည်ဆောက်ခြင်းနှင့် Tailings Storage Facilities၊ အလုပ်ရုံ၊ ရေသိုလှောင်ကန်၊ ဓာတ်ပစ္စည်းသိုလှောင်ရုံ၊ ဓာတ်ခွဲခန်း တို့ပါဝင်သည့် သက်ဆိုင်သော အခြေခံအဆောက်အအုံများ ပါဝင်ပါမည်။

အစိတ်အပိုင်း	ဖော်ပြချက်
ရေထောက်ပံ့ခြင်းနှင့် စီမံခန့်ခွဲခြင်း	• စီမံကိန်းတွင် သောက်သုံးရေ၊ တည်းခိုစခန်း၊ မိုင်းတူးဖော်နေသော ဧရိယာနှင့် စက်ရုံ လည်ပတ်ခြင်း အတွက်မိုးရေ၊မြစ်ရေ၊ချောင်းရေတို့ကို လိုအပ်ပါသည်။ • ပုံမှန်လုပ်ငန်းလည်ပတ်နေသည့် အခြေအနေတွင် လုပ်ငန်းသုံးရေလိုအပ်သည့် စုစုပေါင်းပမာဏသည် တစ်နာရီလျှင် ၁၅၀.၉ ကုဗမီတာ ရှိပါသည်။. • စီမံကိန်းအတွက် လိုအပ်သောရေကို စိုစွတ်သောရာသီဥတုတွင် မူလ နမ့်လ ချောင်းနှင့် နမ့်ပန်ကွျန်းချောင်းမှ ပေါင်း၍ စီးဆင်းလာသော ရေစီးကြောင်းနှင့် တာတမံအတွင်းရှိ သိုလှောင်ထားသော ရေ အသုံးပြုခြင်း၊ Tailing Storage Facilities မှ စစ်ထုတ်ထားသော ရေများကို ပြန်လည် အသုံးပြုပါမည်။
ပို့ကုန်လမ်းကြောင်းနှင့် ထောက်ပံ့ရေးလမ်းကြောင်း	• သန့်စင်ပြီးသတ္တုများကို ဘော်တွင်း သီးသန့်လမ်းကြောင်းအသစ်မှ နမ္မတူသို့ ပို့ဆောင်ပါမည်။ ထိုမှ တဆင့် ကုန်တင်ကားများသည် အများပြည်သူသုံးလမ်းဖြင့် လားရှိုးသို့ ပို့ဆောင်ပြီး နိုင်ငံတကာ ဈေးကွက်ထဲသို့ ဖြန့်ဖြူးပါမည်။ • စီမံကိန်းအတွက် ဗဟိုသိုလှောင်ရုံနှင့် အဓိကပို့ဆောင်ရေးလမ်းကြောင်းကို လားရှိုးမြို့တွင် တည်ဆောက်ထားပါမည်။ သတ္တုကွန်တိန်နာများကို အဓိကလမ်းကြောင်းသို့ ပို့ဆောင်ပြီးနောက် ကုန်တင်ကားများ ပေါ်တင်ပြီး ဆက်လက်ပို့ဆောင်သွားပါမည်။

အစိတ်အပိုင်း	ဖော်ပြချက်
မိုင်းတွင်းအဝင်လမ်း	• အများသုံး နမ္မတူ - မန်တုံလမ်းသည် ဘော်တွင်းသို့ အဝင်လမ်းကြောင်းကို လက်ရှိထောက်ပံ့ပေးပြီး စီမံကိန်းအတွက် အဓိကလမ်းကြောင်းကိုမူ ထောက်ပံ့ပေးခြင်း မရှိပါ။ ဤလမ်းကြောင်းကို ဆောက်လုပ်ရေး ကာလအတွင်း သတ်မှတ်ထားသည့် အချိန်ကာလ တစ်ခုထိသာ အသုံးပြုသွားပါမည်။ • နမ္မတူမှ ကျားစခန်းသို့ လမ်းကြောင်းသစ်ကို နမ္မတူမှ ကျားစခန်းသို့ ဖောက်လုပ်ပြီးသော ရထားလမ်းကို ဖယ်ရှားနေစဉ်အတွင်း ဆောက်လုပ်သွားရန် ရည်ရွယ်ထားပါသည်။ • ကျားစခန်းမှ စက်ရုံသွားရာ လမ်းအသစ် (စက်ရုံသွားလမ်း) ကို ဆိုက်ထဲသို့ သွားလာရလွယ်ကူစေရန် ရည်ရွယ် ထားပါသည်။ • အခြားအဝင်လမ်းသစ်များသည် နမ့်လ ရေသိုလှောင်ကန်၊ TSFs၊ တည်းခိုစခန်းရှိသော စီမံကိန်းနေရာများသို့ သွားလာနိုင်စေရန် ထောက်ပံ့ပေးပါမည်။ • ဟင်းလင်းပွင့်တူးဖော်ထားသောမိုင်းတွင်းကို စက်ရုံနှင့် စွန့်ပစ်သတ္တုပုံ ထားသောနေရာသို့ ဆက်သွယ်ရန် နှစ်လမ်းသွားကားလမ်းသစ်အား ဖောက်လုပ်ထားပါမည်။ • စီမံကိန်းတွင် အကြီးစားယာဉ်အသွားအလာများရှိပါမည်။ လားရှိုးနှင့် နမ္မတူကြား အများပြည်သူသုံးလမ်းမကြီးပေါ် သတ္တုတင်ဆောင်လာသော ကုန်တင်ကားများသည် တစ်ရက်လျှင် အခေါက်ရေ ၆၀နှင့် ၉၀ ကြားရှိပါမည်။
အိမ်ရာများ	• လူပေါင်း ၁၄၀၀နီးပါး နေထိုင်နိုင်သော ဝန်ထမ်းအိမ်ရာများကို ဆောက်လုပ်သွားပါမည်။ • စီမံကိန်းတည်ဆောက်စဉ်နှင့် လည်ပတ်စဉ်ကာလများအတွင်း ဝန်ထမ်း အိမ်ရာများကို အသုံးပြု သွားပါမည်။ • ဒေသခံ လုပ်သားပြည်သူများသည် သူတို့၏အိမ်တွင်သာ နေထိုင်ကြပြီး ဆိုက်ထဲသို့ နေ့စဉ်ကြိုပို့ပေးပါမည်။

အစိတ်အပိုင်း	ဖော်ပြချက်
အလုပ်အကိုင်အခွင့်အလမ်း	• ဆောက်လုပ်ရေးကာလအတွင်း ဝန်ထမ်းပေါင်း ၂,၂၈၅ ယောက်ထိ • လုပ်ငန်းလည်ပတ်စဉ်ကာလအတွင်း ဝန်ထမ်းပေါင်း ၁,၁၁၅ထိ • ဝင်းမြင့်မိုရ်သည် ဦးစားပေး အလုပ်အကိုင်မူဝါဒအရ ဒေသခံ အဖွဲ့အစည်းများ၏ အဖွဲ့ဝင်များကို ခွဲဝေပေး၍ ရရှိနိုင်မည့် အလုပ်အချိုးအစားများကို အများဆုံး ဖြစ်လာစေရန် ရှာဖွေသွားပါမည်။ • ဝင်းမြင့်မိုရ်သည် ဒေသခံ လုပ်သားပြည်သူများ၏ လုပ်အားများ ဖွံ့ဖြိုးတိုးတက်လာစေရန် အလုပ်အကိုင်နှင့်လေ့ကျင့်ရေး အစီအစဉ်များကို အကောင်အထည်ဖော် ဆောင်ရွက်သွားမည်။

ဖျက်သိမ်းခြင်းအဆင့်သည် မိုင်းတူးဖော်ရေး ရပ်စဲပြီးနောက်တွင် စတင်ပြီး အချိန်၂ နှစ်မှ ၃နှစ်ထိ ယူရန် မျှော်မှန်းထားပါသည်။ ၎င်းအဆင့်တွင် အခြေခံအဆောက်အဦများ၊ လိုအပ်သည့် အထောက်အပံ့တိုက်ခန်းများ၊ စက်ပစ္စည်းကိရိယာများနှင့် ဝန်ဆောင်မှုများကို ပျက်ဖျက်ခြင်းများပါဝင်ပါမည်။ ပျက်စီးသွား သည့်ဧရိယာများ ပြန်လည် ပြုပြင်ထိန်းသိမ်းပြီး စိုက်ပျိုးသွားပါမည်။ မြေပေါ်ဟင်းလင်း ပွင့်တူးဖော်ထားသော တွင်းကိုလည်း ရေဖြည့်ပြီး အတည်အကျ တွင်းရေကန်ဖြစ်ပေါ်လာစေရန် ရည်ရွယ်ထားပါသည်။ စွန့်ပစ်သတ္တုများ ပုံထားသော နေရာနှင့် သတ္တုအကြွင်းအကျန်များထားရှိသော Tailings Storage Facilities နေရာများကို မြေကြီးဖြင့် ဖုံးထားပြီး မြက်များ ပြန်လည် စိုက်ပျိုးထားပါမည်။

နောက်ထပ် သိပ္ပံနည်းကျ လေ့လာမှုများကို အသေးစိတ်ပိတ်သိမ်းခြင်း သဘောတရားနှင့် ပြန်လည်ဖွံ့ဖြိုးရေးအစီအစဉ်များကို ဖွံ့ဖြိုးလာစေရန် လုပ်ဆောင်သွားပါမည်။

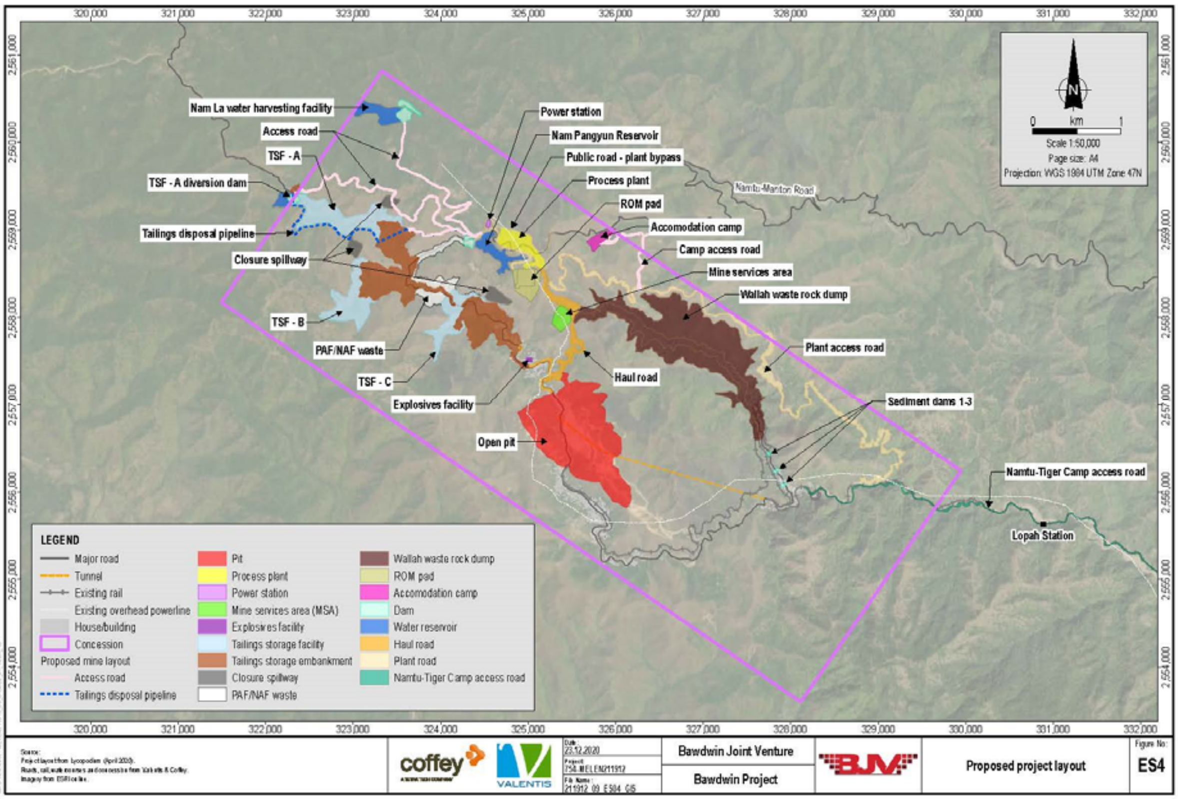


Figure ES.4 Proposed project layout

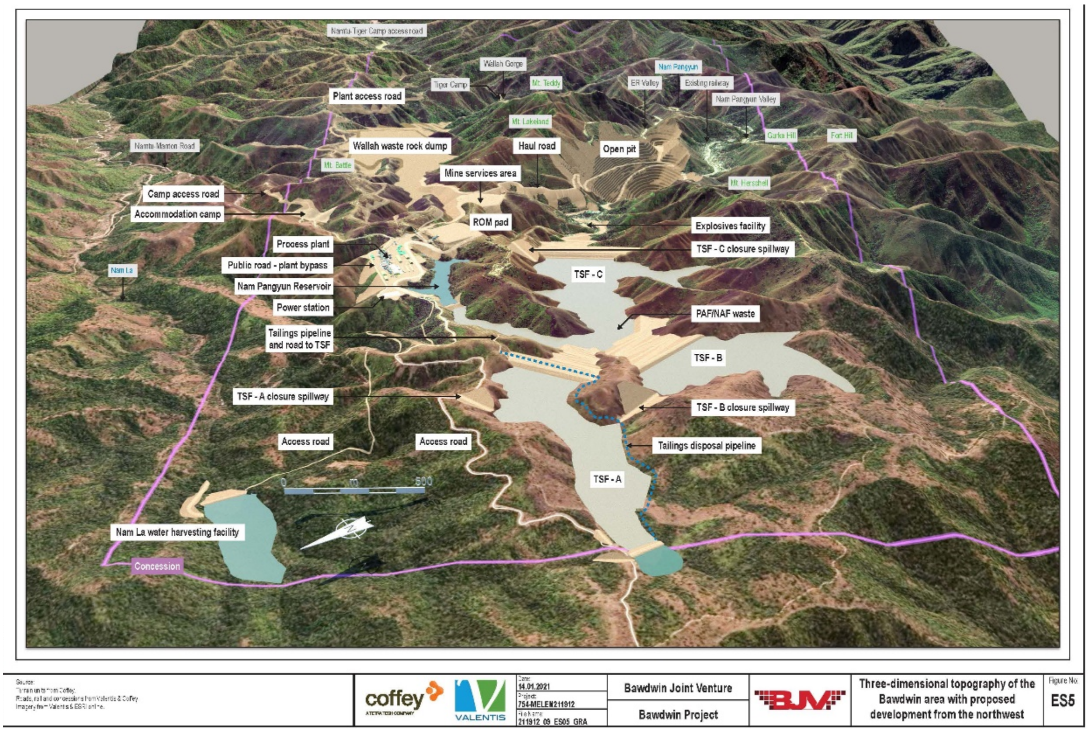


Figure ES.5 Three-dimensional topography of the Bawdwin area with proposed development from the Northwest

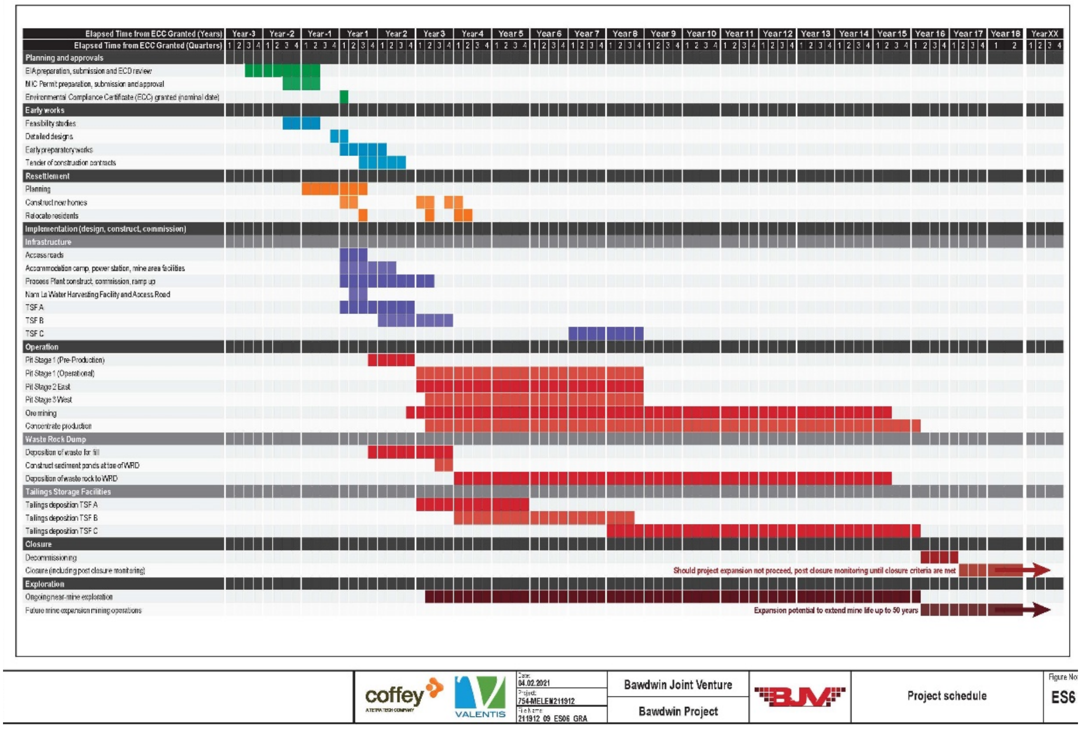


Figure ES.6 Project Schedule

လက်ရှိသဘာဝပတ်ဝန်းကျင်အခြေအနေ

စီမံကိန်းဧရိယာနှင့် အနီးပတ်ဝန်းကျင်၏ လက်ရှိရုပ်ပိုင်းဆိုင်ရာ၊ ဇီဝဗေဒဆိုင်ရာ၊ လူမှုစီးပွားနှင့် ယဉ်ကျေးမှုဆိုင်ရာ ပတ်ဝန်းကျင်အခြေအနေများကို စာတွေ့ နှင့် လက်တွေ့ကွင်းဆင်း စုံစမ်းစစ်ဆေးမှုများ (အခြေခံအချက်အလက်များ လေ့လာမှုများနှင့် ကွင်းဆင်း စစ်တမ်း ကောက်ယူမှုများ) အပေါ် အခြေခံ၍ သတင်းအချက် အလက် များကို စုစည်းပြီး ဖော်ပြထားပါသည်။

လက်ရှိရုပ်ပိုင်းဆိုင်ရာ ပတ်ဝန်းကျင်အခြေအနေ

လက်ရှိ ဘူမိဗေဒ၊ ကုန်းမြေပုံသဏ္ဍာန် နှင့် မြေဆီလွှာ

စီမံကိန်းအများစုသည် နမ့်ပန်ကျွန်းချိုင့်ဝှမ်း၊ ER ချိုင့်ဝှမ်း၊ ဝါးလားတောင်ကြား နှင့် ဆက်စပ်မြစ်လက်တက်များ အပါအဝင် နမ့်ပန်ကျွန်းချောင်း၏ မတ်စောက်ပြီး တောင်တန်း ထူထပ်သော ရေဝေရေလဲဒေသတွင် တည်ရှိသည်။ တောင်စောင်းမြေမျက်နှာသွင်ပြင် အများစု၏ ၂၀% ကျော်သည် ၃၀ % ကျော် လျှော်စောင်းရှိသော ဧရိယာများဖြစ်သည် (WMM၊ 2019)။ စီမံကိန်း၏ အချို့သော အခြေခံအဆောက်အအုံအနည်းအကျဉ်းကိုလည်း အရှေ့မြောက်ဘက်ရှိ နမ့်လရေဝေ ရေလဲဒေသဟု ခေါ်တွင်သော အနီးနားဒေသတွင် တွေ့ရသည်။ လေ့လာမှုနယ်ပယ်၏ မြောက်ဘက်နှင့် အနောက်ဘက်ထောင့်များတွင် ကျန်ရှိနေသော နေရာများအောက် အနည်းငယ် မတ်စောက်သော လှိုင်းထနေသော တောင်ကုန်းများနှင့် ချိုင့်ဝှမ်းဧရိယာများရှိသည်။

လေ့လာမှုဧရိယာတွင်ရှိသော မြေဆီလွှာများသည် အဓိကအားဖြင့် ချိုင့်ဝှမ်းကြမ်းပြင်များပေါ်ရှိ ဒေသအလိုက် နုန်းမြေ နှင့် ကျောက်မြေ အနည်အနှစ်များအပြင် ရာသီဥတုဒဏ်ခံ ချော်မှုန့်ကျောက် (မီးတောင်ပြာများမှ ပြုလုပ်ထားသော ကျောက်) နှင့် သဲကျောက်များတို့ဖြင့် ဖွဲ့စည်းထားပြီး ဒေသတွင်း ဘူမိဗေဒကို ထင်ဟပ်စေသည်။ ဘော်တွင်းဒေသရှိ မြေဆီလွှာများတွင် သတ္တုပါဝင်မှု မြင့်မားသည်ကို တွေ့ရပြီး ရာစုနှစ်များစွာ သတ္တုတွင်း တူးဖော်ခြင်း၊ သတ္တုရိုင်း ပြုပြင်ခြင်း လုပ်ငန်းစဉ်များ နှင့် စွန့်ပစ်ပစ္စည်းများ စွန့်ပစ်ခြင်းကြောင့် ပတ်ဝန်းကျင်ဆိုင်ရာ အမွေအနှစ် ကိစ္စရပ်များနှင့် ဒေသတွင်း တွင်းထွက်ဓာတ်သတ္တုပညာနှင့် ဆက်နွှယ်နေသော သဘာဝအလျောက် ဖြစ်ပေါ်နေသည့် သတ္တုများ စသည်တို့ကြောင့် ဖြစ်သည်ဟု ယူဆနိုင်သည်။ ဟင်းလင်းပြင်ပွင့်များ၊ အရှေ့ဘက် တောင်စောင်းနှင့် ကျားစခန်း ဧရိယာများတွင် အာဆင်းနစ်၊ ခဲနှင့် သွပ် ပါဝင်မှု မြင့်မားသည်ကို တွေ့ရှိရသည်။

မြေအောက်ရေအခြေအနေ

စီမံကိန်းဧရိယာအတွင်း မြေအောက်ရေကို ဇလဘူမိဗေဒဆိုင်ရာ အစိတ်အပိုင်း နှစ်ခုဖြစ်သည့် အက်ကြောင်းရှိ ကျောက်ဆောင်အတွင်း ရေအောင်းလွှာ နှင့် saprolite (ရာသီဥတုဒဏ်ခံ အက်မွနေသော ကျောက်ဆောင်း) ရေအောင်းလွှာတို့တွင် သိုလှောင်ထားသည်။ Saprolite Aquifer

သည် ပုံမှန်အားဖြင့် တောင်ကြောများနှင့် အထက်ဆင်ခြေလျှောများတွင် ပိုထူပြီး ဘော်တွင်းသတ္တုတွင်း၏ ဒေသတွင်း နေရာများတွင် တွေ့ရပြီး ချိုင့်ဝှမ်းကြမ်းပြင်များပေါ်တွင် တွေ့ရှိခြင်းမရှိပေ။ ထိုဒေသရှိ စိမ့်စမ်းရေအများအပြားသည် saprolite aquifer ၏ မျက်နှာပြင်အလွှာဖြစ်ပြီး မြေအောက်ရေကို စွန့်ထုတ်ခြင်း၊ မြေပေါ်ရေအင်္ဂါရပ်များအရ စီးဝင်ခြင်းနှင့် ရပ်ရွာလူထုအတွက် သောက်သုံးနိုင်သောရေအရင်းအမြစ်ကို ထောက်ပံ့ပေးခြင်း ဖြစ်သည်။

မြေအောက်ရေမျက်နှာပြင်ကို စောင့်ကြည့်လေ့လာရာတွင် မြေအောက်ရေမျက်နှာပြင် သည် မြေမျက်နှာပြင်အောက် ၂ မီတာအောက်မှ ခန့်မှန်းခြေ ၁၅၀ မီတာ ခန့်အထိ ရှိပြီး၊ လေ့လာမှုဧရိယာအများစုအတွင်း ပုံမှန်အားဖြင့် အက်ကြောင်းရှိ ကျောက်ဆောင်များအတွင်း ဖြစ်ကြောင်း ညွှန်ပြနေသည်။ လက်ရှိ မြေအောက်မိုင်းတွင်းမှ လုပ်ဆောင်နေဆဲဖြစ်သော မြေအောက်ရေများ ဖယ်ထုတ်ခြင်းသည် မိုင်းတွင်းအနီးတစ်ဝိုက်ရှိ မြေအောက်ရေမျက်နှာပြင်ကို နိမ့်ဆင်းလာစေပါသည်။

ဘော်တွင်းဒေသရှိ မြေအောက်ရေတွင် သဘာဝအတိုင်း သတ္တုအချို့ပါဝင်မှု မြင့်မားနေသည်ဟု မျှော်လင့်ထားသော်လည်း ကျယ်ပြန့်သော သမိုင်းကြောင်းအရ သတ္တုတူးဖော်ရေး လုပ်ငန်းစဉ်များသည် ဆားများနှင့် သတ္တုပျော်ဝင်မှု ပမာဏမြင့်မားစေပြီး မြေအောက်ရေ ညစ်ညမ်းခြင်းကို ဖြစ်စေပါသည်။ အက်ကြောင်းရှိကျောက်ဆောင်အတွင်း ရေအောင်းလွှာမှ မြေအောက်ရေကို စောင့်ကြည့်စစ်ဆေးခြင်းရာတွင် ဒန်၊ ခနောက်စိမ်း၊ အာဆင်းနစ်၊ ကက်မီယမ်၊ သံ၊ ခဲ၊ မန်းဂနိစ်၊ နီကယ်နှင့် သွပ် တို့ စုစုပေါင်းပါဝင်မှု မြင့်မားနေသည်ကို ဖော်ထုတ်တွေ့ရှိခဲ့ပြီး ယင်းတို့သည် အလှအပဆိုင်ရာ သို့မဟုတ် ကျန်းမာရေးဆိုင်ရာအခြေခံ သောက်သုံးရေလမ်းညွှန်ချက်များထက် ကျော်လွန်နေသည်ကို တွေ့ရှိရပါသည်။ Saprolite Aquifer တွင် ခဲ၊ သံ၊ မန်းဂနိစ်နှင့် ဆာလဖိတ် ပျော်ဝင်မှုပမာဏသည် နှိုင်းယှဉ်ထားသော သောက်သုံးရေအရည်အသွေးသတ်မှတ်ချက်ထက် ကျော်လွန်နေပါသည်။

မြေပေါ်ရေအခြေအနေ

လေ့လာမှုဧရိယာရှိ အဓိကရေစီးလမ်းကြောင်းများမှာ နမ့်ပန်ကျွန်း ချောင်းနှင့် နမ့်လချောင်း များဖြစ်ပြီး နမ္မတူမြို့ အနီးရှိ မြစ်ငယ်မြစ်အတွင်းသို့ စီးဆင်းသွားကြသည်။ ဤရေစီးလမ်း ကြောင်းများ၏ မြေပေါ်ရေအရည်အသွေးသည် သဘာဝရေအရည်အသွေးကို ထင်ဟပ်စေရုံသာမက လက်ရှိဒေသခံများ အနီးပတ်ဝန်းကျင်မြေယာများကို အသုံးပြုခြင်း နှင့် ကျယ်ပြန့်သော သမိုင်းကြောင်းအရ သတ္တုတူးဖော်မှုများနှင့် ဆက်စပ်နေသော ပတ်ဝန်းကျင်ဆိုင်ရာ အမွေအနှစ် ပြဿနာနှစ်ရပ်လုံးမှ သက်ရောက်မှုများကိုပါ ထင်ဟပ်စေသည်။

နမ့်ပန်ကျွန်းချောင်းသည် နမ့်ပန်ကျွန်းချိုင့်ဝှမ်းကို ဖြတ်သန်းစီးဆင်းနေပြီး ကျားတူးမြောင်း မှ မြေအောက်ရေထုတ်လွှတ်မှုကြောင့် အထူးသဖြင့် လက်ရှိမိုင်းတွင်း၏ ရေစုန်ဒေသနှင့် အောက်ပိုင်း

ရေဝေရေလဲဒေသများတွင် အန္တရာယ်ဖြစ်စေနိုင်သည့် သတ္တုအဆင့် မြင့်မားသည်ဟု သတ်မှတ်ထားသည်။ ဤညစ်ညမ်းမှုသည် မြစ်အောက်ပိုင်းရပ်ရွာများအတွက် ချောင်း၏ အကျိုးရှိစွာ အသုံးပြုနိုင်စွမ်းကို ကန့်သတ်ထားပြီး ရေလမ်းကြောင်းနှင့် ရေနေဂေဟစနစ်များကိုလည်း သိသိသာသာ ပျက်စီးစေပါသည်။ နမ့်ပန်ကျွန်းသည် မိုးရွာသွန်းမှုကို လျင်မြန်စွာ တုံ့ပြန်နိုင်ပြီး အနည်အနှစ်များ စီးဆင်းခြင်းဖြစ်ပေါ်စေပြီး နောက်ဆက်တွဲအနေဖြင့် ရေထဲတွင်ပါဝင်သော အမှုန်အမွှားစုစုပေါင်းပမာဏ total suspended solids (TSS) ကိုမြင့်တက်စေခြင်း နှင့် ညစ်ထေးနောက်ကျိမှု ကို ဖြစ်စေသည်။

နမ့်လချောင်းတွင် သတ္တုအများစုပါဝင်မှုနည်းပြီး စွန့်ပစ်ပစ္စည်း/ မိလ္လာအညစ်အကြေး ပါဝင်မှုကို တွေ့ရသည်။ နမ့်လရေသွယ်လျှောက်အတွက် ဝင်ပေါက်နှင့် ဆက်နွယ်နေသော မြစ်ငယ်မြစ် နှင့် ပေါင်းဆုံရာ အထက်ပိုင်းတွင် ရေလွှဲဆည်တစ်ခုကို တည်ဆောက်ခဲ့သည်။ အဆိုပါ ရေသွယ်လျှောက်သည် နမ္မတူမြောက်ပိုင်းခရိုင်အတွက် သောက်သုံးရေရရှိရေး ပံ့ပိုးပေးသည့် မြေဆွဲငင်အားဖြင့် စီးဆင်းနေသော တူးမြောင်းဖြစ်သည်။

အခြေခံ ရေအရည်အသွေး စောင့်ကြည့်ခြင်း အကျဉ်းချုပ်ကို ပုံ ES 7 တွင် ဖော်ပြထားပါသည်။ မြစ်ငယ်မြစ်၏ ရေအရည်အသွေးသည် နမ့်ပန်ကျွန်းချောင်း နှင့် နမ့်လချောင်းတို့မှ ထွက်ရှိလာသည်များပေါ်မူတည်ပြီး မြောက်ဘက်မြစ်ကမ်းပါးပေါ်တွင် သမိုင်းဝင်သတ္တုရိုင်းများ အရည်ကျိုခြင်းလုပ်ငန်းနှင့် တောင်ဘက်မြစ်ကမ်းပါးပေါ်တွင် သတ္တုရိုင်းများစုပုံလာပြီး ဓာတ်သတ္တုတူးဖော်ရာမှ ထွက်လာသောစွန့်ပစ်ပစ္စည်းများ စွန့်ပစ်ခြင်းအပါအဝင် နမ္မတူအနီးရှိ သမိုင်းဝင် သတ္တုရိုင်းများ အရည်ကျိုခြင်းလုပ်ငန်းစဉ်များမှ ညစ်ညမ်းမှုများပျော်ဝင်စီးဆင်းလာမှုတို့ကြောင့်လည်း ပြောင်းလဲစေပါသည်။ သတ္တုပါဝင်မှုသည် နမ္မတူမြစ်အထက်ပိုင်းတွင် နည်းပါးပြီး နမ္မတူမှတဆင့် မြစ်အောက်ပိုင်းနှင့် နမ့်လမြစ်ဆုံရာတွင် သတ္တုပါဝင်မှုမြင့်မားလာပြီး နမ့်ပန်ကျွန်းမြစ်ဆုံတဝိုက်တွင်လည်း သတ္တုပါဝင်မှု၊ ရေထဲတွင်ပါဝင်သော အမှုန်အမွှား စုစုပေါင်းပမာဏ (TSS) နှင့် ညစ်ထေးမှုများ သိသိသာသာ များပြားလာပါသည်။

မိုးလေဝသအခြေအနေ

ဘော်တွင်းဒေသ၏ ရာသီဥတုသည် အဓိကဥတုသုံးပါးရှိသော မုတ်သုံရာသီဖြစ်ပြီး အောက်တိုဘာလနှောင်းပိုင်းနှင့် ဖေဖော်ဝါရီလလယ်အကြား အေးမြပြီး အတော်လေးခြောက်သွေ့သော အရှေ့မြောက်မုတ်သုံလေဖြစ်၍ ဖေဖော်ဝါရီလလယ်နှင့် မေလလယ်အကြားသည် ပူပြင်း ခြောက်သွေ့သော မုတ်သုံရာသီဖြစ်ကာ မေလလယ်နှင့် အောက်တိုဘာလနှောင်းပိုင်းအကြား အနောက်တောင်မုတ်သုံလေသည် မိုးရွာသွန်းမှုကို ဖြစ်စေနိုင်သည်။ နှစ်စဉ်ပျမ်းမျှ မိုးရေချိန်လက်မသည် ၁,၅၆၉ မီလီမီတာဖြစ်ပြီး အများအားဖြင့် အနောက်တောင် မုတ်သုံလေနှင့်အတူပါလာသော မိုးသည် အသည်းထန်ဆုံး မိုးရွာသွန်းမှုကိုဖြစ်စေသည်။

ဘော်တွင်းဒေသတွင် ၂၀၀၀ နှင့် ၂၀၁၈ ခုနှစ်ကာလအတော်အတွင်း လစဉ်ပျမ်းမျှအပူချိန်အနိမ့်ဆုံးမှာ အရှေ့မြောက် မုတ်သုံရာသီတွင်ဖြစ်ပြီး ဒီဇင်ဘာလနှင့် ဇန်နဝါရီလတွင် လစဉ်ပျမ်းမျှအနိမ့်ဆုံးမှာ ၁၁°C ဖြစ်သည်။ လစဉ်ပျမ်းမျှအပူချိန်အမြင့်ဆုံးမှာ မုတ်သုံစပ်ကြားရာသီနှင့် အနောက်တောင် မုတ်သုံရာသီအတွင်း ဖြစ်ပြီး ဧပြီလမှ စက်တင်ဘာလအထိ လစဉ်ပျမ်းမျှအပူချိန် အမြင့်ဆုံးမှာ ၂၂ °C ဖြစ်ပြီး ဧပြီလနှင့် မေလတွင် လစဉ်ပျမ်းမျှအမြင့်ဆုံးအပူချိန်မှာ ၃၄°C ဖြစ်သည်။

အပူချိန်တည်ငြိမ်မှုကို သွေဖယ်မှုဖြစ်စဉ်သည် ညဘက်တွင် မြေပြင်များအေးမြလာခြင်းနှင့် လေရွေ့လျားမှုနည်းပါးလာမှုတို့ကြောင့် ပူနွေးသောလေများရှိသည့်အလွှာအောက်တွင် အေးမြသော လေအလွှာတစ်ခု ကျယ်ပြန့်လာသောကြောင့် ဖြစ်သည်။ နမ္မတူတွင် လေထုအခြေအနေ တည်ငြိမ်ခြင်းသည် ပုံမှန်ဖြစ်သော်လည်း ဘော်တွင်းဒေသတွင်မူ မတ်စောက်သော မြေပြင် အနေအထားနှင့် လေများလွတ်လပ်စွာ ရွေ့လျားနိုင်မှုကြောင့် လေထုအခြေအနေ တည်ငြိမ်ခြင်းသည် ကြုံတောင့်ကြုံခဲ ဖြစ်ပြီး ဖြစ်လေ့ဖြစ်ထမရှိပါ။

၂၀၁၉ ခုနှစ် စက်တင်ဘာလ မှ ၂၀၂၀ ခုနှစ် မေလ အတွင်း စောင့်ကြည့်တိုင်းတာမှုအရ ဘော်တွင်းရှိ လေတိုက်ခတ်မှုပုံစံများအပေါ် ပတ်ဝန်းကျင်မြေမျက်နှာသွင်ပြင်ကများစွာသက်ရောက်မှုရှိသည်။ အဆိုပါ ကာလအတွင်း တောင်-အနောက်တောင် လေတိုက်ခတ်မှုများ ဖြစ်ပေါ်နေပြီး လေတိုက်နှုန်း မှာ လေငြိမ်ရာမှ ညင်သာသော လေပြည် (0 m/s မှ 2.4 m/s အထိ) ဖြစ်သည်။ နမ္မတူတွင် နှစ်စဉ် လေတိုက်နှုန်းလားရာသည် တောင်ဘက်သို့ ဦးတည်နေပြီး မုတ်သုံလေသည် ဒီဇင်ဘာလမှ ဧပြီလအထိ အားကောင်းနေပြီး ဇွန်လမှ စက်တင်ဘာလအထိ လေငြိမ်သည့် အခြေအနေဖြစ်သည်။

လေအရည်အသွေး

စီမံကိန်းဧရိယာရှိ လေထုအရည်အသွေးအပေါ် သက်ရောက်မှုရှိသည့် အချက်များတွင် ဘော်တွင်းဒေသနှင့် နမ္မတူအနီးတစ်ဝိုက်ရှိ လမ်းများ (ကျောက်စရစ်ခင်း နှင့် ကတ္တရာခင်း၊ မော်တော်ယာဉ်များမှ ထုတ်လွှတ်မှုများ၊ စက်မှုလုပ်ငန်းဆောင်ရွက်မှု၊ ခုတ်ထွင်ရှင်းလင်းထားသော ဧရိယာများတိုက်စားမှုနှင့် သဘာဝပေါက်ပင်များ လောင်ကျွမ်းခြင်းတို့ ပါဝင်သည်။ အမှုန်အမွှားများ၏ အရည်အသွေးသည် သမိုင်းဝင်တူးဖော်မှုနှင့် ဆက်စပ်နေသော ပတ်ဝန်းကျင်ဆိုင်ရာအမွေအနှစ် ပြဿနာရပ်များကို ထင်ဟပ်စေနိုင်သည်။

အခြေခံလေ့လာမှုများအတွင်း လေထုအရည်အသွေးကို စောင့်ကြည့်ကြည့်ရှုလေ့လာခြင်းသည် ဘော်တွင်းဒေသနှင့် နမ္မတူလေထုအတွင်း လေအရည်အသွေးမှာ ယေဘုယျအားဖြင့် ဓာတ်ငွေ့ထုတ်လွှတ်မှု (SO2 နှင့်NO2) ပမာဏနည်းပါးပြီး အမှုန်အမွှားများ (အရည်အသွေးနှင့် ပမာဏ) အရ အလယ်အလတ်မှ ညံ့ဖျင်းသည်ဟု ဆုံးဖြတ်ထားသည်။ 24 နာရီ စောင့်ကြည့်မှုအတွင်း လေထုအတွင်း အမှုန်အမွှားများ (TSP) နှင့် PM10 ပါဝင်မှုသည် နံနက်ပိုင်းနှင့် နေ့လည်ပိုင်းများတွင် အများဆုံးဖြစ်ပြီး ကတ္တရာမခင်းထားသော လမ်းများပေါ်တွင် ခရီးသည်များသွားလာမှုတို့ကြောင့် ဖြစ်နိုင်ချေရှိပါသည်။ ယေဘုယျအားဖြင့် လေထုအတွင်း အမှုန်အမွှားများ (TSP) ပါဝင်မှု သည်

ဘော်တွင်းဒေသတွင် အများဆုံးဖြစ်၍ ကျားစခန်းတွင် အနည်းဆုံးဖြစ်ပြီး စိုစွတ်သောရာသီတွင်လည်း ပါဝင်မှုပိုမိုနည်းပါသည်ကို တွေ့ရှိရပါသည်။ ဘော်တွင်းကျေးရွာအနီးရှိ နေရာတစ်ခုမှ လွဲ၍ ကျန်စောင့်ကြည့်တိုင်းတာထားသောနေရာအားလုံးတွင် ဖုန်မှုန့်များပါဝင်မှုသည် ချမှတ်ထားသော လမ်းညွှန်ချက်တန်ဖိုးထက် ကျော်လွန်နေပါသည်။

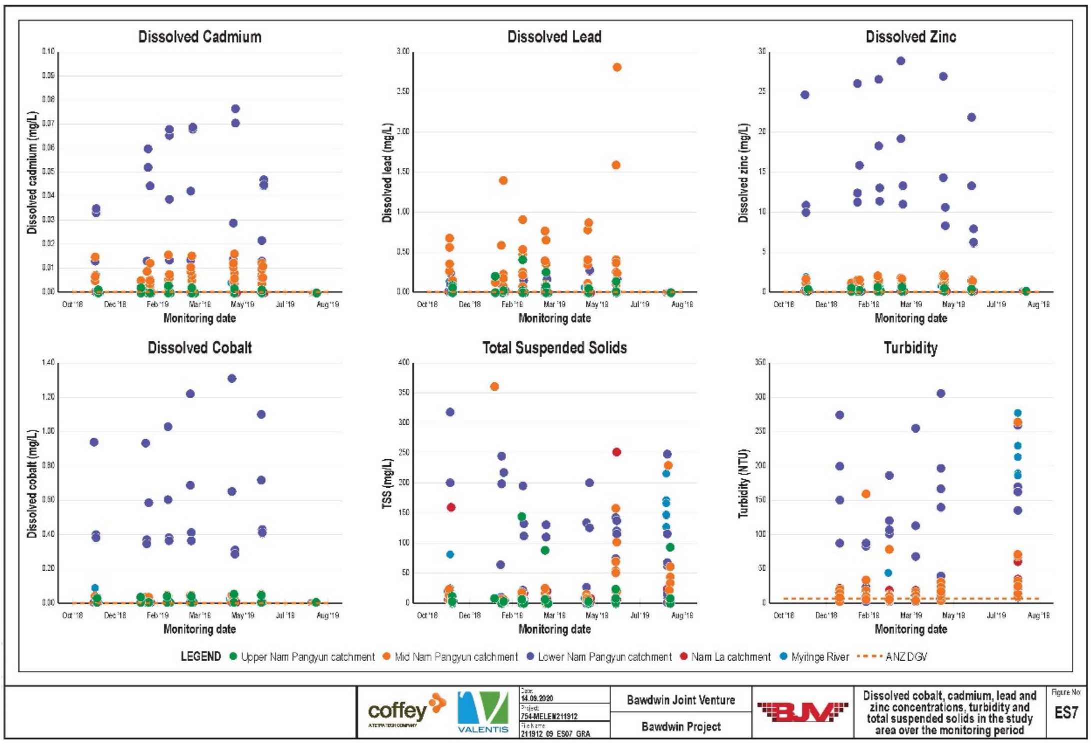


Figure ES.7 Dissolved cobalt, cadmium, lead and zinc concentrations, turbidity and total suspended solids in the study area over the monitoring period

TSP နှင့် PM_{10} ကို ၂၄ နာရီ စောင့်ကြည့်တိုင်းတာရာတွင် စုဆောင်းရရှိလာသည့် ဖုန်မှုန့်များအတွင်း သတ္တုပါဝင်မှုနှင့် တင်ကျန်လာသောမြေမှုန့်များတွင် ခဲနှင့် ခရိုမီယမ်ပါဝင်မှု မြင့်မားပြီး ဘောတွင်း၊ ကျားစခန်းနှင့် နမ္မတူရှိ အချို့နေရာများတွင် ပျမ်းမျှတန်ဖိုးများထက် ကျော်လွန်နေပါသည်။ ၎င်းသည် သမိုင်းဝင်မိုင်းတွင်းလုပ်ငန်းများကြောင့် ညစ်ညမ်းသောဧရိယာများမှ ဖုန်မှုန့်များဖြစ်ပေါ်လာခြင်းကို ထင်ဟပ်စေပါသည်။

ဆူညံသံနှင့်တုန်ခါမှု

စီမံကိန်းဧရိယာရှိ ဆူညံသံသည် အများအားဖြင့် လူနေအိမ်/ကျေးရွာ အတွင်းရှိ လှုပ်ရှားဆောင်ရွက်မှုများ၊ မော်တော်ကားများနှင့် စီးပွားရေးဆိုင်ရာ လုပ်ငန်းဆောက်ရွက်ချက်များနှင့် ဆက်စပ်နေပါသည်။ အခြေခံလေ့လာမှုများအတွင်း ဆူညံသံအဆင့်ကို စောင့်ကြည့်လေ့လာရာတွင် ပျမ်းမျှဆူညံသံအဆင့်သည် နံနက်ပိုင်း (နံနက် ၅း၀၀ မှ နံနက် ၉း၀၀ နာရီကြား) တွင် အမြင့်ဆုံးဖြစ်ပြီး ကျေးရွာအတွင်း ပုံမှန်လှုပ်ရှားမှုများနှင့် ယာဉ်များသွားလာမှုတို့နှင့် ဆက်စပ်နေသည်။ ပျမ်းမျှအသံ ဆူညံမှုအဆင့်မှာ ဘော်တွင်းအထက်ပိုင်းရွာတွင် အမြင့်ဆုံးဖြစ်ပြီး ကျေးရွာအတွင်း ပုံမှန်လှုပ်ရှားဆောင်ရွက်မှုများကြောင့် ဖြစ်ပါသည်။

စီမံကိန်းဧရိယာအတွင်း နေရာအများအပြားရှိ ဆူညံသံအဆင့်များကို အမျိုးသားပတ်ဝန်းကျင် အရည်အသွေး (ထုတ်လွှတ်မှု) လမ်းညွှန်ချက်များနှင့် နှိုင်းယှဉ်ထားပါသည်။ ဤလမ်းညွှန်ချက်များသည် အနီးဆုံး ထိခိုက်ခံစားလွယ်သော လူနေပတ်ဝန်းကျင်၊ စက်မှု သို့မဟုတ် ပညာရေးဆိုင်ရာ နေရာနှင့် စီမံကိန်းတစ်ခုအတွက် အနီးဆုံး ထိခိုက်ခံစားလွယ်သော စက်မှုလုပ်ငန်း သို့မဟုတ် ကုန်သွယ်ရေးနှင့်ဆိုင်သောနေရာများတွင် ခွင့်ပြုနိုင်သော အမြင့်ဆုံးဆူညံသံအဆင့်ကို အကြမ်းဖျင်း ဖော်ပြထားပါသည်။ စီမံကိန်းဧရိယာအတွင်းရှိ လူနေပတ်ဝန်းကျင်များတွင် စောင့်ကြည့်တိုင်းတာထားသည့် LAeq (သတ်မှတ်ထားသောအချိန်အတိုင်းအတာတစ်ခုအတွင်း တိုင်းတာထားသည့် စုစုပေါင်းအသံစွမ်းအင်နှင့် ညီမျှသည်) သည် နေ့အချိန်တွင် စီမံကိန်းတစ်ခုအတွက် အနီးဆုံးထိခိုက်ခံစားလွယ်သောနေရာများတွင် မကျော်လွန်သင့်သည့် လမ်းညွှန်ချက်အဆင့်ထက် ကျော်လွန်နေသည်ကို တွေ့ရသည်။ နေ့ နှင့် ညအချိန်အတွင်း ကူးသန်းရောင်းဝယ်ရေးနေရာများတွင် တိုင်းတာမှုရလာဒ်များသည် အများအားဖြင့် ထုတ်လွှတ်မှုလမ်းညွှန်ချက်အောက်တွင် ရှိနေသော်လည်း 'အလယ်အလတ်မှ အသံကျယ်သည်' ဟု သတ်မှတ်နိုင်သည်။

တုန်ခါမှုအား အခြေခံစုံစမ်းစစ်ဆေးမှုများ ဆောင်ရွက်ခြင်းမပြုလုပ်ရသေးပါ။ သို့သော်လည်း သိသာထင်ရှားသော တုန်ခါမှုကို ဖြစ်နိုင်ခြေရှိသော အရင်းအမြစ်များသည် အသေးစားနှင့် ယာဉ်ကြီးများ အကန့်အသတ်ဖြင့်သွားလာမှု၊ ပြုပြင်ထိန်းသိမ်းခြင်းလုပ်ငန်းများအတွက် စက်ရုံကို အကန့်အသတ်ဖြင့် လည်ပတ်စေခြင်း၊ တူးဖော်မှုလုပ်ငန်းများနှင့် သတ္တုတူးဖော်ခြင်းလုပ်ငန်းများကို ဆောင်ရွက်ရန်အတွက် မြေကြီးများဖယ်ရှားခြင်း တို့ကြောင့် ဖြစ်နိုင်သည်ဟု ခန့်မှန်းထားပါသည်။

ဇီဝမျိုးစုံမျိုးကွဲများ

စီမံကိန်းဧရိယာရှိ ဇီဝဆိုင်ရာပတ်ဝန်းကျင်အပေါ် သစ်တောပြုန်းတီးမှု၊ သမိုင်းဝင် သတ္တုတူးဖော်ခြင်းနှင့် ပြုပြင်ထုတ်လုပ်ခြင်းလုပ်ငန်းစဉ်များ၊ စိုက်ပျိုးရေးလုပ်ငန်းများနှင့် ရာသီအလိုက် မီးရှို့ခြင်းများ စသည့်အချက်များက အကြီးအကျယ် သက်ရောက်မှုရှိနေပြီး ဇီဝဆိုင်ရာဝန်းကျင်အခြေအနေသည် ပြုပြင်မွမ်းမံထားသကဲ့သို့ဖြစ်နေပါသည်။ သတ္တုတူးဖော်ရန် ပိုင်ဆိုင်ထားသောနေရာများတွင် အဓိကအားဖြင့် မြက်ခင်းပြင်များနှင့် ဝါးတောများ ပါဝင်ပြီး ပိုင်ဆိုင်ထားသောနေရာများနှင့် ကျော်လွန်ပြီး အနောက်မြောက်ဘက် အကျယ်အဝန်းပမာဏ(Plates ES.7 မှ ES.9) အထိ အပူလျော့ပိုင်းဒေသ ရောနှောတောင်ကုန်းသစ်တောများကို တွေ့ရှိရသည်။ မြက်ခင်းပြင်နှင့် ဝါးတောများကို ပြုပြင်မွမ်းမံထားသော သို့မဟုတ် ပျက်စီးယိုယွင်းနေသော သဘာဝင်ပေါက်ပင်များဟူ၍ အမျိုးအစားခွဲခြားထားသည်။ သစ်တောခုတ်ထွင်ရှင်းလင်းခြင်းသည် အစောပိုင်းတရုတ်မိုင်းတွင်းနှစ် ကတည်းကတည်ရှိခဲ့ပြီး မြက်ခင်းပြင်နှင့် ဝါးတောများသည် အသစ်တစ်ဖန် ပြန်လည်ရှင်သန်လာပြီး ဆင့်ပွားသစ်တောများကိုကိုယ်စားပြုသည်။ မြက်ခင်းပြင်နှင့် ဝါးတောများ၏ ဧရိယာများတွင် သစ်ပင်ပန်းမန်များနှင့် တိရစ္ဆာန်မျိုးကွဲများ နည်းပါးပြီး ယေဘုယျဆန်ပြီး ခံနိုင်ရည်ရှိဘုံမျိုးစိတ်များကိုသာ အများဆုံးတွေ့ရသည်။ မတူကွဲပြားသော အပင်မျိုးစိတ်များကို မိုင်းတူးဖော်သည့်နေရာပြင်ပအကျော် အပူလျော့ပိုင်းဒေသ ရောနှောတောင်ကုန်းသစ်တောများတွင် ပကတိအခြေအနေအတိုင်း အများဆုံး တွေ့ရှိရသည်။

အပူလျော့ပိုင်းဒေသ ရောနှောတောင်ကုန်း သစ်တောဧရိယာများတွင် ထိန်းသိမ်းစောင့်ရှောက်ရမည့် အရေးပါသော အပင်မျိုးစိတ်နှစ်ခုကို မှတ်တမ်းတင်ခဲ့သည်။ IUCN Red List တွင် ထိခိုက်နိုင်သည်ဟု ယူဆရသည့် Cycaspectinata နှင့် မြန်မာ့သစ်နက် (Dalbergia cultrate) တို့သည် မျိုးသုဉ်းရန် အန္တရာယ်ကျရောက်လုနီးပါးမျိုးစိတ်များ ဟုယူဆရသည်။ ကုန်းနေဒေသရင်း သတ္တဝါများကို အခြေခံလေ့လာမှုများပြုလုပ်ရာတွင် မုဆိုးများသည် ဒေသတွင်း၌ ပြီးခဲ့သော ဆယ်စုနှစ်များအတွင်း သမိုင်းကြောင်းအရတွေ့ရှိရသည့် ထိန်းသိမ်းစောင့်ရှောက်ရမည့် အရေးပါသော မျိုးစိတ်လေးခုကို တင်ပြခဲ့သည်။ ၎င်းတို့မှာ မျိုးသုဉ်းပျောက်ကွယ်လုနီးပါး အန္တရာယ်ရှိမျိုးစိတ်ဖြစ်သည့် တရုတ်သင်းခွေချပ် (Manis pentadactyla); မျိုးသုဉ်းရန် အန္တရာယ်ရှိသော မျိုးစိတ်တစ်မျိုးဖြစ်သည့် တောခွေး(Cuon alpinus); နှင့် ထိခိုက်လွယ်သော မျိုးစိတ်နှစ်ခုဖြစ်သည့် အာရှဝက်ဝံနက် (Ursust thibetanus) နှင့် ခွေးတူဝက်တူ (Arctonyx collaris) တို့ဖြစ်သည်။ သို့သော်လည်း စီမံကိန်းဧရိယာတွင် အဆိုပါ မျိုးစိတ်များရှိနေခြင်းသည် ထိုနေရာတွင် သက်ရှိများ ကျက်စားရာ နေရာများကို ပျက်စီး ယိုယွင်းနိုင်သည့် အလားအလာမရှိဟု အကဲဖြတ်ခဲ့သည်။ ၂၀၂၀ ပြည့်နှစ်တွင် သတ္တုတွင်း အနီးတွင် ထိခိုက်လွယ်သော မျိုးစိတ်ဖြစ်သည့် တောကြီးမြွေဟောက် (Ophiophagus hannah) ကို တွေ့ရှိခဲ့သည်။

စီမံကိန်းဧရိယာရှိ ရေနေဂေဟစနစ်များသည် ရေလမ်းကြောင်းများ၏ အရည်အသွေးအားဖြင့် ကြီးမားစွာသက်ရောက်မှုရှိသည်။ လွန်ကဲစွာပျက်စီးယိုယွင်းပြီး ညစ်ညမ်းနေသော

နမ့်ပန်ကျွန်းချောင်းတွင် ဇီဝမျိုးစုံမျိုးကွဲများကို စစ်တမ်းကောက်ယူမှုအတွင်း မှတ်တမ်းတင်ထားသော ယေဘုယျဆန်သော၊ လိုက်လျောညီထွေရှိသော၊ ခံနိုင်ရည်ရှိသော ကျောရိုးမဲ့သတ္တဝါများနှင့် ငါးမျိုးစိတ်များနှင့်အတူ ဒေသတွင်းမျိုးရင်းများပျောက်ဆုံးပြီး ပျက်ဆီးနေသော ဂေဟစနစ်တစ်ခုရှိသည်။ နမ့်လချောင်းတွင် အရည်အသွေးပိုမြင့်သော ရေနေသတ္တဝါများတွေ့ရပြီး စမ်းချောင်းတစ်လျှောက်တွင် ပကတိအခြေအနေအတိုင်းရှိနေသော သဘာဝပေါက်ပင်များ နှင့် ရေထုညစ်ညမ်းမှုဒဏ်ကို ခံနိုင်ရည်ရှိသော မျိုးစိတ်များနှင့် နမ့်ပန်ကျွန်းချောင်းတွင် မရှိတော့သည့် မျိုးစိတ်များလည်း တွေ့ရသည်။ မြစ်ငယ်မြစ်သည် မြစ်ကမ်းစပ်တွင် ရေနေအပင်များနှင့် သစ်ပင်မျိုးစုံကို အထောက်အကူ ပြုသည့်အပြင် ရေနေသတ္တဝါများအတွက် ကျက်စားရာဒေသကိုလည်း ဖန်တီးပေးသည်။

Plate ES.7 Bamboo forest

Plate ES.8 Grassland forest

Plate ES.9 Sub-tropical mixed hill forest

ယဉ်ကျေးမှုအမွေအနှစ်

ဘော်တွင်းဒေသရှိ ယဉ်ကျေးမှုဆိုင်ရာပတ်ဝန်းကျင်သည် တရုတ်၊ ဗြိတိသျှခေတ်ကတည်းက စတင်၍ မျက်မှောက်ခေတ်ကာလအတွင်းအထိ ခေတ်အဆက်ဆက်မိုင်းတွင်းတူးဖော်ခြင်းကြောင့် ရှုပ်ထွေးသည်။ ဘော်တွင်းဒေသတွင် သတ္တုတူးဖော်မှုများကို ၁၅ ရာစု အစောပိုင်းကတည်းက စတင်ခဲ့ကြသည်။ ဤသမိုင်းကြောင်းနှင့်ဆက်စပ်၍ မြင်သာထင်သာရှိသောအစိတ်အပိုင်းများ (လုပ်ငန်းခွင်နေရာ၊ နေရာများ၊ တည်ဆောက်ပုံများနှင့် ရှေးပစ္စည်းအသုံးအဆောင်များ) သည် အလှအပအနုပညာဆိုင်ရာ ၊သမိုင်းဝင်၊ သိပ္ပံနည်းကျ၊ နည်းပညာဆိုင်ရာ ၊ လူမှုရေးနှင့် ဘာသာရေးဆိုင်ရာ အစရှိသည့် ဖော်ပြ၍ မရသောယဉ်ကျေးမှုတန်ဖိုးများနှင့်လည်း ဆက်စပ်နေသည်။ စီမံကိန်းဧရိယာအတွင်းရှိ ယဉ်ကျေးမှုအမွေအနှစ်ဆိုင်ရာအင်္ဂါရပ်များကို ပုံ ES.8 တွင် ဖော်ပြထားသည်။

တရုတ်တို့ သိမ်းပိုက်ပြီး မိုင်းတွင်းကာလတွင် တောင်ကုန်းခံတပ်များနှင့် တောင်ကြော ကာကွယ်ရေးလိုင်းများကို မိုင်းတွင်းဝန်းကျင်ရှိတောင်ကြောများပေါ်တွင် တည်ဆောက်ခဲ့သည်။ ၎င်းတို့ကို မိုင်းတွင်းကို ခုခံကာကွယ်ရန်၊ ချိုင့်ဝှမ်းအတွင်း အခြေချနေထိုင်မှုများနှင့် မိုင်းတွင်းလုပ်ငန်း လည်ပတ်မှုအခြေအနေများကို စောင့်ကြည့်လေ့လာရန် တည်ဆောက်ခဲ့ခြင်းဖြစ်သည်။ တရုတ် သိမ်းပိုက်ထားသည့် ကာလ အထောက်အထားများနှင့် ရှေးပစ္စည်းအသုံးအဆောင်များကို တရုတ်ပြည်နှင့် ဆက်စပ်နေသောလုပ်ဆောင်ပုံ၊ သတ္တုဖိုအရည်ကျိုသည့်မီးဖိုများနှင့်အတူ နမ့်ပန်ကျွန်းချိုင့်ဝှမ်းတွင် တွေ့ရှိနိုင်သည်။ ယင်းတို့သည် တရုတ်ခေတ်အတွင်း သတ္တုတူးဖော်ခြင်းနှင့် အရည်ကျိုခြင်းလုပ်ငန်းများ၏ အထောက်အထားများဖြစ်ပြီး အရှေ့တောင်အာရှအတွင်း အစောပိုင်း တွင်းထွက်ပစ္စည်း ဖလှယ်မှုနှင့် သတ္တုတူးဖော်ခြင်းကိစ္စများတွင် အထောက်အပံ့ပေးသည့် အကဲဖြတ်မှုများအတွက် တန်ဖိုးဖြစ်သည်။

ကိုလိုနီခေတ် မိုင်းတွင်းတူးဖော်ခြင်းနှင့် ဆက်စပ်နေသော ယဉ်ကျေးမှု အမွေအနှစ် အင်္ဂါရပ်များမှာ သတ္တုတွင်းအခြေခံအဆောက်အအုံနှင့် အဆောက်အဦများ အများစုဖြစ်သည်။ ယနေ့ထိ လည်ပတ်နေဆဲဖြစ်သည့် Marmion shaft နှင့် ရေနွေးငွေ့သုံး အင်ဂျင်များထားရှိသည့် အဆောက်အအုံ (winding house) များသည် ဘော်တွင်းဒေသတွင် မိုင်းတွင်း ပထမဆုံးတူးဖော် အောင်မြင်ခဲ့သည့် အဓိကအချိန်ကာလကို ကိုယ်စားပြုသည့် ၂၀ ရာစု ကိုလိုနီခေတ်တွင် ပြီးပြည့်စုံသည့် ရေနွေးငွေ့သုံးစက်ရုံများ၏ ရှားပါးပြောင်မြောက်သော ဥပမာတစ်ခုဖြစ်သည်။ နမ္မတူ-ဘော်တွင်း မီးရထားလမ်းနှင့် ဘော်တွင်းမြို့လယ်ခေါင်နှင့် ကျားစခန်းပရဝဏ်တို့သည် ကိုလိုနီခေတ်ကာလတွင် အဓိကကျသော အဆောက်အဦများဖြစ်ပြီး မိုင်းတွင်းရှိ ရုံးများ၊ တရုတ်သေဥမင်လိုဏ်ခေါင်း၊ ဘော်တွင်းကျွန်းသစ်ခြံနှင့် ကျားဥမင် စသည့်ပရဝဏ်များလည်း အပါအဝင်ဖြစ်သည်။

ထိုဒေသတွင် ကိုလိုနီနယ်ချဲ့လက်အောက် ခေတ်အဆက်ဆက်အလိုက် ဆက်စပ်နေသော သင်္ချိုင်းများစွာရှိသည်။ သင်္ချိုင်းမြေများတွင် ဇီဝဆိုင်ရာရှေးဟောင်းသုတသနေ၊ လူမှုရေးနှင့် ဘာသာရေးယုံကြည်မှုဆိုင်ရာ တန်ဖိုးထားမှုများရှိနေသည်။ ထိုနေရာအများအပြားသည် ရှုခင်းကောင်းမွန်ထင်ရှားသော နေရာများတွင် တည်ရှိသည်။ လူမှုရေးနှင့် ယုံကြည်သက်ဝင်မှုဆိုင်ရာ အရေးပါသည့် ဘာသာရေးနှင့်ဆိုင်သောနေရာများစွာရှိပြီး ထိုနေရာများကို ဒေသခံလူထုများက တန်ဖိုးထားကြသည်။

လူမှုစီးပွားရေးပတ်ဝန်းကျင်အခြေအနေ

ဘော်တွင်းကျေးရွာအုပ်စုတစ်ကြောတွင် လူဦးရေ ၃,၄၉၉ ဦးရှိပြီး ဘော်တွင်းအထက်ပိုင်းနှင့် အောက်ပိုင်းကျေးရွာများ၊ ကျားစခန်းတို့ ပါဝင်သည်။ ဘော်တွင်းကျေးရွာတစ်ခုစီတွင် ရပ်ကွက်လေးခုနှင့် ကျားစခန်းတွင် ရပ်ကွက်နှစ်ပါဝင်ပြီး စုစုပေါင်းလူဦးရေ ၃,၄၉၉ ဦးရှိပါသည်။ နမ္မတူမြို့တွင် ပန်ဟိုက်ရပ်ကွက်၊ ဟာလင်ကျေးရွာနှင့် ရပ်ကွက် (၇) ခုဖြင့် ဖွဲ့စည်းထားသော သတလရပ်ကွက်တို့ ဖွဲ့စည်းပါဝင်ပြီး ဘော်တွင်းရှိ မိုင်းတူးဖော်ရေးလုပ်ငန်းများတွင် လုပ်ကိုင်နေကြသူများ အခြေကျနေထိုင်ရန်အတွက် တည်ဆောက်ခဲ့ခြင်းဖြစ်သည်။ သတလရပ်ကွက်နှင့် ဟာလင်ကျေးရွာတွင် လူဦးရေ ၅,၆၉၉ ဦးရှိသည်။ ဘောတွင်းသတ္တုတွင်းလည်ပတ်မှုအခြေအနေသည် ဘော်တွင်းဒေသ၏ ဖွဲ့စည်းတည်ဆောက်ပုံ အနေအထား (ဥပမာ - မြေယာပိုင်ဆိုင်ခွင့်သက်တမ်း၊ အိမ်ပိုင်ဆိုင်ခွင့် စသည်) အပေါ်ကို ကြီးမားစွာ သက်ရောက်မှု ရှိပါသည်။

မိုင်းတွင်းတူးဖော်ရေးလုပ်ငန်းသည် ဘော်တွင်းနှင့် နမ္မတူလေ့လာမှုဒေသအတွင်းရှိ ပြည်သူများ အတွက် အလုပ်အကိုင်နှင့် ဝင်ငွေအဓိကရရှိနိုင်သော ရင်းမြစ်ဖြစ်ပြီး အစိုးရ ထောက်ပံ့ ပေးထားသော အိမ်ရာများအတွက်လည်း အခွင့်အလမ်းများ ဖန်တီးပေးနိုင်သောကြောင့် အသက်မွေးဝမ်းကျောင်း လုပ်ငန်းအတွက် အလွန်အရေးပါသည်။ နမ္မတူမြို့တွင် အစားထိုးရွေးချယ်စရာ အလုပ်အကိုင်နှင့် ဝင်ငွေ အခွင့်အလမ်းများ ပိုမိုရရှိနိုင်ပါသည်။ ဟူးဆာ၊ ဟင်ပုတ်နှင့် ကြူဆော့ကျေးရွာ အုပ်စုများ အပါအဝင် အနီးပတ်ဝန်းကျင်ရှိ ကျေးရွာအုပ်စုများသည် စိုက်ပျိုးရေးကို အဓိကထားလုပ်ကိုင်ကြပြီး ဘော်တွင်းနှင့် စီးပွားရေး ချိတ်ဆက်လုပ်ကိုင်မှု နည်းပါးသည်။ နမ့်ပန်ကျွန်းချိုင့်ဝှမ်းတွင် နေထိုင်ကြ သူများသည် ဝင်ငွေရရှိရေးနှင့် အသက်မွေးဝမ်းကျောင်းပြုရန်အတွက် အသေးစားလက်မှုမိုင်းတူး ဖော်ရေးလုပ်ငန်း ကို အားထားလုပ်ကိုင်ကြသည်။

ဘော်တွင်းဒေသတွင် စာသင်ကျောင်း (၉) ကျောင်းရှိနှင့် နမ္မတူတွင် ကျောင်း ၉ ကျောင်းနှင့် နမ္မတူတွင် စာသင်ကျောင်း (၁၁) ကျောင်းရှိပြီး စစ်တမ်းကောက်ယူမှုရလဒ်များအရ ဘော်တွင်းနှင့် နမ္မတူဒေသရှိ ပညာရေးအဆင့်သည် ရှမ်းပြည်နယ်၏ ပျမ်းမျှပညာရေးအဆင့်ထက် မြင့်မားနေကြောင်း တွေ့ရသည်။ ရှမ်းပြည်နယ်တွင် ၄၅ ရာခိုင်နှုန်းနှင့် ဆန့်ကျင်ဘက်ဖြစ်စွာ ဘော်တွင်းနှင့်နမ္မတူတွင် စစ်တမ်းကောက်ယူခဲ့သော ရပ်ရွာလူထု၏ ၈ ရာခိုင်နှုန်းအောက်သာ ပညာရေးမပြီးဆုံးကြသူများ

ဖြစ်ကြသည်။ ဘော်တွင်းနှင့် နမ္မတူလေ့လာမှုဒေသအတွင်းရှိ ရပ်ရွာလူထုအများစုမှာ ဗမာလူမျိုးများဖြစ်ပြီး ဗုဒ္ဓဘာသာကို ကိုးကွယ်ကြသည်။ ဘော်တွင်းဒေသတွင် သာသနာရေးရာ အဆောက်အအုံ (၁၂) ခု နှင့် နမ္မတူတွင် (၁၁) ခုရှိပြီး အချို့မှာ အနီးအနားရှိ ဟူးဆာ၊ ဟင်ပုတ်၊ ကြူဆော့ကျေးရွာတစ်ကြောတွင် ဘာသာရေးဆိုင်ရာကိစ္စများကို ဆောင်ရွက်ပေးသည်။

ဘော်တွင်းနှင့် နမ္မတူလေ့လာမှုဒေသအတွင်းရှိ အိမ်အများစုသည် အခြေခံလူတန်းစားများဖြစ်သည်။ ဘော်တွင်းနှင့် နမ္မတူလေ့လာမှုဒေသအတွင်းရှိ အိမ်ထောင်စုအများစုသည် ရေဖြန့်ဖြူးရေးစံနစ်များကို အဆင်သင့်အသုံးပြုနိုင်ကြသည်။ ဘော်တွင်းနှင့် နမ္မတူရှိ အိမ်ထောင်စုအများစုသည် ရေကို သန့်စင်ပြီးမှ အသုံးပြုကြပြီး မိုးရာသီတွင် ရေရယူသုံးစွဲနေသော ချောင်းများတွင် ရေနောက်ကျိ ညစ်ညမ်းမှုကြောင့် အခြားအရင်းအမြစ်များကို အစားထိုးအသုံးပြုနိုင်ပါသည်။ နမ္မတူမြို့ရှိ အိမ်များသည် အများအားဖြင့် ဘော်တွင်းရှိ အိမ်များထက် အိမ်ကြီးအိမ်ကောင်း ပိုများပြီး ကိုယ်ပိုင် အိမ်သာများကို အသုံးပြုကြသည်။ ဘော်တွင်းရှိ အိမ်သာများသည် အများသူငှာ (အများပြည်သူ) မျှဝေ သုံးစွဲကြပြီး ဒေသန္တရမြစ်များ သို့မဟုတ် ချောင်းများအတွင်းသို့ စွန့်ပစ်ကြသည်။ ဘော်တွင်းနှင့် နမ္မတူတို့တွင် အမှိုက်/စွန့်ပစ်ပစ္စည်း စီမံခန့်ခွဲမှု အထောက်အပံ့များ လိုအပ်နေပြီး လူဦးရေ အများစုမှာ အမှိုက်များကို အထိန်းအကွပ်မရှိ စွန့်ပစ်ခြင်းနှင့် မီးရှို့ခြင်းများ ပြုလုပ်ကြသည်။ ဘော်တွင်းနှင့် နမ္မတူတို့တွင် ပို့ဆောင်ဆက်သွယ်ရေးသည် ပုံမှန်အားဖြင့် ဆိုင်ကယ်ဖြင့် သွားလာခြင်းနှင့် လမ်းလျှောက်ခြင်းများဖြစ်ကြပြီး လမ်းကျဉ်းများကို ယာဉ်များနှင့် လမ်းသွားလမ်းလာများသည် မျှဝေအသုံးပြုကြသည်။

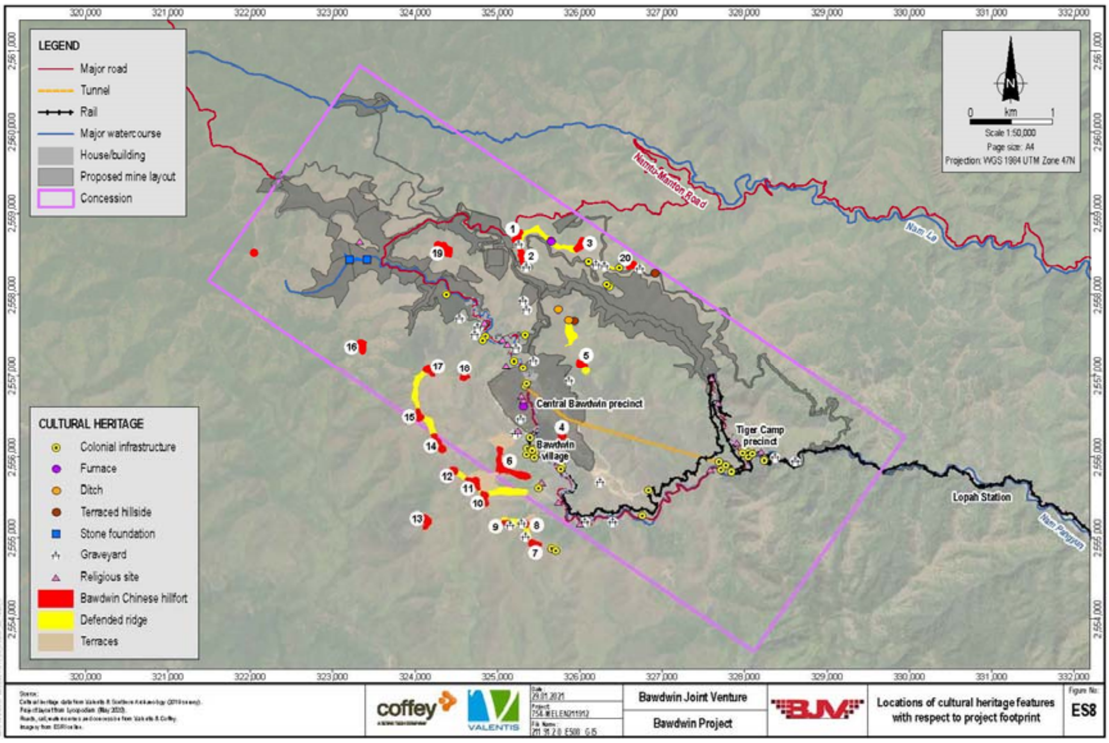


Figure ES.8 Locations of cultural heritage features with respect to project footprint

ကျေးလက်ကျန်းမာရေးစောင့်ရှောက်မှုအခြေအနေ

ဘော်တွင်းနှင့် နမ္မတူဒေသများတွင် အစိုးရဆေးရုံငယ်တစ်ခုနှင့် ဝင်းမြင့်မိုရ် ကုမ္ပဏီမှ ဘော်တွင်းသတ္တုတွင်းရှိ ဝန်ထမ်းများအတွက် ဖွင့်လှစ်ပေးထားသော ပုဂ္ဂလိကဆေးခန်းတစ်ခု၊ ကျားစခန်းရှိ ကျန်းမာရေးစောင့်ရှောက်မှုဌာနခွဲနှင့် နမ္မတူဆေးရုံ စသည့် ကျန်းမာရေးစောင့်ရှောက်မှု ဌာနများ ရှိပါသည်။ လားရှိုးအထွေထွေရောဂါကုဆေးရုံကြီးသည် ဘော်တွင်းမြို့မှ ကီလိုမီတာ ၅၀ ခန့်အကွာတွင် တည်ရှိပြီး ၎င်းဆေးရုံသည် ကျန်းမာရေးဆိုင်ရာ ကုသမှုမျိုးစုံကို ဝန်ဆောင်မှု ပေးနိုင်သည့် ဒေသအတွင်းရှိ တစ်ခုတည်းသော အဆင့်မြင့်ပြည်သူ့ဆေးရုံ ဖြစ်သည်။ ကျန်းမာရေး ဆိုင်ရာ ဝန်ဆောင်မှုများနှင့် ဆရာဝန်များထံမှ သွားရောက်ကုသမှုခံယူရန် အတိုင်းအတာတစ်ခုအထိ အခက်အခဲရှိသော်လည်း၊ ကျန်းမာရေးဆိုင်ရာ ပြုစုထားသော စစ်တမ်းအရ ဖြေဆိုသူအများစုမှာ ကျန်းမာရေးကောင်းမွန်ကြကြောင်း ဖြေဆိုထားသည်ကို ဖော်ပြထားသည်။ ခြုံငုံကြည့်ရလျှင် ဘော်တွင်းနှင့် နမ္မတူ မြို့နယ်လူဦးရေသည် နာတာရှည်ရောဂါ၊ ကူးစက်ရောဂါနှင့် သွေးလွန်တုပ်ကွေးရောဂါ ဖြစ်ပွားမှု အရေအတွက်နည်းပါးသဖြင့် ကျန်းမာရေး ကောင်းမွန်ကြသည်ဟု ထင်ရပါသည်။

ဘော်တွင်းနှင့် နမ္မတူဒေသအတွင်း သတ္တုတူးဖော်မှုနှင့် ဆိုးရွားသော စွန့်ပစ်ပစ္စည်းများ စီမံခန့်ခွဲမှု အလေ့အထ၏ ရလဒ်များကြောင့် လေ့လာမှုဧရိယာအတွင်း အန္တရာယ်ရှိသော သဘာဝ ပတ်ဝန်းကျင်နှင့် ကျန်းမာရေးဆိုင်ရာ ထိတွေ့မှုများစွာရှိပါသည်။ ၎င်းတို့သည် ဖုန်မှုန့်များ၊ သတ္တုများ (အဓိကအားဖြင့် ခဲ) နှင့် ဘက်တီးရီးယားများ (***E. coli)*** တို့နှင့် ထိတွေ့ခြင်း၊ ရှူသွင်းခြင်း၊ စားးသုံးမိခြင်း သို့မဟုတ် အရေပြားနှင့် ထိတွေ့မိခြင်းတို့နှင့် အဓိကသက်ဆိုင်ပါသည်။ ဘော်တွင်း ဒေသခံ ပြည်သူများသည် ပမာဏမြင့်မားသော ခဲ နှင့် အခြားသတ္တုများကို ကြားခံနယ်မှ တစ်ဆင့် ထိတွေ့နိုင်ခြေရှိကြောင်းကို ဘော်တွင်းဒေသ ဧရိယာအတွင်း ခဲပမာဏ တိုင်းတာမှုရလဒ်မှ ညွှန်ပြနေ ပါသည်။ ၎င်းထိတွေ့မှုများသည် လေ့လာမှုဧရိယာအတွင်းရှိ ဒေသခံများအတွက် ဆိုးရွားသော ကျန်းမာရေးအန္တရာယ်ဖြစ်စေနိုင်မှုမှာ သိသာထင်ရှားသော အလားအလာရှိနေပါသည်။

သီးခြား ပတ်ဝန်းကျင်ထိခိုက်မှု ဆန်းစစ်ခြင်း နှင့် ကျန်းမာရေးဆိုင်ရာ ဆန်းစစ်မှုများအတွက် ဝင်းမြင့်မိုရ် ကုမ္ပဏီသည် ၂၀၂၀ ခုနှစ် ဧပြီလ မှ ဇွန်လအတွင်း ဘော်တွင်း သတ္တုမိုင်းရှိ လက်ရှိအလုပ်သမားများ၏ သွေးတွင်းခဲပမာဏကို တိုင်းတာပြီး လုပ်ငန်းခွင် ကျန်းမာရေး စစ်ဆေးမှုများ ဆောင်ရွက်ခဲ့ပါသည်။ ဒေသခံ အလုပ်သမားများနှင့် ဒေသအတွင်း နေထိုင်မှုမရှိသော်လည်း လုပ်ငန်းအရ စာချုပ်ချုပ်ဆိုထားသည့် ဝန်ထမ်းများ အတွက် ကျန်းမာရေးဆိုင်ရာ ဆန်းစစ်ဆောင်ရွက်မှုများ ပြီးမြောက်ခဲ့ပြီးဖြစ်သည်။ အမြဲတမ်း အလုပ်သမား အားလုံးတွင် သွေးတွင်း ခဲပါဝင်မှု ပမာဏမှာ ၁၀ µg/dL အထက်ရှိကြပြီး လုပ်ငန်းအရ စာချုပ်ချုပ်ဆိုထားသည့်အလုပ်သမားများ၏ ၄၈ % နှင့် နှိုင်းယှဉ်ပါက ဆိုးကျိုးများရှိနိုင်မည်ဟု ထင်ရပါသည်။ အမြဲတမ်းအလုပ်သမားများ၏ ၆၅% ကျော်သည် ၄၀ µg/dL ထက်မြင့်သော သွေးတွင်းခဲပါဝင်မှု ပမာဏရှိကြောင်း တိုင်းတာရရှိပြီး ၁၈% ကျော်သည် ၆၅ µg/dL တိုင်းတာရရှိပါသည်။ ၆၅ µg/dLသည် Lead Care 11 ကိရိယာဖြင့် တိုင်းတာနိုင်သော

အမြင့်ဆုံးအဆင့်ဖြစ်သောကြောင့် အချို့သော အလုပ်သမားများတွင် ၎င်းပမာဏထက် ကျော်လွန်သော သွေးတွင်းခဲပါဝင်မှု ပမာဏ အဆင့်များ ရှိနိုင်ပါသည်။

သက်ရောက်မှုများကို ဆန်းစစ်များ

သက်ရောက်မှုများကို ဆန်းစစ်ရန် ချဉ်းကပ်ခြင်း

ပတ်ဝန်းကျင်ထိခိုက်မှု ဆန်းစစ်ခြင်းတွင် အသုံးပြုသည့် သက်ရောက်မှု ဆန်းစစ်သည့်နည်းလမ်းမှာ "သိသာထင်ရှားမှုကို ဆန်းစစ်ခြင်း" ဖြစ်သည်။ စီမံကိန်း၏ ဆက်စပ်လုပ်ဆောင်ချက်များကြောင့် ဖြစ်ပေါ်လာမည့် ပြင်းအားပမာဏ၊ ကြာချိန် ပေါ်မူတည်၍ သိသာထင်ရှားမှုရှိနိုင်သော သက်ရောက်မှုများကို အကဲဖြတ်ဆန်းစစ်ခြင်းသည် အခြေခံကျသော နည်းလမ်းတစ်ခုဖြစ်သည်။ ဖွံ့ဖြိုးတိုးတက်ရေး စီမံကိန်းများအတွက် ဤမူဘောင်သည် လက်ရှိနိုင်ငံတကာ သဘာဝ ပတ်ဝန်းကျင်နှင့် လူမှုရေးဆိုင်ရာ သက်ရောက်မှု ဆန်းစစ်ခြင်းများနှင့် လိုက်လျောညီထွေမှုရှိပြီး မြန်မာနိုင်ငံရှိ သတ္တုတူးဖော်ရေး ကဏ္ဍအတွက် သဘာဝပတ်ဝန်းကျင် ထိခိုက်မှု ဆန်းစစ်ခြင်း လမ်းညွှန်ချက်များတွင် ဖော်ပြထားသည်များကို ပေါ်လွင်စေပါသည်။ အလားအလာရှိသော သက်ရောက်မှုများကို ဆန်းစစ်ခြင်းသည် ကျွမ်းကျင်မှုဆိုင်ရာ အကဲဖြတ်ခြင်း၊ ကွင်းဆင်းလေ့လာ၍ ကောက်ယူစုဆောင်းထားသော အချက်အလက်များ၊ အလားတူပတ်ဝန်းကျင်ရှိ အခြားသော သတ္တုတူးဖော်ရေး စီမံကိန်းများမှ ရရှိထားသော အတွေ့အကြုံများ၊ စီမံကိန်း ပါဝင်ပတ်သက်သူများမှ တုံ့ပြန်ချက်များ၊ သိပ္ပံစာပေများမှ နည်းပညာဆိုင်ရာ အကဲဖြတ်မှု အပေါ် အခြေခံပါသည်။ ပတ်ဝန်းကျင်ထိခိုက်မှု ဆန်းစစ်ခြင်းသည် ကျိုးကြောင်းဆီလျော်မှု၊ မျှတမှုနှင့် အကဲဖြတ် ဆန်းစစ်ခြင်း၏ ကန့်သတ်ချက်များနှင့် မသေချာမှုများကို ဖော်ပြပါသည်။ သက်ရောက်မှုများ၏ သိသာထင်ရှားမှုကို ဆန်းစစ်ရာတွင် အောက်ပါအချက်များပါဝင်သည်။

- စီမံကိန်းကြောင့် ထိခိုက်နိုင်သော သဘာဝပတ်ဝန်းကျင်နှင့် လူမှုရေး (သို့မဟုတ်) လက်ခံသူများ၏ ထိခိုက်လွယ်နိုင်မှုကို ထည့်သွင်းစဉ်းစားခြင်း၊ ထိခိုက်လွယ်နိုင်မှုကို လက်ခံသူများ၏ အရေးပါမှု၊ ပြောင်းလဲနိုင်ရန်အတွက် ၎င်းတို့၏ အားနည်းချက် နှင့် ပြန်လည်သန်စွမ်းနိုင်မှုတို့ကို ဆန်းစစ်ခြင်းဟု အဓိပ္ပာယ်ဖွင့်ဆိုထားပါသည်။
- စီမံကိန်း၏ လုပ်ငန်းအဆင့်များအားလုံးနှင့် ဆက်စပ်သော သက်ရောက်မှုများကို ထည့်သွင်းစဉ်းစားခြင်း၊ ၎င်းသက်ရောက်မှုများကို ဖော်ပြပေးနိုင်မည့် နည်းလမ်းများ နှင့် လက်ရှိအခြေအနေများအရ သက်ရောက်နိုင်မှုများ
- သက်ရောက်မှုများကို လျော့ချနိုင်မည့်နည်းလမ်းများနှင့် စီမံကိန်းအခြေအနေအတွင်း နည်းပညာနှင့် စီးပွားရေးအရ ဖြစ်နိုင်ခြေရှိသော ဝင်းမြင့်မိုရ်၏ ကတိကဝတ်များကို ပေါ်လွင်စေမည့် စီမံခန့်ခွဲမှု အစီအစဉ်များကို ဆောင်ရွက်ခြင်း

- စီမံကိန်းလုပ်ဆောင်ချက်များကြောင့် သဘာဝပတ်ဝန်းကျင်နှင့် လူမှုဝန်းကျင်အပေါ် သက်ရောက်နိုင်မည့် ပြင်းအားပမာဏအား ဆန်းစစ်ပြီးနောက် အဆိုပြုထားသော သက်ရောက်မည့် လျော့နည်းစေမည့် အစီအစဉ်ကို အကောင်အထည်ဖော်ဆောင်ရွက်ခြင်း။
- ကြွင်းကျန်သက်ရောက်မှုများ၏ သိသာထင်ရှားမှုကို ဆန်းစစ်ခြင်း။ ကြွင်းကျန်သက်ရောက်မှု ဆိုသည်မှာ သက်ရောက်မှုများကို လျော့နည်းစေမည့် အစီအစဉ်များကို အကောင်အထည်ဖော် ဆောင်ရွက်ပြီးနောက် ဖြစ်ပေါ်လာနိုင်အုံးမည့် သက်ရောက်မှုများဖြစ်သည်။

သက်ရောက်မှုတွင် ကောင်းကျိုးသက်ရောက်မှုနှင့် ဆိုးကျိုးသက်ရောက်မှု ဟူ၍ ဖြစ်နိုင်ပါသည်။ သက်ရောက်မှုပြင်းအား (အလွန်နည်း၊ နည်း၊ အလယ်အလတ်၊ မြင့် (သို့မဟုတ်) အလွန်မြင့်မား) ကို အောက်ပါရှုထောင့်များအပေါ် မူတည်၍ ပြောင်းလဲမှုပမာဏ နှင့် အမျိုးအစားကို ထည့်သွင်းစဉ်းစားရမည်ဖြစ်သည်။

- သက်ရောက်မှု အတိုင်းအတာ
- သက်ရောက်မှု ပမာဏ (သက်ရောက်မှု၏ ရလဒ်အရ တည်ဆဲအခြေအနေများမှ ပြောင်းလဲမှုသွားနိုင်မှုပမာဏ သို့မဟုတ် သက်ရောက်မှု၏ ပြင်းအား)
- သက်ရောက်မှု ဖြစ်ပွားနိုင်မည့် အချိန်အတိုင်းအတာ (သို့မဟုတ်) ကြိမ်နှုန်း (သက်ရောက်မှု၏ ကြာချိန်နှင့် ကြိမ်နှုန်းကို ဆိုလိုသည်။ တစ်နည်းအားဖြင့် ယာယီသက်ရောက်မှုကို ရေတို (သို့မဟုတ်) ရေရှည် ဖြစ်သည်။)

ကြွင်းကျန်သက်ရောက်မှု၏ သိသာထင်ရှားမှု (အလွန်နည်း၊ နည်း၊ အလယ်အလတ်၊ မြင့် (သို့မဟုတ်) အလွန်မြင့်မား) ကို သက်ရောက်မှု ရှုထောင့်အမျိုးမျိုး၏ ပြင်းအား၊ ကြာချိန် နှင့် အတိုင်းအတာ တို့၏ ပေါင်းခြင်းကို ဖြစ်နိုင်ခြေ နှင့် မြှောက်ခြင်း ဖြစ်သည့် matric approach နည်းလမ်းအသုံးပြု၍ အဆင့်သတ်မှတ်ပါသည်။ ကြွင်းကျန်သက်ရောက်မှုများ၏ သိသာထင်ရှားမှုကို ဇယား ၆.၁ တွင်ဖော်ပြထားပါသည်။

ဇယား ၆.၁ ကြွင်းကျန်သက်ရောက်မှုများ၏ သိသာထင်ရှားမှု Matrix

သက်ရောက်မှုပြင်းအား		Sensitivity of Receptor				
		အလွန်နည်း	**နည်း**	**အလယ်အလတ်**	**မြင့်**	**အလွန်မြင့်**
ကောင်းကျိုး	**အလွန်မြင့်**	အလယ်အလတ်	မြင့်	အလွန်မြင့်	အလွန်မြင့်	အလွန်မြင့်
	မြင့်	နည်း	အလယ်အလတ်	မြင့်	အလွန်မြင့်	အလွန်မြင့်
	အလယ်အလတ်	နည်း	နည်း	အလယ်အလတ်	မြင့်	မြင့်

သက်ရောက်မှုပြင်းအား		Sensitivity of Receptor				
		အလွန်နည်း	**နည်း**	**အလယ်အလတ်**	**မြင့်**	**အလွန်မြင့်**
	နည်း	အလွန်နည်း	နည်း	နည်း	အလယ်အလတ်	အလယ်အလတ်
	အလွန်နည်း	အလွန်နည်း	အလွန်နည်း	အလွန်နည်း	နည်း	အလယ်အလတ်
ဆိုးကျိုး	**အလွန်နည်း**	အလွန်နည်း	အလွန်နည်း	အလွန်နည်း	နည်း	အလယ်အလတ်
	နည်း	အလွန်နည်း	နည်း	နည်း	အလယ်အလတ်	အလယ်အလတ်
	အလယ်အလတ်	နည်း	နည်း	အလယ်အလတ်	မြင့်	မြင့်
	မြင့်	နည်း	အလယ်အလတ်	မြင့်	အလွန်မြင့်	အလွန်မြင့်
	အလွန်မြင့်	အလယ်အလတ်	မြင့်	အလွန်မြင့်	အလွန်မြင့်	အလွန်မြင့်

သက်ရောက်မှု တစ်ခုချင်းစီအတွက် သိသာထင်ရှားမှု အကဲဖြတ်ခြင်းနှင့် ဆက်စပ်၍ မသေချာမှုကို မှတ်သားထားသည်။ မသေချာမှုအတိုင်းအတာသည် ရရှိနိုင်သော သတင်းအချက်အလက်များ၊ ယူဆချက်အဆင့်၊ ခန့်မှန်းချက်၏ သေချာမှုနှင့် သိသာထင်ရှားသော အဆင့်သတ်မှတ်ခြင်းတွင် ထည့်သွင်းမှုတို့၏ ယုံကြည့်ချက်များနှင့် သက်ဆိုင်သည်။

အကျိုးကျေးဇူးများ

ဘော်တွင်းသတ္တုတူးဖော်ရေး စီမံကိန်း၏ အကျိုးကျေးဇူးများမှာ အလုပ်အကိုင်အခွင့်အလမ်းများ၊ ဝန်ထမ်းများ၏ ကျွမ်းကျင်မှုဆိုင်ရာ အလေ့အကျင့်များ ကောင်းမွန်စေခြင်း၊ စီမံကိန်းအတွက် ကုန်စည်နှင့် ဝန်ဆောင်မှုများ ထောက်ပံ့ပေးရန် အခွင့်အလမ်းများ၊ ဒေသဝန်းကျင်၌ စီးပွားရေးလုပ်ဆောင်ချက်များကို ဖြန့်ကြဲပေးခြင်း၊ သဘာဝပတ်ဝန်းကျင်ဆိုင်ရာ ဘေးအန္တရာယ်များနှင့် ထိတွေ့မှုကို လျှော့ချခြင်း၊ ဘော်တွင်းဒေသ ပြန်လည်နေရာချထားပေးသော လူမှုအသိုင်းအဝိုင်းများအတွက် လူနေမှုဘဝကို မြှင့်တင်ပေးခြင်းတို့ ဖြစ်ပါသည်။
စီမံကိန်းသည် မြန်မာ့စီးပွားရေးကို နည်းလမ်းများစွာဖြင့် အကျိုးပြုပါသည်။ ၎င်းတို့မှာ -

- မြန်မာနိုင်ငံမှ royalties and dead rent အပါအဝင် တိုက်ရိုက်ဝင်ငွေရရှိခြင်း (တရားသေငှားငွေဆိုသည်မှာ ငှားရမ်းခြင်း ပြုသူမှ ငှားရမ်းသူပိုင်ရှင်ထံ အမြတ်ရသည် ဖြစ်စေ မရသည် ဖြစ်စေ ပေးရသည့် ငွေ)
- ဝင်းမြင့်မိုရ်ကုမ္ပဏီမှ ပြည်ထောင်စုသမ္မတ မြန်မာနိုင်ငံတော်သို့ ပေးဆောင်ရသော ကုမ္ပဏီ ဝင်ငွေခွန်
- ကုန်သွယ်လုပ်ငန်းအခွန် အပါအဝင် ပြည်ထောင်စုသမ္မတ မြန်မာနိုင်ငံတော်သို့ ပေးဆောင်ရသော သွယ်ဝိုက်အခွန်၊ ၊ withholding tax၊ အကောက်ခွန်နှင့် ကိုယ်ပိုင်ဝင်ငွေခွန်
- ပြင်ဆင်ထားသည့် Production Sharing Contract သို့မဟုတ် သဘောတူညီချက်အရ ရရှိမည့် နောက်ထပ်အကျိုးအမြတ်ခွဲဝေမှု
- နိုင်ငံတော်တွင်းထွက်ကုန် တင်ပို့မှုဝင်ငွေ၊ စုစုပေါင်း ပို့ကုန်ဝင်ငွေ နှင့် ပြည်တွင်း အသားတင်ထုတ်ကုန်အတွက် ပံ့ပိုးမှုများ၊

စီမံကိန်းသည် ကုန်စည်နှင့် ပစ္စည်းများ ဝယ်ယူရေးနှင် အလုပ်အကိုင်အခွင့်အလမ်းများနှင့် ဆက်စပ်နေသော ဒေသတွင်း စီးပွားရေးလှုံ့ဆော်မှုများကို ဖြစ်ပေါ်စေနိုင်ပါသည်။ ဒေသတွင်း ဆောင်ရွက်ဆဲနှင့် အသစ်သစ်သော စီးပွားရေးလုပ်ငန်းများသည် ဒေသတွင်း ကုန်စည်နှင့် ဝန်ဆောင်မှုများအတွက် ဦးစားပေးဝယ်ယူရေး မူဝါဒများမှတစ်ဆင့် ပံ့ပိုးပေးမည်ဖြစ်သည်။ အခြားသော ကုန်စည်နှင့် ပစ္စည်းများကို ရှမ်းပြည်နယ်အတွင်းမှ သာမက မြန်မာနိုင်ငံရှိ နေရာအသီးသီးမှ ဝယ်ယူသွားမည်ဖြစ်သည်။ ဤလုပ်ဆောင်ချက်များသည် ရေရှည်တည်တံ့ ခိုင်မြဲသော ဒေသစီးပွားရေးလုပ်ငန်းများ ထူထောင်ရာတွင် လက်တွေ့အသုံးချနိုင်ရန် ရည်ရွယ် ပါသည်။ ထို့အပြင် ဝင်းမြင့်မိုရ် ကုမ္ပဏီမှ အခြေခံအဆောက်အအုံများ၊ ဒေသတွင်းစီးပွားရေးနှင် အသက်မွေးဝမ်းကြောင်းဆိုင်ရာ ဖွံ့ဖြိုးတိုးတက်မှု ပါဝင်သော မဟာဗျူဟာမြောက် ရပ်ရွာအဆင့် ရင်းနှီးမြှုပ်နှံမှုများ ဆောင်ရွက်ရန်ရှိပါသည်။

စီမံကိန်းအတွက် ဆောက်လုပ်ရေးကာလအတွင်း လုပ်သားအင်အားမှာ လူဦးရေ၂၈၅ဦး ဖြစ်ပြီး လုပ်ငန်းလည်ပတ်သည့်ကာလအတွက်မူ လုပ်သားအင်အားမှာ ၁၁၁၅ဦးဖြစ်ပါသည်။ ဝင်းမြင့်မိုရ်ကုမ္ပဏီသည် အလုပ်အကိုင်ဦးစားပေး မူဝါဒဖြင့် ဒေသခံပြည်သူလူထုများပါဝင်မှု အချိုးအစားကို မြှင့်တင်ရန် ဆောင်ရွက်သွားမည်ဖြစ်သည်။ စီမံကိန်းသည် ဒေသအတွင်း မြန်မာအလုပ်သမားများ၏ အလုပ်အကိုင်အခွင့်အလမ်း၊ ကျွမ်းကျင်မှုဆိုင်ရာ သင်တန်းများကို ပံ့ပိုးပေးသွားမည်ဖြစ်ပြီး စီးပွားရေးကို အကျိုးပြု၍ အလုပ်သမားများကို ဝင်ငွေရရှိစေပါသည်။

သဘာဝပတ်ဝန်းကျင်ဆိုင်ရာ ကိစ္စရပ်များကြောင့် သက်ရောက်မှု နည်းပါးသော နေရာများသို့ လက်ရှိ ထိခိုက်နေသော ဒေသများမှ ရပ်ရွာများကို ပြန်လည်နေရာချထားပေးခြင်းဖြင့် စီမံကိန်းမှ ဘော်တွင်း ဒေသအတွင်း ရပ်ရွာကျန်းမာရေး မြှင့်တင်နိုင်ရန်အတွက် အခွင့်အလမ်းတစ်ခုဖြစ်သည်။ ပြန်လည် နေရာချထားပြီးသည့်နောက် သဘာဝပတ်ဝန်းကျင်ဆိုင်ရာ အန္တရာယ်များနှင့် ထိတွေ့ နိုင်မှုကို

လျော့ချခြင်းသည် ဘော်တွင်းဒေသအတွင်း ရပ်ရွာပြည်သူများ၏ ကျန်းမာရေး အတွက် အဓိကအရေးပါသော ကောင်းကျိုးသက်ရောက်မှုတစ်ခု ဖြစ်လာနိုင်မည်ဟု ခန့်မှန်းရပါသည်။ ပြန်လည်နေရာချထားရေးသည် နမ္မတူဒေသအတွင်း အလုပ်အကိုင် အခွင့်အလမ်းများ တိုးတက်စေခြင်းအပြင် မရှိမဖြစ်လိုအပ်သော ဝန်ဆောင်မှုများနှင့် အရင်းအမြစ်များ (သန့်ရှင်းသောရေ၊ လျှပ်စစ်မီး၊ သန့်စင်ခန်း) နှင့် အိမ်ရာအခြေအနေများ တိုးတက်စေခြင်း စသည့် အကျိုးကျေးဇူးများကို ပေးနိုင်ပါသည်။

ကြိုတင်ခန့်မှန်းထားသောသက်ရောက်မှုများ

ဘော်တွင်းသတ္တုတူးဖော်ရေး စီမံကိန်း၏ သဘာဝပတ်ဝန်းကျင်နှင့်လူမှုဝန်းကျင်တို့ဆိုင်ရာ အဓိက သက်ရောက်မှုများ၏ အကျဉ်းချုပ်ကို အောက်ပါအတိုင်း ဖော်ပြထားပါသည်။

မြေဆီလွှာပုံပန်းသွင်ပြင်နှင့် ၎င်းအပေါ်သက်ရောက်မှုများ

စီမံကိန်းတည်ဆောက်ခြင်းနှင့် လုပ်ငန်းလည်ပတ်ခြင်းကြောင့် ဘော်တွင်းဒေသအတွင်း မြေသားများ မိုင်းတွင်းမှ စွန့်ပစ်ပစ္စည်းများနှင့် မြေဆီလွှာပမာဏ ရွေ့လျားမှုဆိုင်ရာ သိသာထင်ရှားစွာ ပြောင်းလဲမှု ဖြစ်လာမည်ဖြစ်သည်။

TSFs နှင့် Wallah မှ ထွက်ရှိလာသော စွန့်ပစ်ကျောက်အစုအပုံနှင့် အပွင့်အတိုင်း ထားထားသည့် ကျင်းတို့သည် ကြီးမားသော အမြဲတစ်စေ မြေသားပုံစံ အသွင်အပြင်များကို ကိုယ်စားပြုသည်။ TSFs နှင့် Wallah မှ ထွက်ရှိလာသော ကျောက်အစုအပုံ တို့ကို ရေရှည်တည့်တံ့နိုင်ရန်ရည်ရွယ်ပြီး ဒီဇိုင်းဆွဲကာ မြေတိုက်စားမှုကို လျှော့ချပေးစေနိုင်ပါသည်။ တည်ရှိပြီးသော ကျင်းကို တိုးချဲ့ပြီး လုပ်ငန်းပိတ်သိမ်းပြီးနောက် ရေကန်ဖြစ်လာမည်ဖြစ်သည်။ မြေပုံသဏ္ဍာန်ပြောင်းလဲမှုများကို ပုံ ES.9 တွင် ဖော်ပြထားပါသည်။

မြေဆီလွှာတူးဖော်ခြင်း၊ သိုလှောင်ခြင်းနှင့် ကိုင်တွယ်ခြင်းကိစ္စရပ်များတွင် ရာသီဥတုဒဏ်ခံနိုင်သည့် မြေဆီလွှာများကို ဖုံးအုပ်ခြင်း၊ မြေဆီလွှာနှင့် မြေအောက်သွင်ပြင်ကို မှန်ကန်စွာ ခွဲခြားသတ်မှတ်ခြင်း နှင့် မြေမျက်နှာပြင်ကျုံ့ခြင်းတို့ကို လျှော့ချခြင်းများပါဝင်မည်ဖြစ်သည်။ ဆောက်လုပ်ရေး ကာလ အတွင်း အရေးပါသည်မှာ မြေဆီလွှာပုံသွင်းခြင်းကို ကန့်သတ်ခြင်း၊ ကောင်းမွန်သော မြေဆီလွှာ ပြန်လည်ထူထောင်ခြင်းနှင့် အပင်များကောင်းမွန်စွာ ပြန်လည်ရှင်သန်ရေးနှင့် မြေဆီလွှာ တည်ငြိမ်မှုကို မြှင့်တင်ပေးနိုင်ခြင်းတို့ဖြစ်သည်။

ညစ်ညမ်းသော မြေဆီလွှာများရောနှောနေခြင်းကို လျှော့ချနိုင်ရန် အဓိကဆောင်ရွက်ရမည့် အချက်များမှာ ညစ်ညမ်းနေသော မြေဧရိယာများကို ခွဲခြားခြင်း၊ ပြန်လည်ပြုပြင်နိုင်ရန်အတွက် ၎င်းညစ်ညမ်းနေသည့် မြေများကို အသုံးပြုခြင်းမှ ရှောင်ကြဉ်ခြင်း၊ မြေဆီလွှာအောက်ခြေဇုန်ရှိ ညစ်ညမ်းသော မြေဆီလွှာတွင် ပိုမိုနက်ရှိုင်းစွာ မြှုပ်နှံခြင်းနှင့် ညစ်ညမ်းသောမြေဆီလွှာများ ဖုံးလွှမ်းခြင်း၊ ပြန်လည်ကုစားခြင်း (သို့မဟုတ်) စွန့်ပစ်ခြင်း တို့ပါဝင်ပါသည်။

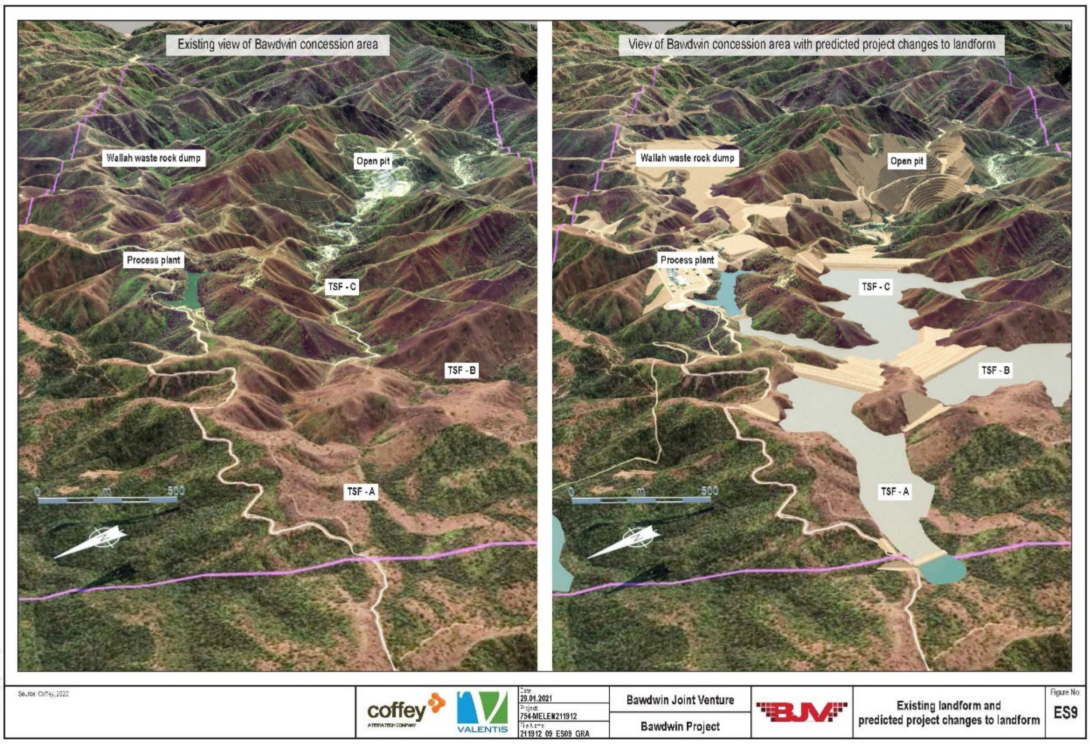
မြေဆီလွှာနှင့် ၎င်း၏ ပုံပန်းသွင်ပြင်အပေါ် အဓိက သက်ရောက်မှုများ (သိသာထင်ရှားစွာ သက်ရောက်မှုနှင့် အထက်) မှာ အောက်ပါအတိုင်းဖြစ်သည်။

- ဟင်းလင်းပွင့်အတိုင်းထားထားသည့် ကျင်း ဖွဲ့စည်းခြင်းနှင့် လုပ်ဆောင်ချက်များကြောင့် မြေပြင်သဏ္ဍာန်ပြောင်းလဲခြင်း၊ TSFs ဆောက်လုပ်ခြင်းနှင့် စွန့်ပစ်ကျောက်အစုအပုံများ၊ မြေပြင်ယူနစ်အားလုံးတစ်လျောက် ပျက်ပြယ်သွားသော တွင်းအတွက် သိသာထင်ရှားသော သက်ရောက်မှုနှင့် မြေပြင်ယူနစ်အပေါ်မူတည်၍ စွန့်ပစ်ကျောက်အစုအပုံများ နှင့် TSF ၏ မြင်မားစွာသက်ရောက်မှုမှ အလယ်အလတ်သက်ရောက်မှု၊
- မြေဆီလွှာတိုက်စားခံရခြင်း (သို့မဟုတ်) ညံ့ဖျင်းသော မြေဆီလွှာစီမံခန့်ခွဲမှုတို့ကြောင့် ဂေဟစနစ်များကို အကျိုးပြုနိုင်မည့် မြေအသုံးပြုမှု လျော့နည်းသွားခြင်း - မတ်စောက်သော တောင်တန်းမြေပြင်ယူနစ်အတွက် သိသာထင်ရှားသော မြင့်မားသည့် သက်ရောက်မှု၊

မသေချာမရေရာသော ဧရိယာများတွင် မြေဆီလွှာနှင့် ၎င်း၏ ပုံပန်းသွင်ပြင်အပေါ် သက်ရောက်မှုကို အကဲဖြတ်ဆန်းစစ်ခြင်းတွင် ဆောက်လုပ်ရေးနည်းလမ်းများနှင့် ဒီဇိုင်းအသေးစိတ်၊ ပိတ်သိမ်းမည့် ဒီဇိုင်းပုံစံများ၊ ပြန်လည်ပြုပြင်ရေးနှင့် ပိတ်သိမ်းရန်အတွက် လိုအပ်သည့် ပစ္စည်းပမာဏ ညီမျှမှုရှိ/မရှိ နှင့် ယခင်သတ္တုတူးဖော်ခြင်းလုပ်ငန်းများမှ လက်ရှိကာလ ညစ်ညမ်းမှုအတိုင်းအတာ တို့ပါဝင်ပါသည်။

မြေအောက်ရေပေါ်သက်ရောက်မှု

စီမံကိန်းသည် မြေအောက်ရေအပေါ် နည်းအမျိုးမျိုးဖြင့် ချိတ်ဆက်မှုရှိပါသည် - လက်ရှိ မြေအောက်ရေစွန့်ထုတ်ပေးသည့် စမ်းရေတွင်းများအပေါ်တွင် အဆောက်အအုံများထားရှိခြင်း၊ မြေအောက်ရေကို တွင်းမှတစ်ဆင့် တူးယူခြင်း (တွင်းတူးမြောင်းများမှ တစ်ဆင့်၊ ကျားးဥမင် လိုဏ်ခေါင်းမှ တစ်ဆင့် စုပ်ယူခြင်း)၊ TSFs နှင့် စွန့်ပစ်ကျောက်တုံးများနှင့် တွင်းပေါက်များ (တွင်းရေကန် ဖြစ်လာသည့်အခါ ပိတ်သိမ်းခြင်း) နှင့် ရေလှောင်ကန်များမှ ရေများစိမ့်ထွက်ခြင်းမှ မြေအောက်ရေပမာဏ တိုးများလာစေမည်ဖြစ်ပြီး ။ ရေစိမ့်ထွက်မှုတွင် မြင့်မားသော သတ္တုများနှင့် ဆာလဖိတ်များ ပါဝင်နိုင်ဖွယ်ရှိပြီး TSF မှ စိမ့်ထွက်မှုတွင် ကြွင်းကျန်နေသော ဓာတ်ပစ္စည်းများ ပါဝင်နိုင်ပါသည်။ စိမ့်ထွက်မှုသည် ဒေသအတွင်းရှိ မြေအောက်ရေ၏ အရည်အသွေးကို လျှော့ချနိုင်ရန် အလားအလာရှိပါသည်။



လက်ရှိမြေမျက်နှာသွင်ပြင် အနေအထားနှင့် စီမံကိန်းကြောင့် ပြောင်းလဲသွားမည့် မြေဆီလွှာပုံပန်းသွင်ပြင်

မြေအောက်ရေနှင့် စပ်လျဉ်းသည့် ဒီဇိုင်းရေးဆွဲခြင်း စီမံခန့်ခွဲမှုများတွင် ရေဆိုးရေညစ်များ စိမ့်ထွက်မှု လျော့နည်းစေရန် TSFs နှင့် Wallah စွန့်ပစ်ပစ္စည်း စွန့်ပစ်မည့်နေရာ၏ ဒီဇိုင်း တည်ဆောက်မှုနှင့် လည်ပတ်ဆောင်ရွက်မှုတို့ပါဝင်သည်။ အဆောက်အအုံများတွင် ရေစိမ့်ဝင်မှုနည်းပါးစေရန်နှင့် ရေများကို စုဆောင်းထားနိုင်ရန် ရေအောက်မြောင်းများကို တပ်ဆင်ထားမည်ဖြစ်ပြီး မစွန့်ပစ်မီ ပြန်လည်အသုံးချခြင်းနှင့် ကုစားခြင်းတို့ကို ဦးစားပေးဆောင်ရွက်မည်ဖြစ်သည်။ အခြားသော လျော့နည်းစေမည့် နည်းလမ်းများနှင့် စီမံခန့်ခွဲမှုများတွင် လက်ရှိမြေအောက်ရေကို ရေအရင်းအမြစ် အဖြစ်အသုံးပြုနေသည့် ဘော်တွင်းဒေသ နှင့် Tiger Camp ဒေသများ ပြန်လည်နေရာချထားခြင်း၊ စွန့်ပစ်ကျောက် အစုအပုံနှင့် ဟင်းလင်းပွင့်ထားထားသော ကျင်းများသို့ ရေဆိုးများစိမ့်ဝင်နိုင်ခြင်းကို လျှော့ချနိုင်ရန်နှင့် TSF များပိတ်သိမ်းရန်အတွက် ဒီဇိုင်းနှင့် နည်းဗျူဟာများအတွက် TSF တာတမံဇုန်များအတွင်း ရေအရည်အသွေး စီမံခန့်ခွဲမှုများ ဆောင်ရွက်ထားရှိမည်။

မြေအောက်ရေအပေါ် အဓိကသက်ရောက်မှုများ (သိသာထင်ရှားစွာ သက်ရောက်မှုနှင့် အထက်) မှာ အောက်ပါအတိုင်းဖြစ်သည်။

- ရေနေဂေဟစနစ်များကို ပံ့ပိုးပေးနိုင်ခြင်းလျော့နည်းလာမှုနှင့် စမ်းချောင်းများအပေါ်တွင် စီမံကိန်းအဆောက်အအုံများ နေရာချထားခြင်းကြောင့် စမ်းရေတိုက်ရိုက်ဆုံးရှုံးလာမှုကြောင့် - ဘော်တွင်းဒေသအတွင်းရှိ စမ်းရေတွင်း ၁၆ ခုအနက် စမ်းရေတွင်း ၆ ခုအပေါ် သိသာထင်ရှားသော မြင့်မားသည့်သက်ရောက်မှု

- TSFs မှ စိမ့်ထွက်မှုများကြောင့် saprolite နှင့် ကျိုးကြေနေသော ကျောက်များကြောင့် မြေအောက်ရေကို ညစ်ညမ်းစေခြင်း - နမ့်ပန်ကျွန်း, နမ့်လ နှင့် စမ်းရေတွင်းများ၏ ရေတွင်း saprolite အပေါ် သိသာထင်ရှားသော သက်ရောက်မှု၊ နမ့်ပန်ကျွန်း၊ နမ့်လ တို့၌ ကျိုးကြေနေသော ကျောက်များအပေါ် သိသာထင်ရှားသော သက်ရောက်မှုမှာ မြင့်မားသည်။
- စွန့်ပစ်ကျောက်အစုအပုံမှ စိမ့်ထွက်မှုများကြောင့် နမ့်ပန်ကျွန်း ရေသေရေလွှဲဒေသ၌ saprolite နှင့် ကျိုးကြေနေသော ကျောက်များကြောင့် မြေအောက်ရေကို ညစ်ညမ်းစေခြင်း - ရေတွင်း saproliteအပေါ် သိသာထင်ရှားသော သက်ရောက်မှုနှင့် ကျိုးကြေသော ကျောက်များအပေါ် အလယ်အလတ်မှ မြင့်မားသော သက်ရာက်မှုရှိနိုင်ပါသည်။ ညစ်ညမ်းသော မြေအောက်ရေသည် Wallah ချိုင့်ဝှမ်းရှိ ရေမျက်နှာပြင် အသွင်အပြင်သို့ ပြောင်းလဲနိုင်ကြောင်း မျှော်လင့်ရပါသည်။

မြေအောက်ရေအပေါ် သက်ရောက်မှု အကဲဖြတ်ဆန်းစစ်ခြင်းနှင့် စပ်လျဉ်း၍ မသေချာမရေရာသော ဧရိယာတွင် မြေအောက်ရေကို ခွဲခြမ်းစိတ်ဖြာထားခြင်းမရှိခြင်း၊ ခန့်မှန်းထားသော ရေအရည် အသွေးနှင့် စိမ့်ထွက်မှုနှုန်းပမာဏ၊ ဘူမိဓာတုဆိုင်ရာ ခွဲခြမ်းစိတ်ဖြာထားခြင်းမရှိခြင်း၊ မြေအောက်ရေ စီးဆင်းမှု ပုံစံ (ဥပမာအားဖြင့် စီးဆင်းမှုပြောင်းလဲခြင်း မြေအောက်ရေတင်ခြင်း) နှင့် ကျိုးကြေ နေသော ကျောက်ရေပြင်၏ လက်ရှိရေအရည်အသွေးနှင့် ခန့်မှန်းရေအရည်အသွေး တို့ပါဝင်ပါသည်။.

မြေပေါ်ရေပေါ်သက်ရောက်မှု

စီမံကိန်းနှင့် မြေပေါ်ရေ၏ အပြန်အလှန် သက်ရောက်မှုအများစုသည် နမ့်ပန်ကျွန်း၏ ရေဖမ်းဧရိယာအတွင်း တည်ရှိနေမည်ဖြစ်သော်လည်း နမ့်လရေဖမ်းဧရိယာကို ထိခိုက်စေသည့် အပြန်အလှန်သက်ရောက်မှုများလည်း ရှိနေပါသည်။ နမ့်ပန်ကျွန်းမြစ်နှင့် နမ့်လမြစ်တို့သည် မြစ်ငယ်မြစ်၏ မြစ်လက်တက်များဖြစ်ကြပါသည်။

အဆိုပြုစီမံကိန်းသည် လမ်းများဖောက်လုပ်ခြင်း၊ ရေလမ်းကြောင်းဖြတ်ကျော်ခြင်း၊ မြစ်ရေလွှဲများနှင့် ဆည်များတည်ဆောက်ခြင်းကြောင့် ရေမျက်နှာပြင်ကို တိုက်ရိုက်ဆုံးရှုံးစေခြင်း၊ ချောင်းရေ တိုက်စားခြင်း၊ နုန်းအနည်အနှစ်များ ပို့ချခြင်းနှင့် ရေစီးကြောင်းယိုယွင်းလာခြင်း စသည်တို့ကြောင့် ရေစီးကြောင်းများကို တိုက်ရိုက်ထိခိုက်စေမည်ဖြစ်ပါသည်။ စမ်းချောင်းများလွှဲခြင်း၊ ရေစုပ်ယူခြင်း၊ ရေထုတ်ခြင်းနှင့် မြေပုံသဏ္ဍာန်နှင့် ရေနုတ်မြောင်းပြောင်းလဲမှုများကြောင့် ဖြစ်ပေါ်သည့် ပြောင်းလဲ မှုများနှင့် ရေလွှမ်းမိုးမှုအန္တရာယ် အပြောင်းအလဲများ ပါဝင်နိုင်ပါသည်။ အနှောက်အယှက် ဖြစ်စေသော ဧရိယာများမှ စီးဆင်းလာခြင်း၊ ပရောဂျက်မှ စွန့်ပစ်ရေများနှင့် ရေဆိုးထုတ်ခြင်း၊ စွန့်ပစ် ကျောက်တုံးများမှ မြေအောက်ရေနှင့် အပေါ်ယံရေများ စွန့်ထုတ်ခြင်းနှင့် သတ္တုများ အထူးသဖြင့် ခဲနှင့် မျက်နှာပြင်ရေများ ကြွယ်ဝလာမည်ဟု ခန့်မှန်းထားသည့် TSFs များကြောင့် ဖြစ်ပေါ်မည်ဖြစ်သည်။ ဆိုင်းငံ့ထားသော အနည်များ လည်း မြင့်မားလာမည်။ ရေစုန်၏ အောက်ပိုင်းကြမ်းပြင်ရှိ

အနည်အနှစ်များ၏အရည်အသွေးများသည် သတ္တုဓါတ်ပါဝင်မှုမြင့်မားပြီး ညစ်ညမ်းသော အနည်အနှစ်များ နှင့် ၎င်းအနည်အနှစ်များ ၏ရွေ့လျားမှုကြောင့်လည်း ပြောင်းလဲနိုင်ပါသည်။

မြေပေါ်ရေ အပေါ်ထိခိုက်မှုအနည်းဆုံးဖြစ်စေရန် အသုံးပြုမည့်အဓိကဒီဇိုင်းနှင့် စီမံခန့်ခွဲမှု အစီအမံများ တွင်ပါဝင်သည့်အချက်များမှာ- စွန့်ပစ်ရေ မဝင်ရောက်မီကာလတွင် မြေပေါ်ရေ၏ ပျော်ဝင် အနည်အနှစ်များကို လျှော့ချရန် ရေကာတာများတည်ဆောက်ခြင်း၊ TSFs နှင့် စွန့်ပစ် ကျောက်ပုံ များအတွင်းရှိ ရေနုတ်မြောင်းစနစ်များသည် စိမ့်ထွက်လာမည့် ရေအမြောက်အများကို စုဆောင်း ဖမ်းယူပြီး ၎င်းရေကို စွန့်ထုတ်ခြင်းမပြုမီ သန့်စင်ခြင်း၊ မိုင်းတွင်းမှထွက်ရှိလာမည့်ရေများကို မစွန့်ပစ်မီ သန့်စင်ခြင်း စသည်တို့ပါဝင်ပါသည်။ စီမံကိန်းပိုင်ရှင်သည် စွန့်ပစ်ရေများအားလုံးကို မြန်မာနိုင်ငံ၏ စံချိန်စံနှုန်း များအတိုင်း သန့်စင်ရန် ရည်ရွယ်ထားပါသည်။

နမ့်ပန်ကျွန်းမှ ရေကို ထုတ်ယူမည်ဖြစ်သော်လည်း ထုတ်ယူမည့် ရေပမာဏ၏ တစ်စိတ်တစ်ပိုင်းကို မိုင်းတွင်းမှ ထွက်ရှိလာမည့်မြေအောက်ရေနှင့် ပြန်လည် ဖြည့်တင်းစေမည်ဖြစ်ပါသည်။ နမ္မတူမြစ် အပါအဝင် မြစ်အောက်ပိုင်းရှိ ရေအသုံးပြုသူများတွင် ဖြစ်ပေါ်လာနိုင်သည့် ရေစီးဆင်းမှု လျော့နည်း လာမှုအပေါ် သက်ရောက်မှုလျော့နည်းစေရန်အတွက် နမ့်လမြစ်မှ ရေကိုထုတ်ယူရာတွင် ရေစီးဆင်းမှု များသည့်မိုးရာသီတွင်ထုတ်ယူမည်ဖြစ်ပြီး ခြောက်သွေ့ရာသီတွင် အသုံးပြုရန် စုဆောင်း ထားမည် ဖြစ်ပါသည်။ ဝင်းမြင့်မိုရ်သည် လုံလောက်သည့် ရေပမာဏများ နမ္မတူမြစ်သို့ စီးဆင်းစေမည် ဖြစ်ကြောင်းနှင့် ရေစုပ်ယူမှုသည် မြစ်၏အောက်ပိုင်း ရေသုံးစွဲသူများအတွက် လျော့နည်းမှု မဖြစ်စေကြောင်း ကိုလည်း ဝင်းမြင့်မိုရ်မှ အာမခံမည်ဖြစ်ပါသည်။

ဆောက်လုပ်ရေးလုပ်ငန်း၏ သက်ရောက်မှုများကို လျှော့ချရန်အတွက် မြေသားလုပ်ငန်းများကို ခြောက်သွေ့ရာသီတွင် ဆောင်ရွက်သွားမည် ဖြစ်ပါသည်။ မိုင်းတွင်းကို အနှောင့်အယှက်ဖြစ်စေမည့် ဧရိယာအတွင်း ဝင်ရောက်လာမည့် ရေပမာဏကို တတ်နိုင်သမျှလျှော့ချကာ မြေတိုက်စားမှုနှင့် အနည်အနှစ်များ ထိန်းချုပ်ရေးအစီအမံများအား အကောင်အထည်ဖော်ဆောင်ရွက် သွားမည် ဖြစ်ပါသည်။

မြေပေါ်ရေအပေါ်ကျရောက်မည့် အဓိက သက်ရောက်မှုများမှာ-

- ဂေဟစနစ်နှင့် အကျိုးရှိရှိ အသုံးချမှုအတွက် ထောက်ပံ့နိုင်စွမ်းကို ထိခိုက်စေမည့် instream နှင့် riparian စားကျက်များဆုံးရှုံးခြင်းကြောင့် စားကျက်များဆုံးရှုံးခြင်း - နန့်ပယွန်း အလယ်ပိုင်းနှင့် အောက်ပိုင်းရေဝေဧရိယာပိုင်းများထက် ရေအရည်အသွေးနှင့် ရေနေသတ္တဝါတို့ နေထိုင် ကျက်စားရန် အတွက် ပိုမိုကောင်းမွန်သော နန့်ပယွန်းအထက်ပိုင်း ရေဖမ်းဧရိယာ အပေါ် သိသာထင်ရှားသော သက်ရောက်မှုများ၊ နန့်ပယွန်း၏ ၃ ကီလိုမီတာအထိ underdrain အဖြစ် ပြောင်းလဲခြင်းခံရမည် ဖြစ်ပြီး ရေစီးကြောင်းနှင့် မြစ်ချောင်းစားကျက်များ ပြောင်းလဲသွားမည် ဖြစ်ပါသည်။

- စီမံကိန်းကာလအတွင်း ရေထုတ်ယူမှုများကြောင့် မြေပေါ်ရေစီးကြောင်း ပြောင်းလဲမှုများ ဖြစ်ပေါ်လာပြီး ဂေဟစနစ်နှင့် အခြားအကျိုးရှိသောအသုံးပြုမှုများ၏ ပံ့ပိုးပေးနိုင်စွမ်းကို ထိခိုက်စေခြင်း - စီမံကိန်းကာလအတွင်း ခြောက်သွေ့ကာလများတွင် နမ့်လ၏ မြစ်ညာပိုင်းအတွက် သက်ရောက်မှုမှာ မြင့်မားပါသည်။
- စီမံကိန်းအဆောက်အဦများကြောင့် ဖြစ်ပေါ်ပြောင်းလဲလာသော ရေလွှမ်းမိုးမှုအန္တရာယ်- flood modelling မလုပ်ဆောင်ရသေးသောကြောင့် နမ့်လနှင့် အခြား စုံစမ်းရန် ကျန်ရှိနေသည့် နေရာများအတွက် သက်ရောက်နိုင်သည့် အလားအလာမှာ မြင့်မားပါသည်။
- စီမံကိန်းရင်းမြစ်များမှ ညစ်ညမ်းမှုနှင့် TSFs များမှ စီးဆင်းလာသော ညစ်ညမ်းမှုများကြောင့် ရေထု ညစ်ညမ်းပြီး ဂေဟစနစ်ကို ထိခိုက်စေမှု - နမ့်ပန်ကျွန်းအထက်ပိုင်းအတွက် အလွန်အရေး ပါသော သက်ရောက်မှုတစ်ခုဖြစ်သည်။
- TSS၊ အနည်များ၊ ဓါတ်သတ္တုများကြောင့် ရေထုညစ်ညမ်းပြီး ဂေဟစနစ်ကိုထိခိုက်စေမှု- TSF A နှင့် B တို့မှ စီးဆင်းလာမည့် နမ့်လအတွက် အလွန်အရေးပါသော သက်ရောက်မှုတစ်ခုဖြစ်သည်။

မြေပေါ်ရေအပေါ် သက်ရောက်မှုများကို အကဲဖြတ်ခြင်းပြုလုပ်ရာတွင် ပေါ်ပေါက်လာနိုင်သည့် မရေရာခြင်းများတွင် အရေအတွက် ခန့်မှန်းချက် နှင့် အောက်ပိုင်းတွင် ရေအရည်အသွေးနှင့် စီးဆင်းမှု ပြောင်းလဲခြင်း မရှိခြင်း၊ အနည်အနှစ်များ သယ်ယူပို့ဆောင်ခြင်းနှင့် အနည်ကျမှု modelling မရှိခြင်း၊ ပတ်ဝန်းကျင် ရေဟန်ချက် မသေချာမရေရာမှုများ နှင့် ရေလွှမ်းမိုးမှု အန္တရာယ်တို့ စသည်တို့ ပါဝင်သည်။

လေထုအရည်အသွေးအပေါ် သက်ရောက်မှုများနှင့် GHG ထုတ်လွှတ်မှုများ

လေထုအရည်အသွေးအပေါ် သက်ရောက်မှုများ၏ အရင်းအမြစ်များမှာ ဖုန်မှုန့်ထုတ်လွှတ်မှု၊ အနည်ကျမှုနှင့် ဓာတ်ငွေ့ထုတ်လွှတ်မှုတို့ ဖြစ်ကြပါသည်။ ဖုန်မှုန့်ထုတ်လွှတ်မှုသည် လေထုအတွင်းတွင် အမှုန်အမွှားများနှင့် ဖုန်မှုန့်များကို ဖြစ်ပေါ်စေနိုင်ပါသည်။ လေထုအရည်အသွေး အပေါ် ဖြစ်နိုင်ခြေရှိသော ပြင်းထန်မှုနှင့် အကျိုးသက်ရောက်မှုအတိုင်းအတာကို တွက်ချက်ရန်နှင့် စည်းမျဉ်းစည်းကမ်းလိုက်နာမှုတို့ကို နှိုင်းယှဉ်ရန် သရုပ်ဖော်ခြင်းကို မလုပ်ဆောင်နိုင်သေးသော်ငြား စီမံကိန်းအတွင်းနှင့် စီမံကိန်းအနီးတစ်ဝိုက်ရှိ အချို့နေရာများတွင် လေထုအတွင်းရှိ ဖုန်မှုန့်များ တိုးလာမည်ဟု ခန့်မှန်း ရပါသည်။

စီမံကိန်းလည်ပတ်နေစဉ်အတွင်း ဖြစ်ပေါ်လာမည့် ဖုန်မှုန့်အများစုသည် ဟင်းလင်းပွင့် တူးဖော်ထားသည့် မိုင်းဧရိယာ၊ သိုလှောင်ရုံများ၊ စွန့်ပစ်ကျောက်စုပုံရာ နေရာများ၊ အဓိက ဆောက်လုပ်ရေး လုပ်ဆောင်သည့် နေရာများနှင့် ပို့ဆောင်ရေးလမ်းများတစ်လျှောက် စသည်တို့ ဖြစ်ပါသည်။ စီမံကိန်းလည်ပတ်နေစဉ်အတွင်း ဖြစ်ပေါ်လာမည့် ဖုန်မှုန့်များ၏ အရင်းအမြစ်များသည် အဓိကအားဖြင့်

သတ္တုတူးဖော်ခြင်း၊ သတ္တုတွင်းအတွင်း ဖောက်ခွဲခြင်း၊ သတ္တုရိုင်းများနှင့် စွန့်ပစ်ကျောက်များ သယ်ယူခြင်းနှင့် ကြွင်းကျန်သတ္တုများ ခြောက်သွေ့ရာမှ ထွက်ရှိခြင်း စသည်တို့ မှ ဖြစ်ပါသည်။

စီမံကိန်းမှ ထွက်ရှိလာမည့် အဓိကဓာတ်ငွေ့ထုတ်လွှတ်မှုများမှာ ဓာတ်အားပေးစက်ရုံနှင့် မော်တော်ကားများမှ ထွက်ရှိလာမည့် ဆာလဖာဒိုင်အောက်ဆိုဒ်နှင့် နိုက်ထရိုဂျင်ဒိုင်အောက်ဆိုဒ်များ ဖြစ်ကြပါသည်။ နိုက်ထရိုဂျင်ဒိုင် အောက်ဆိုဒ် မှလွဲ၍ ဓာတ်အားပေးစက်ရုံများမှ ထုတ်လွှတ်သော ဓာတ်ငွေ့များ၏ ပမာဏသည် ဓာတ်အားပေးစက်ရုံများအတွက် သတ်မှတ်ထားသည့် မြန်မာနိုင်ငံ၏ စံနှုန်းသတ်မှတ်ချက်အောက် လျော့နည်းမည်ဟု ခန့်မှန်းရပါသည်။ ထို့အပြင် စီမံကိန်းတွင် အသုံးပြုမည့် မော်တော်ကားများနှင့် ကုန်တင်ယာဉ်များ၏ အိတ်ဇောများမှ ထွက်ရှိလာမည့် ဓာတ်ငွေ့များကြောင့် ပို့ကုန်လမ်းကြောင်းအပါအဝင် အသုံးပြုသော လမ်းတစ်လျှောက် လေထု အရည်အသွေးကို လျော့ကျစေနိုင်ပါသည်။

စီမံကိန်းတည်ဆောက်ခြင်း၊ လည်ပတ်ခြင်းနှင့် ဖျက်သိမ်းခြင်းမှထွက်ရှိလာမည့် ဖန်လုံအိမ် ဓါတ်ငွေ့ထွက်ရှိမှု (Scope 1 emissions) သည် နှစ်စဉ် ပျှမ်းမျှ 133.50 kt CO2-e/annum ဟု ခန့်မှန်း ထားပြီး စီမံကိန်းကာလတစ်လျှောက် စုစုပေါင်း 2,269.50 kt CO2-e ကို ထုတ်လွှတ်နိုင်မည်ဟု ခန့်မှန်း ထားပါသည်။ GHG ဓာတ်ငွေ့ထုတ်လွှတ်မှုအများစုသည် သတ္တုတွင်း၏ လုပ်ငန်းလည်ပတ်မှုကာလ (၁၇ နှစ်) အတွင်း ဖြစ်ပေါ်မည်ဖြစ်ပါသည်။ ဓာတ်အားပေးစက်ရုံ မှထွက်ရှိလာမည့် ဓာတ်ငွေ့ ထုတ်လွှတ်မှုမှာ အများဆုံးဖြစ်ပြီး စီမံကိန်းတစ်လျောက်လုံး ထုတ်လွှတ်မှု၏ ၆၆ ရာခိုင်နှုန်းခန့် အထိ ဖြစ်မည်ဟု ခန့်မှန်းထားပါသည်။ ဒုတိယအများဆုံး ဓာတ်ငွေ့ထုတ်လွှတ်မှုမှာ မော်တော်ယာဉ်များမှ ဖြစ်ပြီး ယင်းတို့သည် စုစုပေါင်း ဓာတ်ငွေ့ ထုတ်လွှတ်မှု၏ ၃၃ ရာခိုင်နှုန်းအထိ ပါဝင်မည်ဖြစ်သည်။ ပေါက်ကွဲစေတတ်သော ပစ္စည်းများနှင့် စွန့်ပစ်ပစ္စည်းများသည် စုစုပေါင်းဓာတ်ငွေ့ထုတ်လွှတ်မှု၏ ၀.၃ ရာခိုင်နှုန်း ဖြစ်ပါသည်။

လေထုအရည်အသွေးပေါ် ထိခိုက်သက်ရောက်မှုကို ဆန်းစစ်ရာတွင် အဓိကသက်ရောက်ခြင်းခံရမည့် အုပ်စုများကို ပုံ ES.10, ES.11 နှင့် ES.12 တို့တွင် ဖော်ပြထားပါသည်။

လေထုအရည်အသွေးအပေါ် သက်ရောက်မှုများကို ရှောင်ရှားရန် အဓိကလုပ်ဆောင်ရမည့် လျော့ချ ရေးနည်းလမ်းမှာ လေထုအရည်အသွေးအပေါ် အကြီးမားဆုံးသက်ရောက်မှုများ ဖြစ်ပေါ်နိုင် သည့် စီမံကိန်း ဧရိယာနှင့် အနီးတစ်ဝိုက်တွင်ရှိသော ရပ်ရွာများကို ပြန်လည်နေရာချထားပေးရေး ဖြစ်ပါ သည်။ စီမံကိန်းဆောင်ရွက်မှုများနှင့်စပ်လျဉ်း၍ ၎င်းတို့၏ တည်နေရာပေါ် မူတည်၍ အမျိုးမျိုးသော သက်ရောက်ခံရသူများကို အချိန်ကာလအလိုက် ပြန်လည်နေရာချထားမည်ဖြစ်သည်။ စစ်တပ် အခြေစိုက်စခန်းကိုမူ ယခုကာလအတွင်း ပြန်လည်နေရာချထားရန် စီစဉ်မထားသော်လည်း စစ်တပ်နှင့် တိုင်ပင်ဆွေးနွေး၍ ပြန်လည်နေရာချထားနိုင်ရန် ဆုံးဖြတ်ထားပါသည်။ ဘော်တွင်း

အခြေစိုက် စစ်တပ်စခန်းအား စီမံကိန်းပိုင်ရှင်မှ ရွှေ့ပြောင်းနိုင်ခြင်း မရှိသောကြောင့် အဆိုပါ အခြေစိုက်စခန်းမှာ ဘော်တွင်းမိုင်နေရာတွင် ဆက်လက်တည်ရှိနေနိုင်ပါသည်။

လေထုအရည်အသွေးကို ထိခိုက်မှုအနည်းဆုံးဖြစ်စေရန် ဆောင်ရွက်မည့် အခြားဒီဇိုင်းနှင့် စီမံခန့်ခွဲမှု အစီအမံများတွင် ခေတ်မီသော စက်ရုံ၊သေချာစွာပြုပြင်ထိန်းသိမ်းထားသော မော်တော်ယာဉ်များနှင့် စက်ကိရိယာများကိုသာ အသုံးပြုခြင်း၊ ဖုန်မှုန့်လျော့ချခြင်းအစီအမံများ (ဥပမာ၊ လမ်းများကို ရေဖြင့် ပက်ဖြန်းခြင်း)၊ သစ်ပင်ပန်းမန်များ ပျိုးထောင်ခြင်းနှင့် ပြန်လည်ထူထောင်ရေးဆိုင်ရာ အစီအမံများ၊ မြေတိုက်စားမှု နှင့် မြေဆီလွှာအနည်အနှစ် ထိန်းချုပ်ရေး အစီအမံများ စသည်တို့ပါဝင်ပါသည်။

လေထုအရည်အသွေးအပေါ် သိသိသာသာ နှင့် အထက် ထိခိုက်နိုင်သော အဓိကသက်ရောက်မှု များမှာ အောက်ပါအတိုင်းဖြစ်ပါသည်။

- ဆောက်လုပ်ရေးကာလအတွင်း လေထုအမှုန်အမွှားများ တိုးပွားလာခြင်းနှင့် ဖုန်မှုန့်များ စုပုံလာခြင်းကြောင့် လေအရည်အသွေး လျော့ကျသွားခြင်း - ဘော်တွင်း အထက်ကျေးရွာ လေထုအတွင်း (၇ လ နှင့် ၈ လ ကြာပြီးနောက် ပြန်လည်နေရာချထားခြင်း မပြုရသေးခင်) နှင့် ကျားစခန်းကျေးရွာလေထုအတွင်း သိသိသာသာထိခိုက်နိုင်ခြင်း၊ ဘော်တွင်းအခြေစိုက် စစ်တပ် စခန်းနှင့် ဘော်တွင်း အောက်ပိုင်း ကျေးရွာလေထုအတွက် အဓိကထိခိုက်နိုင်ခြင်း၊
- လုပ်ငန်းဆောင်ရွက်နေစဉ်အတွင်း လေထုအမှုန်အမွှားများ တိုးပွားလာခြင်းနှင့် ဖုန်မှုန့်များ စုပုံလာခြင်းကြောင့် လေအရည်အသွေး လျော့ကျသွားခြင်း - ဘော်တွင်းအခြေစိုက် စစ်တပ် စခန်းနှင့် ဘော်တွင်း အောက်ပိုင်း ကျေးရွာလေထုအတွက် အဓိကထိခိုက်နိုင်ခြင်း (ဆောက်လုပ်ရေးလုပ်ငန်းများ စတင်ပြီးနောက် ပြန်လည်နေရာချထားခြင်း မဆောင်ရွက်ရ သေးခင်)
- မိုင်းပိတ်သိမ်းပြီးနောက် လေထုအမှုန်အမွှားများ တိုးပွားလာခြင်းနှင့် ဖုန်မှုန့်များ စုပုံလာခြင်းကြောင့် လေအရည်အသွေး လျော့ကျခြင်း - စစ်တပ်အခြေစိုက်စခန်းအတွက် သိသိသာသာ မြင့်မြင့်မားမား ထိခိုက်နိုင်ခြင်း၊
- ဓာတ်အားပေးစက်ရုံလည်ပတ်နေစဉ်အတွင်း ထုတ်လွှတ်သည့် ဓာတ်ငွေ့များကြောင့် လေထု အရည်အသွေးကို လျော့ကျစေခြင်း - မီတာ ၄၀၀ အကွာတွင် တည်ရှိနေသည့် စစ်တပ် အခြေစိုက်စခန်းအတွက် အဓိက သိသိသာသာ မြင့်မြင့်မားမား ထိခိုက်နိုင်ခြင်း

လေထုအရည်အသွေးအပေါ် သက်ရောက်မှုများကို အကဲဖြတ်ခြင်းရာတွင် ဓာတ်ငွေ့နှင့် ဖုန်မှုန့်များ ထုတ်လွှတ်မှုနှင့် သတ္တုပါဝင်မှု၊ ဖုန်မှုန့်အရွယ်အစားနှင့် မည်ကဲ့သို့ ကွဲပြားသည်ကို ကြိုတင် ခန့်မှန်းနိုင်သော သရုပ်ပြမော်ဒယ်မရှိခြင်း မသေချာမရေရာသော အခြင်းအရာအဖြစ် ပါဝင်နေပါသည်။

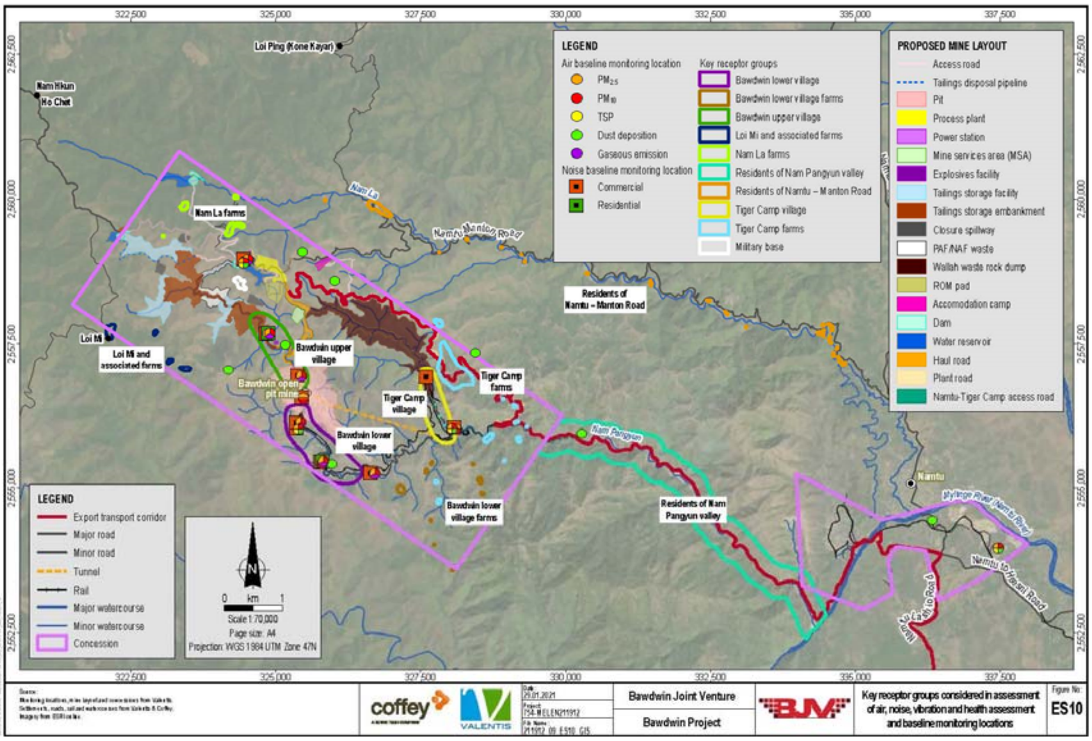


Figure ES.10 Key receptor groups considered in assessment of air, noise, vibration and health assessment and baseline monitoring locations

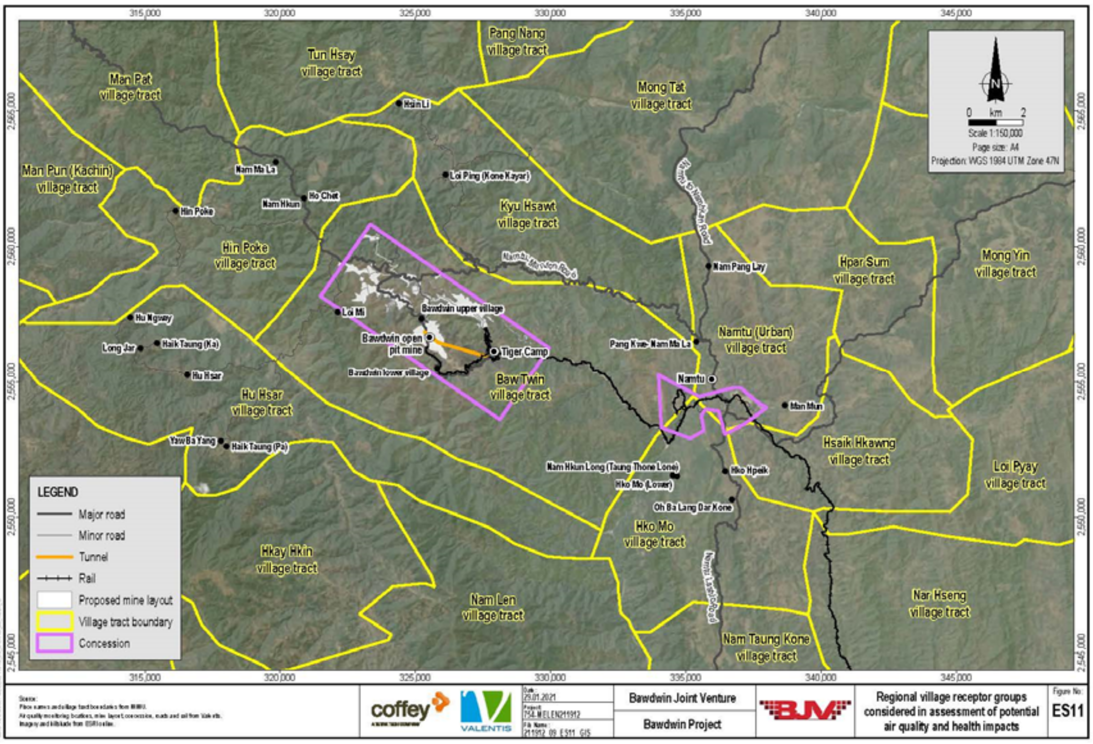


Figure ES.11 Regional village receptor groups considered in assessment of potential air quality and health impacts

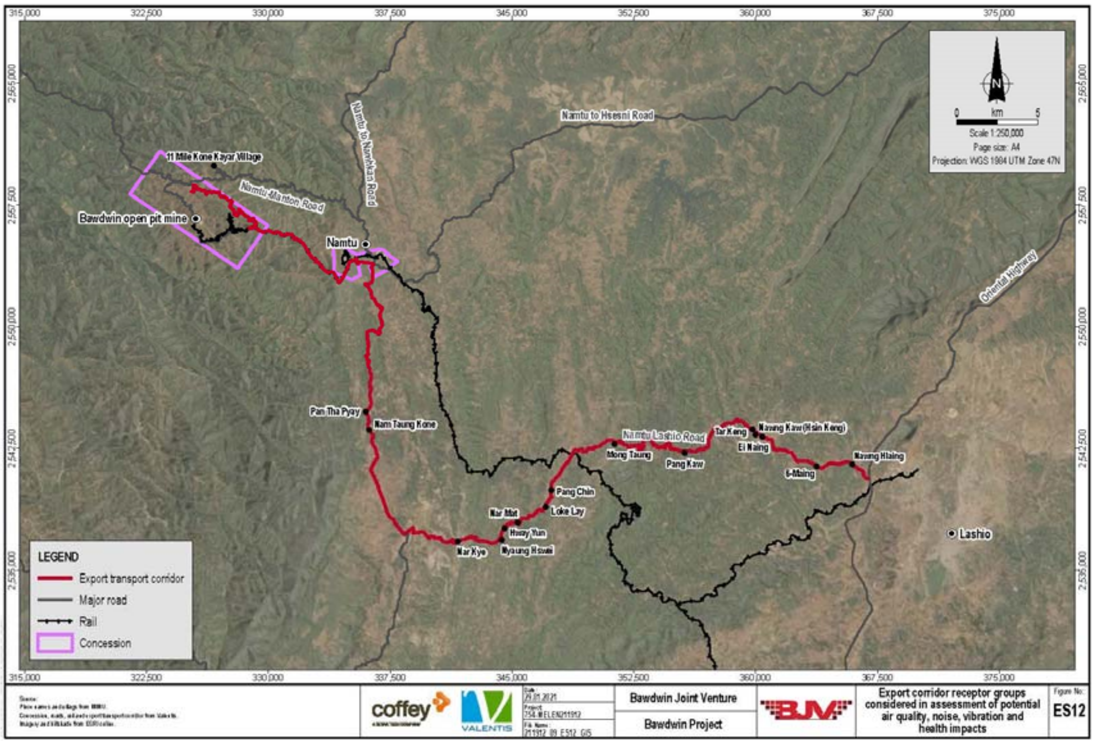


Figure ES.12 Export corridor receptor groups considered in assessment of potential air quality, noise, vibration and health impacts

ဆူညံသံနှင့် တုန်ခါမှုအပေါ် သက်ရောက်မှု

စီမံကိန်းလုပ်ငန်းများသည် ဆူညံသံနှင့် တုန်ခါမှုတို့ကို ဖြစ်ပေါ်စေပါသည်။ သို့သော်လည်း ဆူညံသံ ပြင်းထန်မှု အမြင့်ဆုံးနေရာမှ ရပ်ရွာလူထု အားပြန်လည်အခြေချနေထိုင်ခြင်းဖြင့် ကျန်းမာရေးနှင့် သာယာအဆင်ပြေရေးအတွက် အလားအလာရှိသည့် ပြင်းထန်သော သက်ရောက်မှုများကို ကန့်သတ်ထားနိုင်မည် ဖြစ်ပါသည်။ ဆူညံသံနှင့် တုန်ခါမှု အရည်အသွေးသက်ရောက်မှုများကို ဆန်းစစ်ဆုံးဖြတ်ရာတွင် ထည့်သွင်းစဉ်းစားထားသော အဓိက receptor အုပ်စုကို ပုံ ES.10 နှင့် ES 12 တွင် ဖော်ပြထားပါသည်။

အဓိကသက်ရောက်မှုရှောင်ရှားရေးနည်းလည်းမှာ စီမံကိန်းဧရိယာနှင့် ကပ်လျက် တည်ရှိနေသော ရပ်ရွာလူထုများကို ပြန်လည်နေရာချထားပေးရေး ဖြစ်ပါသည်။ နောက်ထပ် လျှော့ချရေး နည်းလမ်းအဖြစ် လုံခြုံစိတ်ချရသည့် ဖောက်ခွဲမှု စီမံခန့်ခွဲရေး လုပ်ထုံးလုပ်နည်းများကို အသုံးပြုခြင်း ဖြင့် ဆူညံသံနှင့် တုန်ခါမှုဆိုင်ရာ ဆိုးကျိုး သက်ရောက်မှု များကို ကန့်သတ်လျှော့ချရန် အကောင် အထည်ဖော် ဆောင်ရွက်သွားမည်ဖြစ်ပါသည်။

အဓိက ဆူညံသံနှင့် တုန်ခါမှု သက်ရောက်မှုများ (သက်ရောက်မှုအမြင့်ဆုံး သို့မဟုတ် အထက်များ) မှာ

- လုပ်ငန်းလည်ပတ်သည့် စက်ရုံ၊ ဓာတ်အားပေးစက်ရုံ၊ TSF-B နှင့် TSB-C ဖို့မြေနှင့် မြေသယ်လမ်းများ ဆောက်လုပ်ခြင်းကြောင့် ဆူညံသံနှင့် တုန်ခါမှုအဆင့်များ မြင့်တက် လာခြင်း - စစ်တပ်အခြေစိုက်စခန်းအတွက် အလွန်အရေးပါသော သက်ရောက်မှု တစ်ခုဖြစ်သည်။
- လမ်းများနှင့် အဆောက်အဦများ ဆောက်လုပ်ခြင်းနှင့် ဆောက်လုပ်ရေးဆိုင်ရာ ယာဉ်များ သွားလာမှုတို့ကြောင့် ဆူညံသံနှင့် တုန်ခါမှုအဆင့်များ မြင့်တက်လာခြင်း - နမ့်လ လယ်မြေ (စီမံကိန်းစတင်ပြီး ၇ လမှ ၉ လအကြာတွင် ၎င်းတို့ နေရာပြောင်းရွှေ့ခြင်းမတိုင်မီ)။
- မိုင်းတွင်းလုပ်ငန်းကြောင့် ဆူညံသံနှင့် တုန်ခါမှုအဆင့်များ မြင့်တက်လာခြင်း - ဘော်တွင်းအောက်ရွာအတွက် အကျိုးသက်ရောက်မှု အမြင့်ဆုံး (ဆောက်လုပ်မှု စတင်ပြီးနောက် လပေါင်း ၃၀ မှ ၃၂ လအထိ ပြန်လည်နေရာချထားခြင်းမပြုမီအထိ)။

ဆူညံသံသက်ရောက်မှုများကို ဆန်းစစ်ဆုံးဖြတ်ခြင်းနှင့်စပ်လျဉ်းသည့် မသေချာမရေရာသော နယ်ပယ်များတွင် ဆူညံသံထုတ်လွှတ်မှု ခန့်မှန်းချက်များမရှိခြင်းနှင့် တုန်ခါမှုနှုန်း တိုင်းတာသော ပုံစံငယ်တို့ပါဝင်သည်။

ဇီဝမျိုးစုံမျိုးကွဲအပေါ် သက်ရောက်မှုများ

ဇီဝမျိုးစုံမျိုးကွဲမျိုးကွဲများအပေါ် သက်ရောက်မှုများတွင် စားကျက်နေရာများ ဆုံးရှုံးခြင်း သို့မဟုတ် ပျက်စီးခြင်းနှင့် သို့မဟုတ် သစ်ပင်ပန်းမန်များနှင့် တိရစ္ဆာန်မျိုးစိတ်များ လျော့နည်းခြင်းတို့ ပါဝင်သည်။ စီမံကိန်းသည် လက်ရှိ မိုင်းတွင်းကို ချဲ့ထွင်ရန်နှင့် TSFs၊ ကျောက်အမှိုက်ပုံ၊ ရေလှောင်ကန်နှင့် လမ်းများ အပါအဝင် အခြေခံ အဆောက်အအုံများ တည်ဆောက်ရန်အတွက် လက်ရှိ အပင်များကို ဖယ်ရှားမည် ဖြစ်သည်။ ဖယ်ရှားခံရသော နေရာအများစုသည် ဒေသတွင်းရှိရင်း စွဲမျိုးစိတ်များကို ပံ့ပိုးပေးသောကြောင့် ထိခိုက်နိုင်မှုနည်းသော အပင်အမျိုးအစားဖြစ်သည့် မြက်ခင်းပြင်နှင့် ဝါးများပေါက်ရောက်လျက်ရှိသည်။

သစ်ပင်ပန်းမန်များနှင့် တိရစ္ဆာန်များ၏ နေရင်းဒေသများ ဆုံးရှုံးခြင်းနှင့် ပျက်စီးယိုယွင်းခြင်း၊ စီမံကိန်းတွင်း အသုံးပြုယာဉ်များနှင့် စက်ယန္တရားများနှင့် မတော်တဆ တိုက်မိခြင်း၊ ပိုးမွှားများနှင့် ပေါင်းပင်များ ပျံ့နှံ့ခြင်းနှင့် စီမံကိန်း ဆူညံသံနှင့် ဖုန်မှုန့်များမှ တိရစ္ဆာန်များကို အနှောင့်အယှက်ပေးခြင်းစသည်တို့ကြောင့် သစ်ပင်ပန်းမန်များနှင့် တိရစ္ဆာန်များအပေါ် သက်ရောက်မှုများ ဖြစ်ပေါ်လာနိုင်သည်။ ဒေသအလိုက် အန္တရာယ်ဖြစ်စေနိုင်သည့် အနေအထားရှိသော သစ်ပင်ပန်းမန်များနှင့် တိရစ္ဆာန်များ အများအပြားရှိသော်လည်း စီမံကိန်းဧရိယာသည် အဓိကကျသော လူဦးရေကို ထောက်ပံ့ ပေးနိုင်မည်ဟု ခန့်မှန်းထားခြင်းမရှိသောကြောင့် အဆိုပါမျိုးစိတ်များအတွက် အကျိုးသက်ရောက်မှုများကို ခန့်မှန်း၍မရပေ။

နမ့်ပန်ယွန်းရှိ ရေနေဂေဟစနစ်အပေါ် သက်ရောက်မှု နည်းပါးမည်ဟု ခန့်မှန်းရပြီး ထိုရေဝပ်ဒေသတွင် တည်ရှိနေသော အနည်အနှစ်များနှင့် ညစ်ညမ်းမှုများမှာ ရာစုနှစ်ကြာ မိုင်းလုပ်ငန်းများကြောင့် နှစ်ရာနှင့်ချီ၍ ရှိနေပြီဖြစ်သည်။ နန်းလမြစ်အတွင်း အနည်ထိုင်ခြင်းနှင့် စီးဆင်းမှုပြောင်းလဲခြင်းများ သည် ၎င်း၏ ဂေဟစနစ်ဆိုင်ရာ အရေးပါမှု မြင့်မားသောကြောင့် နမ့်ပန်ကျွန်းနှင့် နှိုင်းယှဉ်ပါက ပိုမိုသိသာထင်ရှားသော သက်ရောက်မှုများကို ကိုယ်စားပြုပါသည်။

ဇီဝမျိုးစုံမျိုးကွဲများ၏ သက်ရောက်မှုများကို လျှော့ချရန် ဒီဇိုင်းရေးဆွဲခြင်းနှင့် စီမံခန့်ခွဲမှုလျော့ချရေးနည်းလမ်းများတွင် ခုတ်ထွင်ရှင်းလင်းခြင်း၊ တိုက်စားခြင်းနှင့် အနည်အနှစ်များကို ထိန်းချုပ်ခြင်း၊ တိုးတက်သော ပြန်လည်ထူထောင်ရေးနှင့် အပင်ငယ်များ ပြန်လည်စိုက်ပျိုးခြင်းနှင့် နမ်းလမြစ်ရေစီးဆင်းမှု (အထူးသဖြင့် ခြောက်သွေ့ကာလများတွင်) ကို ထိန်းသိမ်းရန် လုပ်ငန်းစဉ်များ ပါဝင်သည်။

အဓိက ဇီဝမျိုးစုံမျိုးကွဲများ သက်ရောက်မှုများ (သက်ရောက်မှုအမြင့်ဆုံး သို့မဟုတ် အမြင့်ဆုံးအထက်) မှာ

- မြေယာရှင်းလင်းခြင်း၊ ညစ်ညမ်းခြင်း နှင့် ဒေသရင်းမဟုတ်သော မျိုးစိတ်များ ဝင်ရောက်လာခြင်း - စီမံကိန်းဧရိယာရှိ အခြားမျိုးစိတ်များနှင့် နှိုင်းယှဉ်ပါက သစ်ပင်ပန်းမန်များနှင့် တိရစ္ဆာန်များ ကွဲပြားမှုပိုမိုမြင့်မားသည့် အပူပိုင်း ရောနှောတောင်ကုန်း သစ်တောများ

အတွက် မြင့်မားသော အကျိုးသက်ရောက်မှုများကြောင့် စားကျက်မြေ ဆုံးရှုံးခြင်းနှင့် ပျက်စီးခြင်းကို ဖြစ်စေနိုင်ပါသည်။ ခန့်မှန်းခြေအားဖြင့် စားကျက်မြေ ၁၂ ဟက်တာ ဆုံးရှုံးနိုင်ပါသည်။

ဇီဝဗေဒဆိုင်ရာသက်ရောက်မှုများကို ဆန်းစစ်ဆုံးဖြတ်ခြင်းနှင့် စပ်လျဉ်းသော မသေချာရေရာသော နယ်ပယ်များတွင် လုံခြုံရေးနှင့်ဆက်စပ်သော ဝင်ရောက်ခွင့် ကန့်သတ်ချက်များ၊ ရေအရည်အသွေးနှင့် ရေပမာဏသက်ရောက်မှုများ၊ မိုင်းပိတ်သိမ်းခြင်းနှင့် ပြန်လည်ထူထောင်ရေး အသေးစိတ်အချက်အလက်များရရှိရန် ခက်ခဲမှုကြောင့် အခြေခံစစ်တမ်းဒေတာကန့်သတ်ချက်များရှိနေပါသည်။

ယဉ်ကျေးမှုအမွေအနှစ်များအပေါ် သက်ရောက်မှု

ရာစုနှစ်ခြောက်ခုကျော် စဉ်ဆက်မပြတ် လူသားများ သွားလာနေထိုင်လာမှုကြောင့် ဘော်တွင်းမြေအကျယ်အဝန်းသည် သတ္တုတွင်းလုပ်ငန်းနှင့် ဆက်စပ်နေသောရှုပ်ထွေးသည့် သမိုင်းကြောင်း တစ်ခုရှိပါသည်။ ဘော်တွင်း၏ ယဉ်ကျေးမှုအမွေအနှစ်တန်ဖိုးအများစုမှာ ဘာသာရေး နေရာများနှင့် သင်္ချိုင်းနေရာများကဲ့သို့သော ဒေသခံများအတွက် အရေးပါသည့် နေရာများအပြင် သမိုင်းဝင်သတ္တုတူးဖော်ရေး လုပ်ငန်းများလည်း ပါဝင်နေပါသည်။

စီမံကိန်းတည်ဆောက်မှုသည် ခေတ်သစ်တွင် ဘော်တွင်းသတ္တုတူးဖော်ခြင်း၏ အမွေအနှစ်အဖြစ်ဆက်လက်တည်ရှိနေမည်ဖြစ်သော်လည်း သတ္တုတူးဖော်ခြင်းနှင့် ပြုပြင်ခြင်းလုပ်ငန်းများကို ပံ့ပိုးကူညီရန်အတွက် ဘော်တွင်းရှိ တည်ရှိပြီးသော အခြေခံ အဆောက်အအုံအချို့ နှင့် ဘော်တွင်းအခြေခံ အဆောက်အအုံအသစ်များ တည်ဆောက်ခြင်းအပေါ် အကျိုးဆက်အနေဖြင့် သက်ရောက်မှုရှိမည် ဖြစ်သည်။ ၎င်းသည် အခြေခံအားဖြင့် ရှိရင်းစွဲသမိုင်းဆိုင်ရာ သတ္တုတူးဖော်ခြင်းဆိုင်ရာအကြောင်းအရာကို ပြောင်းလဲစေမည်ဖြစ်သော်လည်း လုပ်ငန်းလည်ပတ်စဉ် လုပ်ငန်းများ၏ ကဏ္ဍများကို မှတ်တမ်းတင်ရန်၊ သုတေသနပြုကာ ထိန်းသိမ်းစောင့်ရှောက်ရန် အခွင့်အလမ်းတစ်ခုအဖြစ် တည်ရှိနေမည် ဖြစ်ပါသည်။

ယဉ်ကျေးမှုအမွေအနှစ်များအပေါ် သက်ရောက်မှုရှိနိုင်သည့် အရင်းအမြစ်များဖြစ်သည့် စီမံကိန်းတည်ဆောက်သည့် ကာလတစ်လျှောက် အနှောင့်အယှက် သို့မဟုတ် ဆုံးရှုံးခြင်း၊ ဝင်ရောက်မှုကို ကန့်သတ်ထားခြင်း၊ ပတ်ဝန်းကျင် ရှုမျှော်ခင်း လက္ခဏာရပ်များကို ပြုပြင်မွမ်းမံခြင်း စသည်တို့ ပါဝင်သည်။

အဆိုပြုထားသော စီမံခန့်ခွဲမှုလုပ်ငန်းစဉ်များသည် လူသိများသော ယဉ်ကျေးမှု အမွေအနှစ်နေရာများအား ထိခိုက်မှုအနည်းဆုံးဖြစ်စေရန် ရည်ရွယ်ပြီး ရှောင်ရှားရန် မဖြစ်နိုင်သောအခါ အနာဂတ်တွင် ဘော်တွင်းသတ္တုတွင်း၏ သမိုင်းကြောင်းကို ပေါ်လွင်စေရန်နှင့် မီးမောင်းထိုးပြနိုင်

စေရန် အဓိကကျသော အရာများကို ကျယ်ကျယ်ပြန့်ပြန့် မှတ်တမ်းတင် ထိန်းသိမ်းထားခြင်းစသည့် နည်းလမ်းများ ပါဝင်ပါသည်။

ယဉ်ကျေးမှုအမွေအနှစ်များအပေါ် သက်ရောက်မှုများကို စီမံခန့်ခွဲရန်၊ အမွေအနှစ်များကို ပြန်လည်ဖော်ထုတ်ခြင်း၊ ပြန်ခြင်းနှင့် သိမ်းဆည်းခြင်းအတွက် ယဉ်ကျေးမှုအမွေအနှစ် စီမံခန့်ခွဲမှုအစီအစဥ်ကို အကောင်အထည်ဖော် ဆောင်ရွက်မည်ဖြစ်သည်။ ယဉ်ကျေးမှုအမွေအနှစ်များ စီမံခန့်ခွဲရေး အစီအစဥ်တွင် သီးသန့် သတ္တုတူးဖော်ရေးပြတိုက်ရှိ လက္ခဏာရပ်များ၏ အဓိက အစိတ် အပိုင်းများကို ထိန်းသိမ်းစောင့်ရှောက်ရန် လုပ်ငန်းစဉ်များ ပါဝင်မည်ဖြစ်ပါသည်။ သင်္ချိုင်းများနှင့် အခြားအရေးကြီးသော ရှေးဟောင်းသုတေသနဆိုင်ရာလက္ခဏာများအတွက် စစ်ဆေးခြင်း၊ တူးဖော်ခြင်း၊ သိမ်းဆည်းခြင်းနှင့် နေရာရွှေ့ပြောင်းခြင်းအတွက် အရည်အချင်းပြည့်မီသော ရှေးဟောင်း သုတေသန ပညာရှင်များ၊ စည်းကမ်းထိန်းသိမ်းရေးအဖွဲ့များ၊ ရပ်ရွာနှင့် သင့်လျော်သော ဘာသာရေးနှင့်/ သို့မဟုတ် ရပ်ရွာခေါင်းဆောင်များနှင့်အတူ တည်ဆောက်မည်ဖြစ်သည်။ ခိုင်မာသော ယဉ်ကျေးမှုဆိုင်ရာ ဆက်နွယ်နေသော သို့မဟုတ် ဒေသခံလူထုလက်ရှိအသုံးပြုနေသည့် သင်္ချိုင်းများကို ရပ်ရွာ ပြန်လည်နေရာချထားရေးအစီအစဉ်၏ တစ်စိတ်တစ်ပိုင်းအဖြစ် ပြန်လည်တည်ဆောက်ရန်/ နေရာချထားပေးရန် ခန့်မှန်းထားပါသည်။ လူသိများသော သင်္ချိုင်းကုန်းများနှင့် ဘာသာရေး နေရာများကို ၎င်းတို့၏ လက်ရှိနေရာများမှ ဆုံးရှုံးနိုင်သော်လည်း ၎င်းတို့ကို ဖျက်ဆီးမည့် အစား နေရာရွှေ့ပြောင်း ရဖွယ် ရှိပါသည်။.

ယဉ်ကျေးမှုအမွေအနှစ်များ စီမံခန့်ခွဲရေးအစီအစဥ်တွင် ယဉ်ကျေးမှုအမွေအနှစ်များ၏ တန်ဖိုးများနှင့် အရေးကြီးသည့် လိုက်နာဆောင်ရွက်ရမည့် စီမံခန့်ခွဲမှုလျော့ချရေးနည်းလမ်းများကို စီမံကိန်း ဝန်ထမ်းများ သိရှိစေရန် အတွက် ပညာပေးအစီအစဉ်များပြုလုပ်သွားရန် လုပ်ထုံးလုပ်နည်းများ ပါဝင်မည်ဖြစ်ပါသည်။ ပညာပေးအစီအစဉ်များတွင် ပါဝင်သည့် လုပ်ငန်းများမှာ စာချုပ်များတွင် လိုအပ်ချက်များ ထည့်သွင်းခြင်း၊ လုပ်သားအင်အား မိတ်ဆက်ခြင်း၊ ယဉ်ကျေးမှုဆိုင်ရာ အသိပညာ ပေးသင်တန်း၊ လုပ်သားအင်အား လေ့ကျင့်ရေး၊ ပညာရေးနှင့် အသိအမြင်၊ လိုက်နာမှု စစ်ဆေးခြင်းနှင့် စောင့်ကြည့်ခြင်း စသည့် လုပ်ငန်းစဉ်များ ပါဝင်မည်ဖြစ်ပါသည်။ ရွှေ့ပြောင်းထားခံရသော သို့မဟုတ် သိမ်းဆည်းထားသော ယဉ်ကျေးမှု အမွေအနှစ်အင်္ဂါရပ်များသည် ၎င်းတို့တွင် လိုအပ်သော အကာအကွယ်နှင့် စောင့်ရှောက်မှုနှင့် ထိန်းသိမ်းမှုအဆင့်များရှိကြောင်း သေချာစေရန်အတွက် သင့်လျော်သော စီမံခန့်ခွဲမှုအစီအစဉ်များ ရှိမည်ဖြစ်သည်။ ဘော်တွင်းမိုင်းအတွင်း ပြန်လည်နေရာချထားခြင်းခံရသော နေရာများနှင့် လက္ခဏာရပ်များ အနီးတစ်ဝိုက်တွင် 'မသွားရ' ဇုန်များ အဖြစ် သတ်မှတ်ထားမည် ဖြစ်သည်။

ရှေးဟောင်းအမွေအနှစ်ယဉ်ကျေးမှုဆိုင်ရာ အဓိက သိသာထင်ရှားမှုရှိသော သက်ရောက်မှုများမှာ-

- မြေတူးခြင်းနှင့် မိုင်းတူးဖော်ခြင်းတို့ကြောင့် ဆိုက်များနှင့် တန်ဖိုးများဆုံးရှုံးမှု - လူသိများသော တရုတ်ခေတ် မိုင်းတူးဖော်ခြင်းနှင့် သတ္တုအရည်ကျိုရာ နေရာများ၊ တရုတ် ကျောက်တုံးတံတား အခြေခံအုတ်မြစ်တည်ဆောက်ခြင်း၊ တရုတ်ဈေးဆိုင် အဆောက်အဦများနှင့် ပိုကြီးမားသော/ ရှားပါးသော ရှေးဟောင်းပစ္စည်းများနှင့် တရုတ်အသက်မွေးဝမ်းကျောင်း အလုပ်များ၏ အထောက်အထားများ စသည်တို့အတွက် အဓိကသိသာ ထင်ရှားမှုရှိသော သက်ရောက်မှု၊ သင်္ချိုင်းများ၊ အမည်မသိ တရုတ်ခေတ် အရည်ကျိုသည့် အထောက်အထားများ၊ သေးငယ် ကျယ်ပြန့်သော ရှေးဟောင်းပစ္စည်းများ နှင့် တရုတ်အသက်မွေးဝမ်းကျောင်း အလုပ်များ၏ သက်သေအထောက်အထားများ စသည်တို့အတွက် အရေးပါမှု မြင့်မားသော အကျိုး သက်ရောက်မှု၊ အစီရင်ခံစာ အကျဉ်းချုပ်စာမျက်နှာ ၈ ရှိပုံသည် စီမံကိန်းနှင့် ပတ်သက်၍ ယဉ်ကျေးမှုအမွေအနှစ်အသွင်အပြင်များ၏ တည်နေရာများကို ပြသထားပါသည်။
- စီမံကိန်း၏ Footprints များမှ အရာဝတ္ထုများနှင့် နေရာများအား ဖယ်ရှားဖျက်သိမ်းခြင်းကြောင့် ဖြစ်ပေါ်လာသော ဆုံးရှုံးမှု - ကိုလိုနီခေတ်အခြေခံအဆောက်အအုံ (Marmion Shaft နှင့် winding house)၊ နမ္မတူ - ဘော်တွင်း ရထားလမ်းတို့အတွက် အဓိကအရေးပါသော အကျိုးသက်ရောက်မှု၊
- မြေတူးဖော်ခြင်းနှင့် သတ္တုတွင်းတူးဖော်ခြင်းတို့ကြောင့် ဆိုက်နေရာများနှင့် တန်ဖိုးများအပေါ် အနှောင့်အယှက်ဖြစ်စေခြင်း - ပိုကြီးမားသော/ရှားပါးသောရှေးဟောင်းပစ္စည်းများနှင့် တရုတ် အသက်မွေးဝမ်းကျောင်းဆိုင်ရာ သက်သေအထောက်အထားများအတွက် မြင့်မားအရေးပါသော အကျိုးသက်ရောက်မှု၊
- ဘေးပတ်ဝန်းကျင်ရှုခင်းများ ပြုပြင်မွမ်းမံခြင်းကြောင့် လျော့ပါးလာသော အမွေအနှစ်တန်ဖိုး - တရုတ်တောင်ကုန်းများနဲ့ ခုခံကာကွယ်ပေးသောတောင်ကြော၊ ပေါ်လွင်ထင်ရှားသော တောင်ကြောများနှင့် တောင်ကမ်းပါးများပေါ်တွင် တည်ရှိနေသော သင်္ချိုင်းများ၊

ယဉ်ကျေးမှုအမွေအနှစ်များအပေါ် သက်ရောက်မှုများအား ဆုံးဖြတ်ခြင်းနှင့် စပ်လျဉ်း၍ သေချာမှုမရှိသော ဧရိယာများမှာ မြေပေါ်စစ်ဆေးခြင်းသာလျှင် ဆောင်ရွက်ထားသောကြောင့် မြေအောက်တွင် တည်ရှိနေနိုင်သည့် အမွေအနှစ်လက္ခဏာများ၏ တည်နေရာများအား မသိရှိနိုင်ခြင်း - ယဉ်ကျေးမှုအမွေအနှစ်ဆိုင်ရာ လက္ခဏာများ၏ တိကျသော သက်တမ်းများနှင့် တန်ဖိုးများ၊ အချို့သော စီမံအုပ်ချုပ်မှုနှင့် အချို့အကြောင်းအရာများ၏ သိသာထင်ရှားမှုအပေါ် လူအများ၏ သဘောထားမှတ်ချက် အစရှိသည်တို့၏ တည်နေရာများပါဝင်ပါသည်။

လူမှုရေးဆိုင်ရာသက်ရောက်မှုများ

စီမံကိန်းတွင် လူမှုရေးနှင့် လူမှုစီးပွားဆိုင်ရာ အကြောင်းချင်းရာများအတွက် မတူညီမှုသော အဆင့်များအပေါ် မူတည်၍ သက်ရောက်ရန် ဖြစ်နိုင်ချေရှိပါသည်။ လူမှုရေးဆိုင်ရာ သက်ရောက်မှု များကို ဆုံးဖြတ်နိုင်ရန် အဓိက အချက်သုံးချက်ကို ဖွင့်ဆိုထားပြီး ဆီလျော်သော စံတန်ဖိုးများလည်း ပါဝင်ပါသည်။ ယင်းအချက်များမှာ-

- ဒေသခံများ၏ စီးပွားရေး၊ အသက်မွေးဝမ်းကျောင်းနှင့် မြေအသုံးပြုမှုများ

- နေထိုင်မှု အခြေအနေများ၊ လူမှုရေးဆိုင်ရာစည်းလုံးမှုနှင့် လုံခြုံရေး
- ကျန်းမာရေး၊ ပညာရေးနှင့် အခြားဝန်ဆောင်မှုများအား ချင့်ချိန်ဆုံးဖြတ်ခြင်း

လူမှုရေးဆိုင်ရာ သက်ရောက်မှုဧရိယာများအား လူနေရပ်ကွက်တည်နေရာ (ရေဝေကုန်းတန်း နယ်နိမိတ်များ၊ ကျေးရွာအုပ်စုနယ်နိမိတ်များ၊ စီမံကိန်း၏ ထိစပ်နေရာ၊ အငှားနယ်နိမိတ်များ၊ ထောက်ပံ့ရေးဆိုင်ရာ လမ်းကြောင်းများ) ကို ထည့်သွင်းစဉ်းစားခြင်းနှင့် ကျေးရွာများနှင့် ထိစပ်နေရာတွင် ဆောင်ရွက်သော စီမံကိန်းလုပ်ဆောင်မှု အမျိုးအစားပေါ် မူတည်၍ ကျယ်ပြန့်စွာ သတ်မှတ်ထားပါသည်။

လူမှုရေးဆိုင်ရာ သက်ရောက်ခံရနိုင်သည့် ဇုန်ခြောက်ခုအား သတ်မှတ်ဖော်ပြထားပါသည်။ ယင်းတို့အား အစီရင်ခံစာ အကျဉ်းချုပ်စာမျက်နှာ ၁၃ နှင့် ၁၄ ရှိ ပုံများတွင် ဖော်ပြထားပါသည်။

- ဇုန် ၁ - အပေါ်နှင့် အောက်ဘော်တွင်းကျေးရွာများ အပါအဝင် ဘော်တွင်း လူနေရပ်ကွက်များ၊ ကျားစခန်း (နမ့်လှကျေးရွာ၊ ဘော်တွင်းလုပ်ကွက်၏ တောင်ဘက်နှင့် အရှေ့ဘက်အပိုင်းတို့တွင် ကျယ်ပြန့်စွာ ရှိသော ရွာငယ်များနှင့် လူနေအိမ်များ)
- ဇုန် ၂ - ဘော်တွင်းလုပ်ပိုင်ခွင့်ဧရိယာတွင်းရှိ ကျေးရွာအုပ်စုများနှင့် ကပ်လျက်ရှိသော ကျေးရွာများ (လွိုင်မိကျေးရွာ၊ ဘော်တွင်းလုပ်ကွက်အတွင်းရှိ မြေအား အသုံးပြုထားသော ဆက်စပ်စိုက်ပျိုးမွေးမြူရေးခြံများ)
- ဇုန် ၃ - နမ္မတူမြို့
- ဇုန် ၄ - နမ့်ပန်ကျွန်းတောင်ကြားတလျှောက် လမ်းကြောင်းနှင့် ယင်း၏ ပြန့်ကြဲနေသော စိုက်ပျိုးမွေးမြူရေးခြံငယ်များ၊ အခါအားလျော်စွာရှိသော လက်ယက်မိုင်းတွင်းများ
- ဇုန် ၅ - စီမံကိန်းမှ အသုံးပြုမည့် နမ္မတူနှင့် လားရှိုးကြားလမ်းမကြီးတလျှောက် ကျေးရွာများ
- ဇုန် ၆ - လားရှိုး

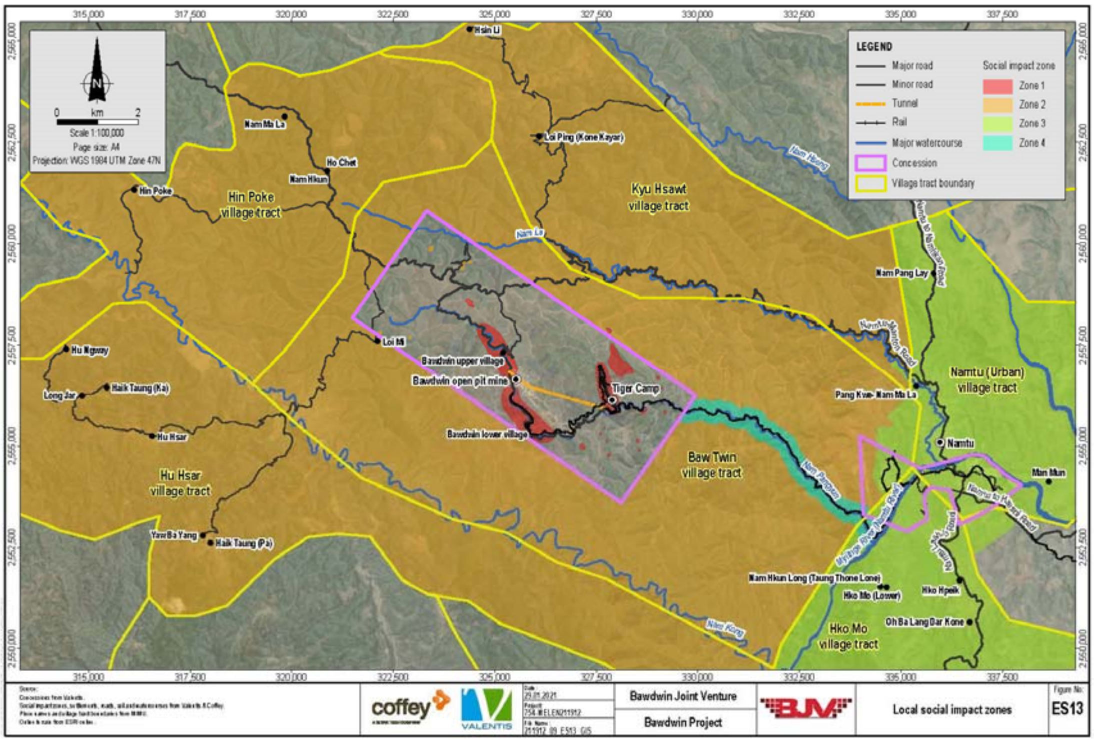


Figure ES.13 Local social impact zones

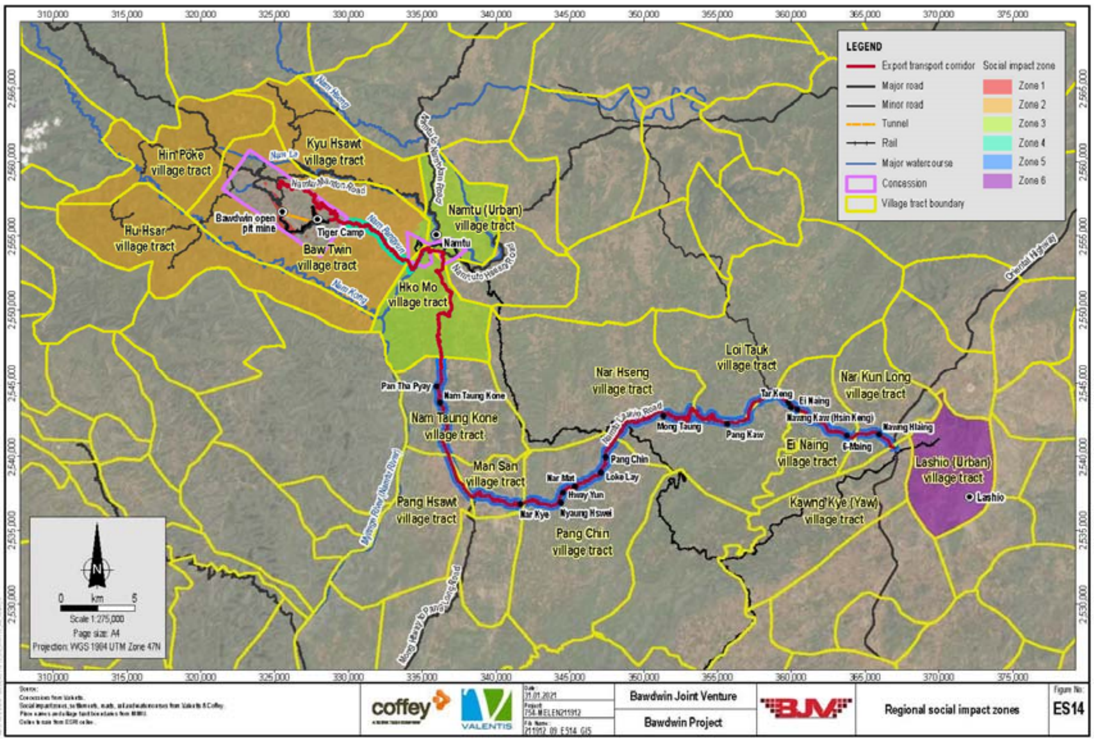


Figure ES.14 Regional social impact zones

ဘော်တွင်းစီမံကိန်းတွင် ဘော်တွင်း မိုင်းတူးဖော်ခြင်းလုပ်ငန်းထက် အဓိကအားဖြင့် ပို၍ကြီးမားသော လုပ်ငန်းခြေရာပါဝင်ပါသည်။ စုစုပေါင်း လုပ်ငန်းခြေရာဧရိယာမှာ ခန့်မှန်းခြေအားဖြင့် ၄၇၀ ဟက်တာ ဖြစ်ပါသည်။ ဘော်တွင်းစီမံကိန်းသည် ဘော်တွင်းလုပ်ပိုင်ခွင့်တွင် ပါဝင်သော်လည်း ၎င်းသည် ယခင် သတ္တုတူးဖော်ရေးကာလများတွင် ဖြစ်ပွားခဲ့သည့် သတ္တုတူးဖော်ရေးလုပ်ငန်းများကြောင့် မြေနေရာ များအား တိုက်ရိုက်နှင့် သွယ်ဝိုက် အနှောင့်အယှက်ဖြစ်စေသော အကျိုးသက်ရောက်မှုရှိပါသည်။ ဘော်တွင်းလုပ်ကွက်အတွင်း ရှိနေပြီးသော လူနေရပ်ကွက်များအား ရွှေ့ပြောင်းနေရာချထားခြင်းကို လုပ်ဆောင်ရန် လိုအပ်ပါသည်။

စီမံကိန်းတွင် စီမံကိန်းအား အထောက်အကူဖြစ်စေရန် အခြေခံအဆောက်အဦအသစ်များနှင့် လမ်းများ အပါအဝင် အများပြည်သူသုံး အခြေခံအဆောက်အဦအချို့အား အသုံးပြုမှု မြင့်မားလာ စေပါသည်။ ကြီးမားသော မိုင်းတူးဖော်ခြင်းနှင့် ဆက်စပ်သော လူမှုစီးပွားသက်ရောက်မှုများတွင် အလုပ်အကိုင်အခွင့်အလမ်းများ၊ စီမံကိန်းအတွက် လိုအပ်သော ကုန်ပစ္စည်းများနှင့် ဝန်ဆောင်မှုများ၊ စီမံကိန်းနေရာသို့ ပြင်ပလူများ ရွှေ့ပြောင်းဝင်ရောက်လာမှု၊ လူမှုရေးဆက်ဆံရေးပြောင်းလဲမှုများနှင့် လူထုအတွက် မြင်ကွင်းပသာဒပြောင်းလဲမှုများ (ရှုခင်းပသာဒ၊ လေထု၊ ဆူညံသံများ) ပါဝင်ပါသည်။

ဝင်းမြင့်မိုရ်ကုမ္ပဏီသည် လူမှုဆိုင်ရာစီမံခန့်ခွဲမှုအစီအစဉ်များအား စီမံကိန်း၏ ကောင်းကျိုး/ အကျိုး အမြတ်များ တိုးမြင့်စေခြင်းနှင့် ဖြစ်နိုင်ချေရှိသော အနုတ်သဘောဆောင် သက်ရောက်ထိခိုက်မှုများ အား လျှော့ပါးစေခြင်း တို့ပေါ်ရည်ရွယ်၍ အကောင်အထည်ဖော်ဆောင်ရွက်ပါမည်။ ဘော်တွင်းမိုင်း လုပ်ကွက်အတွင်းရှိ လူနေရပ်ကွက်များ ရွှေ့ပြောင်းနေရာချထားခြင်းသည် လူမှုဆိုင်ရာ သက်ရောက်မှု တစ်ခုသာမက မိုင်းတူးဖော်ခြင်း လုပ်ငန်းတိုးပွားလာမှုနှင့် ဆက်စပ်နေသော ပတ်ဝန်းကျင်ဆိုင်ရာ ဘေးအန္တရာယ်များနှင့်အန္တရာယ်များနှင့် လူထုအကြား ထိတွေ့ဆက်ဆံမှုများကို လျှော့ချရန် အတွက် ကုစားခြင်းနှင့် လျှော့ချရေးနည်းလမ်းတစ်ခုလည်းဖြစ်ပါသည်။ ဝင်းမြင့်မိုရ်သည် မူရင်းနေရပ်နှင့် တူညီသော သို့မဟုတ် ပိုမိုတိုးတက်လာသော ပညာရေး၊ ကျန်းမာရေးဝန်ဆောင်မှုများ၊ ဘာသာရေး ဆိုင်ရာ အဖွဲ့အစည်းများကို အသစ်ရွှေ့ပြောင်းနေရာချပေးထားသော ကျေးရွာတွင် စီစဉ်ပေးရန် ကတိကဝတ်ပြုထားပါသည်။ ဒေသခံလူထုအား နမ္မတူမြို့အနီးတွင် ပြန်လည်နေရာချထားခြင်း ခံရပါက ဈေးများ၊ ဆိုင်များ၊ အခြားဝန်ဆောင်မှုများကို ပိုမိုကောင်းမွန်စွာ ရရှိနိုင်ပါသည်။

လူမှုဆိုင်ရာအချက်များနှင့် စပ်လျဉ်း၍ အဓိကသက်ရောက်မှုများမှာ အောက်ပါအတိုင်းဖြစ်ပါသည်။

- မိုင်းတူးဖော်ခြင်းနှင့် ဆက်စပ်သော အလုပ်အကိုင်အခွင့်အရေးများ - မိုင်းဧရိယာ အတွင်းရှိ ကျေးရွာများအတွက် အဓိကသိသာထင်ရှားသော အပြုသဘောဆောင် သက်ရောက်မှုများ (ဇုန်-၁)
- အသက်မွေးဝမ်းကြောင်းဆိုင်ရာ ကိစ္စရပ်များအတွက် မြေ/အရင်းအမြစ်များ ဆုံးရှုံးမှု- ဘော်တွင်း စိုက်ပျိုးမွေးမြူရေးခြံ နှင့် လူနေရပ်ကွက်များအတွက် သိသာထင်ရှားသော သက်ရောက်မှု (ဇုန်-

၁ခ) ၊ ထုတ်လုပ်အားကောင်းသော စိုက်ပျိုးရေးနယ်မြေများနှင့် စုဆောင်းရေးနေရာများကို ဝင်ရောက်နိုင်ခြင်းအား ဆုံးရှုံးမည့် လွိုင်မိ လူနေရပ်ကွက် (ဇုန်-၁ဂ)၊

- စီမံကိန်း၏ တည်ဆောက်ရေးလုပ်ငန်းများကြောင့် ဘေးဖြစ်စေနိုင်သော ရုပ်ပိုင်းဆိုင်ရာ နေထိုင်မှု အနေအထားများ - ကျားစခန်းကျေးရွာနှင့် ၎င်းပတ်ဝန်းကျင် ရွာမြေများ၊ ပြန်လည်နေရာချထားခြင်း မပြုရသေးခင် ဘော်တွင်းအောက်ပိုင်း ကျေးရွာ နှင့် ၎င်းပတ်ဝန်းကျင်ရှိ စိုက်ပျိုးမွေးမြူရေးခြံများအား သိသာထင်ရှားသော သက်ရောက်မှု၊
- ပြန်လည်ရွှေ့ပြောင်းနေရာချခြင်းပြုလုပ်ထားသော ဘော်တွင်းလူနေရပ်ကွက်များအတွက် တိုးတက်လာသော ရုပ်ပိုင်းဆိုင်ရာ နေထိုင်မှု အနေအထားများ - ရွှေ့ပြောင်းနေရာချခြင်းကို ပြုလုပ်သော ဘော်တွင်းလူနေရပ်ကွက် (ဇုန်-၁) အတွက် အဓိကသိသာထင်ရှားသော အပြုသဘော (ကောင်းကျိုး) သက်ရောက်မှု၊
- စီမံကိန်းအတွက် ရွှေ့ပြောင်းနေရာချခြင်းကြောင့် ပြောင်းလဲသွားသော လူမှုဆက်ဆံရေးနှင့် လူမှုရေးဆိုင်ရာအထောက်အထားများ ပျက်စီးဆုံးရှုံးမှု - ပြန်လည်နေရာချထားခြင်းခံရသော ဘော်တွင်းမိုင်းအတွင်းရှိ လူနေရပ်ကွက် (ဇုန်-၁) အတွက် သိသာမြင့်မားထင်ရှားသော သက်ရောက်မှု၊
- ဘာသာရေးဆိုင်ရာအဖွဲ့အစည်းများသို့ ဝင်ရောက်ခြင်းနှင့် ဝတ်ပြုရာနေရာများအား ပိတ်ဆို့ထားခြင်းကြောင့် ဘော်တွင်းပတ်ဝန်းကျင်ရှိ ကျေးရွာများအတွက် ထောက်ပံ့ပေးခြင်းတို့အား ထိခိုက်မှုရှိစေခြင်း- လုပ်ပိုင်ခွင့်အတွင်းရှိ ပတ်ဝန်းကျင်ကျေးရွာများအတွက် သိသာထင်ရှားသော သက်ရောက်မှု (ဇုန်-၂)

လူမှုရေးဆိုင်ရာအကျိုးသက်ရောက်မှုများ၏ အကဲဖြတ်မှု နှင့် ဆက်စပ်သော သေချာရေရာမှုမရှိသည့် နယ်ပယ်များတွင် ပြန်လည်နေရာချပေးရန် အစီအစဉ် (တည်နေရာ နှင့် အလားအလာရှိသော အသက်မွေးဝမ်းကျောင်း ပြန်လည်ထူထောင်ခြင်းအပါအဝင်) ၊ အချို့သော ထိခိုက်ခံအုပ်စုများ၏ လူမှုစီးပွားရေးပတ်ဝန်းကျင်၊ မြင်ကွင်းပသာဒအပြောင်းအလဲများအပေါ် လူထု၏ အမြင်နှင့် သဘောထားများ၊ ပြောင်းရွှေ့မှု၏ အလားအလာရှိသော အတိုင်းအတာ၊ လေထုအရည်အသွေး၊ ဆူညံသံနှင့် တုန်ခါမှုအကျိုးသက်ရောက်မှုများကို ထောက်ပံ့ရန် တွက်ချက်မှုပုံစံရေးဆွဲမှုမရှိခြင်းတို့ ပါဝင်ပါသည်။

ကျန်းမာရေးသက်ရောက်မှုများ

စီမံကိန်းနှင့် ဆက်နွယ်နေသော လုပ်ဆောင်မှုများသည် လူထုအား ပတ်ဝန်းကျင်အခြေခံသော ကျန်းမာရေးအန္တရာယ်များ (အန္တရာယ်ရှိသောပစ္စည်းများ သို့မဟုတ် အခြေအနေများနှင့် ထိတွေ့မှု၊ လူမှုစီးပွားနှင့်ဆက်စပ်သော ယာဉ်မတော်တဆဖြစ်ပွားမှုအန္တရာယ်များ၊ လူများ၏ တည်နေရာနှင့် ထိတွေ့မှုပေါ် မူတည်၍ ကွဲပြားခြားနားသော ကျန်းမာရေးသက်ရောက်မှုများ) ကို တိုက်ရိုက်သော်လည်းကောင်း၊ သွယ်ဝိုက်၍သော်လည်းကောင်း၊ တစ်စတစ်စတိုးပွားလာ၍ သော်လည်းကောင်း

ပြောင်းလဲပေးပါသည်။ ကျန်းမာရေးထိခိုက်မှုကို ဆန်းစစ်ရာတွင် သတ်မှတ်ထားသော အဓိကလူနေအိမ်အုပ်စုများကို ပုံ ES 10 နှင့် ES 12 တွင်ပြသထားပါသည်။

မြေထု၊ ရေထု၊ လေထုနှင့် အစားအစာများတွင် ပါဝင်နေသည့် သတ္တုပမာဏ၏ ရရှိနိုင်သော ဒေတာများအား တွက်ချက်မှုပေါ်အခြေခံ၍ ဘော်တွင်းနှင့် နမ္မတူလူနေရပ်ကွက်များမှ လက်ရှိထိတွေ့ခံစားနေရသော ကျန်းမာရေးဆိုင်ရာ ဆိုးကျိုးများဖြစ်စေနိုင်သည့် အမျိုးမျိုးသော လမ်းကြောင်းများရှိပါသည်။ ကျန်းမာရေးအညွှန်းကိန်းများ၊ ဆေးစစ်ချက်များ၊ ထိုးထွင်းကြည့်ရှုရန် မလိုအပ်သော ဆေးခန်းတွင် ရောဂါစစ်ဆေးခြင်းများနှင့် ပတ်သက်၍ လူထုနှင့် တွေ့ဆုံဆွေးနွေးမေးမြန်းခြင်း၏ ရလဒ်များအရ လေ့လာမှုဧရိယာများတွင် ရှိနေသည့် ခဲ အစရှိသည့် ညစ်ညမ်းစေသောပစ္စည်းများနှင့် ထိတွေ့ရခြင်းတို့သည် တိကျသော ဆက်စပ်မှုရှိနေကြောင်း ဖော်ပြမထားပါ၊ လုပ်ငန်းခွင် ကျန်းမာရေးစစ်ဆေးရာတွင် အလုပ်သမားများ၏ သွေးနမူနာတွင် ခဲဓာတ်ပါဝင်မှုမြင့်မားနေကြောင်း တွေ့ရှိရသည်။

စီမံကိန်းတည်ဆောက်ရာတွင် ဖုန်မှုန့်၊ မြေကြီး၊ ရေအရည်အသွေးလျော့ချခြင်းတို့ကို တိုးမြင့်စေခြင်းကြောင့် ကျန်းမာရေးထိခိုက်စေခြင်း သို့မဟုတ် လက်ရှိအခြေအနေများကို ပိုမိုဆိုးဝါးစေပါသည်။ ယင်းတို့ကြောင့် လူထုကျန်းမာရေးအတွက် အန္တရာယ်ရှိသော အခြေအနေများကို နောက်ထပ်ဖြစ်ပေါ်စေသည့် အလားအလာရှိပါသည်။ ထို့အပြင် လုပ်သားအင်အားများပြားလာမှုက ရောဂါဖြစ်ပွားခြင်းနှင့် ကူးစက်ပျံ့နှံ့စေခြင်းကို ဖြစ်စေရန် အလားအလာရှိပါသည်။

ပြန်လည်နေရာချထားခြင်း မတိုင်မီ ဘော်တွင်း အထက် နှင့် အောက် ကျေးရွာများနှင့် အနီးအနားဒေသခံများသည် ခဲကဲ့သို့ သတ္တုများပါဝင်နေသည့် ဖုန်ထုတ်လွှတ်ခြင်းများကို ခံစားရနိုင်သည်။ ဒေသခံများနေထိုင်နေသည့် တည်နေရာအပေါ် မူတည်၍ အဆိုပါ ဖုန်များကို ရှူသွင်းခြင်း သို့မဟုတ် မြိုချနိုင်သည့် အလားအလာ ရှိသည်။ ယင်းကြောင့် လူတို့၏ ခန္ဓာကိုယ်ထဲတွင် ရှိနှင့် ပြီးသားဖြစ်နေသည့် မြင့်မားနေသည့် ခဲဓါတ်ပမာဏကို ထပ်မံတိုးမြင့်စေနိုင်သည်။

ဘော်တွင်းဧရိယာအတွင်းမှ လူနေရပ်ကွက်များအား ပြန်လည်နေရာချထားခြင်းက ခဲကဲ့သို့ သတ္တုများပါဝင်မှု မြင့်မားနေသော မြေကြီးနှင့် ရေညစ်ညမ်းစေသည့် အန္တရာယ်ရှိ ဧရိယာများမှ လူများအားပြောင်းစေခြင်းကို ဖြစ်ပေါ်စေပါသည်။ ဘော်တွင်းရှိ လူနေရပ်ကွက်များ ပြန်လည်နေရာချထားခြင်းနှင့် ရေသန့်ဖြန့်ဖြူးရေးနှင့် ခေတ်မီရေဆိုးစနစ်များပါဝင်သော ရွာသစ်များတည်ဆောက်ခြင်းတို့ကြောင့် စီမံကိန်းသည် ပတ်ဝန်းကျင်နှင့် သက်ဆိုင်သော အန္တရာယ်များကို ထိတွေ့ခြင်းမှ လျော့ချပေးနိုင်ရုံသာမက အဆိုပါရွှေ့ပြောင်းနေရာချထားသော လူများ၏ ကျန်းမာရေးအပေါ် အပြုသဘောဆောင် သက်ရောက်မှုများအား ဖြစ်စေပါသည်။ ကျေးရွာများအား ရွှေ့ပြောင်းနေရာချထားခြင်းသည် လုပ်ငန်းလည်ပတ်စဉ်ကာလအတွင်း လူထုဘေးကင်းလုံခြုံမှုကို ခြိမ်းခြောက်နိုင်သော ဘေးအန္တရာယ်များကို (ဥပမာ - ပေါက်ကွဲမှုသက်ရောက်ခံ ဧရိယာများအား ဖယ်ရှားခြင်း) နည်းပါးစေပါသည်။

ကျန်းမာရေးအပေါ် အဓိကသက်ရောက်မှုများ (မြင့်မားသော သို့မဟုတ် ပို၍ မြင့်မားသော ထိခိုက်သက်ရောက်မှုများ) မှာ-

- စီတည်မံကိန်းကြောင့် ဖြစ်ပေါ်စေသည့် ပတ်ဝန်းကျင်ဆိုင်ရာ အန္တရာယ်များ (ညစ်ညမ်းဖုန်မှုန့်နှင့် ရေထု)အား ထိတွေ့မှု - တည်ဆောက်ဆဲကာလ အတွင်း ကြိုတင်ရွှေ့ပြောင်း နေရာချခြင်း မပြုရသေးခင် ဘော်တွင်းအပေါ်ပိုင်း ကျေးရွာအား ထိခိုက်မှု၊ ကြိုတင်ရွှေ့ပြောင်း နေရာချခြင်း မပြုရသေးခင် ကျားစခန်းကျေးရွာနှင့် စက်ရုံသွားရာလမ်းတစ်လျှောက် တည်ရှိမနေသော ကျားစခန်း စိုက်ပျိုးမွေးမြူရေးခြံများနှင့် နမ့်ပန်ကျွန်းတောင်ကြားရှိ နေထိုင်သူဒေသခံများနှင့် ဘော်တွင်းအောက်ပိုင်းကျေးရွာအား တည်ဆောက်ခြင်းနှင့် လုပ်ငန်းလည်ပတ်ခြင်း အချိန် ကာလများတွင် ပြန်လည်နေရာချထားခြင်းမပြုခင် အဓိကသိသာထင်ရှားသော သက်ရောက်မှု၊ တည်ဆောက်ခြင်းနှင့် လုပ်ငန်းလည်ပတ်ခြင်းအချိန်ကာလများတွင် စစ်တပ်အခြေစိုက်စခန်းအား သိသိသာသာထင်ထင်ရှားရှား သက်ရောက်မှု၊
- လူနေရပ်ကွက်များအား ပြန်လည်ရွှေ့ပြောင်းနေရာချပြီးနောက် စီမံကိန်း၏ နောက်ဆက်တွဲ ရလဒ်အဖြစ် ပတ်ဝန်းကျင်ဆိုင်ရာ အန္တရာယ်များအား ထိတွေ့ခံစားရမှု လျော့ပါးလာခြင်း (ညစ်ညမ်းဖုန်မှုန့်နှင့် ရေထု) - ဘော်တွင်းအောက်ပိုင်းကျေးရွာစိုက်ပျိုးမွေးမြူရေးခြံများ၊ စက်ရုံသွားရာလမ်းတစ်လျှောက် တည်ရှိမနေသော ကျားစခန်းရှိ စိုက်ပျိုးမွေးမြူရေးခြံများနှင့် နမ့်လုစိုက်ပျိုးမွေးမြူရေးခြံများအတွက် သိသာမြင့်မားထင်ရှားသော အပြုသဘောသက်ရောက်မှု၊ ဘော်တွင်း အပေါ်ပိုင်းကျေးရွာ၊ ဘော်တွင်းအောက်ပိုင်းကျေးရွာ နှင့် ကျားစခန်း ကျေးရွာ တို့အတွက် အဓိကသိသာထင်ရှားသောအပြုသဘောဆောင်သက်ရောက်မှု၊
- ရေဆိုးသန့်စင်စနစ်နှင့် သန့်ရှင်းပြီး ညစ်ညမ်းမှု ကင်းမဲ့သောရေ ရရှိနိုင်သော ပြောင်းလဲမှုများ- ဘော်တွင်းမိုင်းဧရိယာအတွင်းရှိ လူနေရပ်ကွက်များအတွက် အသင့်အတင့်မှ မြင့်မားသိသာ ထင်ရှားသော အပြုသဘောဆောင်သက်ရောက်မှုများ

လူမှုရေးဆိုင်ရာသက်ရောက်မှုများနှင့်စပ်လျဉ်း၍ သေချာမှုမရှိသော ဧရိယာများတွင် လူထု၏ သွေးတွင်းခဲပါဝင်နှုန်းများ၊ အချို့ထိခိုက်ခံအုပ်စုများ (ရထားလမ်းတစ်လျှောက်ရှိ (နမ့်ပန်ကျွန်း တောင်ကြော) ၏ ပတ်ဝန်းကျင်နှင့် ဆိုင်သော ကနဦးအချက်အလက်များ)၊ ဒေသခံများအား ပြန်လည်နေရာချထားမည့် နေရာ၊ ကနဦးညစ်ညမ်းမှုထိတွေ့ခြင်း အဆင့်များနှင့် ကျန်းမာရေးအား သက်ရောက်မှုရှိသော အခြားအကြောင်းအရာများနှင့် ဆက်စပ်သော မသေချာမှုများ (လေထု အရည်အသွေး၊ ဆူညံသံနှင့် တုန်ခါမှု၊ မြေပေါ်မြေအောက်ရေ) တို့ပါဝင်ပါသည်။

ဘေးအန္တရာယ်များအား အကဲဖြတ်ဆန်းစစ်ခြင်း

စီမံကိန်းနှင့်စပ်လျဉ်း၍ စီစဉ်ထားသော သို့မဟုတ် သိရှိပြီးသော ဖြစ်ရပ်များ၊ ဖြစ်နိုင်ချေရှိသော သက်ရောက်မှုများအား ထည့်သွင်းခြင်းကြောင့် မထင်မှတ်ထားသော သို့မဟုတ် ဖြစ်နိုင်ချေ နည်းသော ဖြစ်ရပ်များအတွက် သက်ရောက်မှုဖြစ်နိုင်ချေနည်းပါးပါသည်။ မထင်မှတ်ထားသော ဖြစ်ရပ်များတွင် သဘာဝဘေးအန္တရာယ်များ၊ ကပ်ဘေးများ၊ စက်ရုံအလုပ်ရုံဆိုင်ရာ၊ မိုင်းတူးဖော်ခြင်းဆိုင်ရာ အန္တရာယ်များ ပါဝင်သည့် အပြင် စီမံကိန်းအောင်မြင်မှုအတွက် သက်ရောက်နိုင်သည့် အကျိုးဆက်များလည်း ရှိနိုင်ပြီး အနီးနားပတ်ဝန်းကျင်ပေါ် စီမံကိန်းကြောင့် သက်ရောက်မှု ပြင်းအား ကိုလည်း မြင့်မားစေပါသည်။

သဘာဝဘေးအန္တရာယ်များ

သဘာဝဖြစ်ရပ်များသည် မိုင်းတွင်းတွင် အဆောက်အအုံပျက်ယွင်းခြင်းကဲ့သို့ ပတ်ဝန်းကျင်နှင့် လူမှုဆိုင်ရာ သက်ရောက်မှုရှိနိုင်ခြင်း) ကဲ့သို့သော ပတ်ဝန်းကျင် သို့မဟုတ် လုံခြုံရေးဆိုင်ရာ မတော်တဆဖြစ်ရပ်ကို ဖြစ်ပေါ်စေနိုင်ပါသည်။ ငလျင်များ၊ မြေပြိုခြင်းများ၊ မုန်တိုင်းများနှင့်/ သို့မဟုတ် ရေကြီးမှုများသည် စီမံကိန်းနှင့် ဆက်စပ်အဆောက်အဦများအား ဖျက်ဆီးနိုင်ချေရှိခြင်း၊ TSFs များအား ပျက်စီးစေခြင်း၊ စွန့်ပစ်ပစ္စည်းများစုပုံခြင်း၊ ရေသိုလှောင်ဆည်များ၊ တွင်းနံရံပွင့်ခြင်း၊ ပတ်ဝန်းကျင်သို့ ညစ်ညမ်းစေမည့်ပစ္စည်းများ အထိန်းအကွပ်မဲ့ စွန့်ထုတ်မှုဖြစ်စေခြင်းစသသည့် ပတ်ဝန်းကျင်နှင့် လူ့ကျန်းမာရေးကို ထိခိုက်စေခြင်းတို့ကို ဖြစ်ပေါ်စေနိုင်ပါသည်။

စီမံကိန်းသည် ဘော်တွင်းပြတ်ရွေ့ကြောဇုန် အတွင်းရှိ ငလျင်လှုပ်ရှားမှု အသင့်အတင့်ရှိသော ဧရိယာ အတွင်းတွင် တည်ရှိနေသောကြောင့် ငလျင်သက်ရောက်မှုကို ခံစားရနိုင်ချေအန္တရာယ်ရှိပါသည်။ မိုးရွာသွန်းမှုများခြင်း၊ ငလျင်များနှင့် တောင်ပြိုခြင်းတို့ကြောင့် မြေပြိုခြင်းကို ဖြစ်ပွားစေနိုင်ပါသည်။ နောင်လာမည့်ဆယ်စုနှစ်များ အတွင်း မြန်မာနိုင်ငံတွင် ရာသီဥတုပြောင်းလဲမှုကြောင့် မုန်တိုင်းများ၊ ရေကြီးမှုများ၊ မိုးခေါင်ရေရှားခြင်းများ၊ မိုးရွာသွန်းမှုများ၊ အပူချိန်စသော သဘာဝဘေး အန္တရာယ်များသည် ပိုမိုဆိုးဝါးစွာမြင့်တက်လာနိုင်ချေရှိကြောင်း ခန့်မှန်းရပါသည်။

မိုးခေါင်ရေရှားခြင်းသည် စီမံကိန်း၏ လုပ်ငန်းလည်ပတ်ခြင်းအတွက် လိုအပ်သော ၁နာရီလျှင် ၁၅ဂ ကုဗမီတာ သို့မဟုတ် ၂.၈ မဂ္ဂကုဗမီတာ ရှိသော ရေရရှိနိုင်မှုကို လျော့နည်းစေနိုင်ပါသည်။ ရေကို စိုစွတ်ရာသီတွင် စုဆောင်းပြီး တစ်နှစ်ပတ်လုံးအသုံးပြုပါသည်။ ပုံမှန်မဟုတ်သော ခြောက်သွေ့ပြီး စိုစွတ်သောရာသီသည် ရေကို လုံလောက်စွာ မထောက်ပံ့ပေးနိုင်ပေ။ ခြောက်သွေ့ရာသီ အတောအတွင်း နမ့်လုမှ ရေကို ထုတ်ယူသုံးစွဲခြင်းသည် ရေစီးဆင်းမှုကို လျော့ပါးစေပြီး လူနေရပ်ကွက်များအတွက် ရရှိနိုင်သည့် ရေပမာဏကိုလည်း လျော့နည်းစေရုံသာမက ရေအရင်းအမြစ်များ လျော့နည်းလာခြင်းအပေါ် တွန်းအားဖြစ်စေနိုင်ပါသည်။

ဘေးအန္တရာယ်များ

ဘေးအန္တရာယ်များကဲဖြတ်ဆန်းစစ်ခြင်းတွင် တိုးပွားလာသောဘေးအန္တရာယ်များမှာ-

- စက်ရုံအလုပ်ရုံဆိုင်ရာ မိုင်းတူးဖော်ခြင်းနှင့်ဆိုင်သော အန္တရာယ်များ (ဥပမာအားဖြင့် စက်ယန္တရားများမတော်တဆဖြစ်ပွားခြင်း၊ TSF များပျက်ယွင်းခြင်း၊ တွင်းနံရံပျက်စီးခြင်းနှင့် မီးဘေးအန္တရာယ်)
- လုပ်ငန်းခွင်နှင့် အလုပ်သမားဆိုင်ရာ ကျန်းမာရေးနှင့် လုံခြုံရေးဆိုင်ရာအန္တရာယ်များ
- နိုင်ငံရေးမတည်ငြိမ်ခြင်းနှင့် အငြင်းပွားမှုများ
- TSF များပျက်စီးခြင်းနှင့် စွန့်ပစ်ပစ္စည်းများစုပုံခြင်းသည် စီမံကိန်းနှင့်သက်ဆိုင်သော အဓိက အန္တရာယ်ဖြစ်ပြီး လူနှင့်/သို့မဟုတ် မြစ်အောက်ပိုင်းရှိ ပတ်ဝန်းကျင်ကိုသက်ရောက်စေသည့် ညစ်ညမ်းမှုကို ဖြစ်စေရန် နောက်ဆုံးတွင်အလားအလာရှိပါသည်။

ဖြစ်နိုင်ချေကို လျှော့ချရန်နှင့်/ သို့မဟုတ် ဒီဇိုင်းရေးဆွဲခြင်းအား ဖြစ်နိုင်ချေရှိသော အများဆုံးအစားအစာ (PMF)၊ ဖြစ်နိုင်ချေရှိသော အများဆုံးမိုးရွာသွန်းခြင်း (PMP)၊ လျောင်အများဆုံး ဖြစ်ပွားနိုင်မှု (MCE)၊ သက်ဆိုင်သော စံသတ်မှတ်ချက်များ၊ ရလဒ်များတည်ဆောက်ခြင်းတို့ဖြင့် ထည့်သွင်းစဉ်းစားပြီး ယင်းဖြစ်ရပ်၏အကျိုးဆက်များကို လျော့ပါးစေရန် စီမံခန့်ခွဲမှုနည်းလမ်းများနှင့် ဒီဇိုင်းရေးဆွဲထိန်းချုပ်ခြင်းကိုတတ်နိုင်သမျှဆောင်ရွက်ပေးရပါသည်။

ဖြစ်ရပ်များကို အဓိကအန္တရာယ်ရှိနိုင်ကြောင်း အကဲဖြတ်ထားခြင်းမရှိပေ။ ယင်းဖြစ်ရပ်များ၏ ပုံမှန် ထက်သာလွန်သော အန္တရာယ်ရှိသည့် အကျိုးဆက်များမှာ-

- ယာဉ်မတော်တဆမှုများ၊ TSF ပျက်စီးခြင်း၊ မီးဘေးအန္တရာယ်နှင့်/သို့မဟုတ် ပေါက်ကွဲမှုများ၊ လျှပ်စစ်အန္တရာယ်များ၊ စက်ပစ္စည်းချို့ယွင်းခြင်း၊ စက်ပစ္စည်းပျက်စီးခြင်း၊ အဆောက်အအုံ ပျက်စီးခြင်း၊ ပေါက်ကွဲမှုဖြစ်ခြင်း၊ ကျောက်စလွင့်စင်ခြင်း၊ အမြင့်မှ ပြုတ်ကျခြင်း၊ နိုင်ငံရေး မတည်ငြိမ်ခြင်း နှင့် အငြင်းပွားမှုများ စသည်တို့ကြောင့် သေဆုံးမှုဖြစ်နိုင်ချေ နှင့်/သို့မဟုတ် ပြင်းထန်သော ထိခိုက်မှုများ (ဖြစ်နိုင်ချေမရှိ) တို့ဖြစ်နိုင်ပါသည်။
- မီးဘေးနှင့်/ သို့မဟုတ် ပေါက်ကွဲမှုများကြောင့် ပတ်ဝန်းကျင်နှင့် အနီးနားရှိ လူနေရပ်ကွက်များအပေါ် အဓိကအကျိုးဆက်များရှိနိုင်ပါသည်။

ဆက်စပ်သက်ရောက်မှုများ

ဆက်စပ်သက်ရောက်မှု ဆန်းစစ်အကဲဖြတ်ခြင်း ဆိုသည်မှာ စီမံကိန်းဧရိယာ၏ သက်ရောက်လွှမ်းမိုးမှု ဧရိယာအတွင်းတွင် ရှိသည့် လုပ်ငန်းလည်ပတ် ဆောင်ရွက်နေသော အခြားလုပ်ငန်းများ၊ အတည်ပြုချက် ရယူထားသော လုပ်ငန်းများ၊ အဆိုပြုထားသောလုပ်ငန်းများမှ ဖြစ်ပေါ်လာနိုင်သည့် ထိခိုက်မှုများနှင့် ၎င်းထိခိုက်မှုများအား ဆန်းစစ်အကဲဖြတ်ခြင်းပင်ဖြစ်ပါသည်။

ဆက်စပ်သက်ရောက်မှုများဖြစ်ပေါ်စေနိုင်သော စီမံကိန်းများ၏ တည်နေရာများအား ပုံ ES. ၁၅ တွင် ဖော်ပြထားရှိပါသည်။ အဆိုပါစီမံကိန်းများတွင် ဓါတ်သတ္တုတူးဖော်ရေးစီမံကိန်းများ၊ လျှပ်စစ်နှင့် ဓါတ်အားပေး စီမံကိန်းများ၊ အဝေးပြေးလမ်းနှင့် ရထားလမ်းစီမံကိန်းများ ပါဝင်ပါသည်။

မြေဆီလွှာနှင့် မြေမျက်နှာသွင်ပြင်

ပိုမိုကျယ်ပြန့်သော နယ်နိမိတ်တွင် ဓါတ်သတ္တုတူးဖော်ရေးစီမံကိန်းများသည် မြေမျက်နှာ သွင်ပြင်များကို ဆိုးကျိုးသက်ရောက်စေနိုင်ခြင်းနှင့် မြေဆီလွှာတိုက်စားမှုများကို ဖြစ်ပေါ်စေနိုင်ပါသည်။ လျှပ်စစ်ဓါတ်အားပေးရေးစီမံကိန်းများအပါအဝင် လမ်းတံတားများ တည်ဆောက်ခြင်းများကလည်း မြေမျက်နှာသွင်ပြင်နှင့် မြေဆီလွှာများအပေါ် သက်ရောက်မှုများ ဖြစ်ပေါ်စေနိုင်ပါသည်။ ဓါတ်သတ္တုတူးဖော်ရေးစီမံကိန်းများသည် ရှမ်းပြည်နယ်မြောက်ပိုင်း၏ မြေမျက်နှာသွင်ပြင်နှင့် မြေဆီလွှာ အရည်အသွေးအား ခြိမ်းခြောက်မှုများ ဖြစ်ပေါ် စေနိုင်ပါသည်။

လေအရည်အသွေး

ဘော်တွင်းစီမံကိန်း၏ ရုပ်ပိုင်းဆိုင်ရာသက်ရောက်မှုများအနေဖြင့် မိုင်းဧရိယာအနီးဝန်းကျင်ရှိ လေကာများကြောင့် ကန့်သတ်ထားခံရခြင်းကြောင့် စီမံကိန်းစတင်ပြီးနောက် လုပ်ဆောင်သည့် သတ္တုရိုင်းတူးဖော်မှုများကြောင့် အနည်းငယ်သော ဆက်စပ် သက်ရောက်မှုများသာ ဖြစ်ပေါ်နိုင်မည် ဖြစ်ပါသည်။ လေထုအရည်အသွေး ဆက်စပ် သက်ရောက်မှုအနေဖြင့် သတ္တုရိုင်းမိုင်းနှင့်ကပ်လျက် ဆောက်လုပ်ရေး လုပ်ငန်းများ လုပ်ဆောင်ခြင်းမှ ထွက်ပေါ်လာသည့် အမှုန်အမွှားကြောင့် ဖြစ်ပွားနိုင်ပါသည်။ အခြားသော စီမံကိန်းများသည် ဘော်တွင်းစီမံကိန်း၏ သက်ရောက်လွှမ်းမိုးမှု ဧရိယာ အတွင်းတွင် ကျရောက်ခြင်း မရှိသော်လည်း လေထုအရည်အသွေး ဆက်စပ်သက်ရောက်မှု ရှိနိုင်ပါသည်။ သို့သော် နမ္မတူနှင့် ဘော်တွင်းရှိ ဖော်ပြပါစီမံကိန်းများမှအပ လေကာများအား သီးခြားထားရှိရမည်။

မြေပေါ်ရေ

မြစ်ငယ်မြစ်တစ်လျှောက်တွင် နမ္မတူ ၃၂ မိုင် ရှိ WMM ကုမ္ပဏီလီမိတက်မှ အကောင်အထည်ဖော် ဆောင်ရွက်လျက်ရှိသည့် သံသတ္တုရိုင်းထုတ်လုပ်ခြင်းလုပ်ငန်းနှင့် Myanmar Apex သတ္တုတူးဖော်ရေး

ကုမ္ပဏီလီမိတက်မှ အကောင်အထည်ဖော်ဆောင်ရွက်နေသော ဇင့်ထုတ်လုပ်ရေးလုပ်ငန်းတို့ တည်ရှိပါသည်။ ၎င်းစီမံကိန်းများမှ ထွက်ရှိသည့် အနည်အနှစ်များသည် မြစ်ထဲသို့ ရောက်ရှိနိုင်ပေရာ ရေအရည်အသွေးနှင့် မြစ်ငယ်မြစ်၏ အကျိုးဖြစ်ထွန်းမှုအပေါ် သက်ရောက်မှု ရှိစေနိုင်ပါသည်။

NCEH မှ အဆိုပြုတင်ပြထားသည့် နမ္မတူ (သီပေါ) စီမံကိန်းနှင့် MEPE မှ တည်ဆောက်ဆဲဖြစ်သည့် အထက်ရဲရွာရေလှောင်တမံ (ရေအားလျှပ်စစ်) စီမံကိန်းတို့တည်ဆောက်ခြင်းကြောင့် ဇလဗေဒ အုပ်ချုပ်မှုစနစ်ကို ထိခိုက်စေနိုင်ပြီး ရေကြီးမှုအန္တရာယ်နှင့် ရေကြီးရေလျှံမှုများအပြင် ရေအရည် အသွေးအား ထိခိုက်စေနိုင် ပါသည်။

မြေအောက်ရေ

ဘော်တွင်းစီမံကိန်း၏ မြေအောက်ရေပေါ် အဓိကသက်ရောက်မှုအနေဖြင့် နမ့်လုရေဝေရေလဲနှင့် နမ့်ပန် ရေဝေရေလဲဒေသအတွင်း Wallah အမှိုက်ပုံနှင့် TSFs မှ reagents များ၊ ဆာလဖိတ်နှင့် metals များ စိမ့်ဝင်ခြင်းကြောင့် မြေအောက်ရေအရည်အသွေးညစ်ညမ်းခြင်းတို့ ဖြစ်ပေါ်စေပါသည်။ အကြီးစား သတ္တုတူးဖော်ရေးလုပ်ငန်းများ လုပ်ဆောင်ခြင်းကြောင့် မြေအောက်ရေနှင့် ပတ်သက်၍ ဆက်စပ်သက်ရောက်မှုများ ဖြစ်ပွားနိုင်ပါသည်။ သို့သော်လည်း ၎င်းစီမံကိန်းများသည် ဘော်တွင်းမှ ၁၆ ကီလိုမီတာနှင့် ၃၆၅ ကီလိုမီတာ အတွင်းတွင် တည်ရှိခြင်းကြောင့် နမ့်ပန်နှင့် နမ့်လု ရေဝေရေလဲ ဒေသအတွင်းရှိ အပိုင်းအစများ သို့မဟုတ် ကျိုးကြေနေသော ကျောက်ရေနေလွှာများအား ထိခိုက်မှုမရှိနိုင်ပေ။

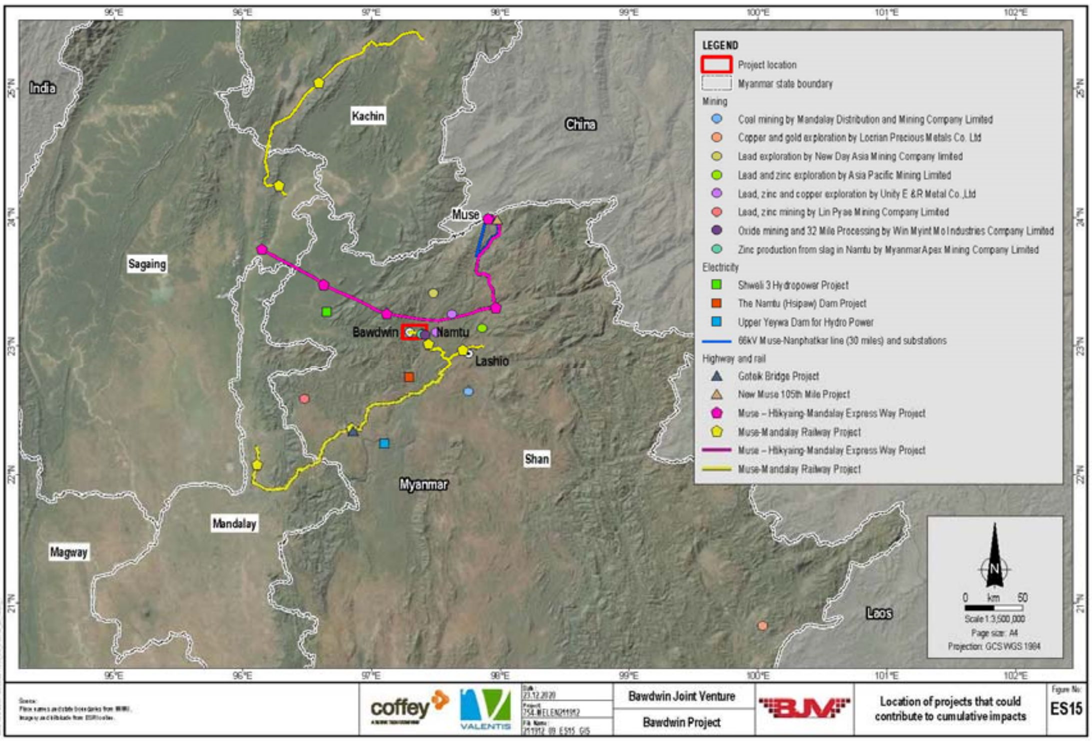


Figure ES.15 Location of projects that could contribute to cumulative impacts

ဇီဝဗေဒဆိုင်ရာ

ပတ်ဝန်းကျင်ထိခိုက်မှု ဆန်းစစ်ခြင်းကြောင့် ဘော်တွင်းစီမံကိန်းကြောင့် ဇီဝပတ်ဝန်းကျင်အပေါ် ရုပ်ပိုင်းဆိုင်ရာ အကျိုးသက်ရောက်မှုများ အနေဖြင့် အပူပိုင်းဒေသရောနှောတောင်ကုန်းသစ်တောများ၏ နေရင်းဒေသများ ဆုံးရှုံးခြင်းနှင့် ပျက်စီးခြင်းတို့ကို ကန့်သတ်ထားသည်။ အခြားသော အဆိုပြုစီမံကိန်းများ ဆောင်ရွက်ခြင်းမှလည်း ဇီဝပတ်ဝန်းကျင်ကို အတိုင်းအတာတစ်ခုအထိ သက်ရောက်မှုရှိနိုင်ပြီး ဆက်စပ်သက်ရောက်မှုများ ဖြစ်ပေါ်စေပါသည်။ စီမံကိန်းတည်နေရာပေါ် မူတည်၍ ပေါက်ရောက်ရာ သစ်ပင်ပန်းမန်များနှင့် သက်ရှိသတ္တဝါတို့၏ စားကျက်များအပေါ် သက်ရောက်မှုများ အပေါ် မူတည်၍ ကွဲပြားနိုင်ပါသည်။

ယဉ်ကျေးမှုအမွေအနှစ်

ဘော်တွင်းသတ္တုမိုင်းရှိ ယဉ်ကျေးမှုအမွေအနှစ်များ၏ အရေးပါမှုနှင့် ထူးခြားမှု အများစုသည် မိုင်း၏ သမိုင်းကြောင်းနှင့် ဆက်စပ်နေပေရာ ဘော်တွင်းလုပ်ကွက်နှင့် အခြားအဆိုပြုထားသော စီမံကိန်းများတည်ရှိသည့် မီးရထားလမ်းတစ်လျှောက်တွင် ယဉ်ကျေးမှုအမွေအနှစ်များဆိုင်ရာ ဆက်စပ် သက်ရောက်မှုများ မရှိနိုင်ပေ။ မူဆယ်-မန္တလေး မီးရထားစီမံကိန်းသည် ဖြစ်နိုင်ချေ အစောပိုင်းအဆင့်တွင် ရှိနေဆဲဖြစ်ပြီး ၎င်း၏ ညှိနှိုင်းမှုဆိုင်ရာ အချက်အလက်မှာ မသေချာသေးကြောင်း သိရှိရပါသည်။

ဆူညံသံနှင့်တုန်ခါမှု

ဘော်တွင်းစီမံကိန်းမှ ဆူညံသံနှင့်တုန်ခါမှု ရုပ်ပိုင်းဆိုင်ရာ သက်ရောက်မှုများအနေဖြင့် လုပ်ကွက်အတွင်းတွင် နေထိုင်သည့် ထိခိုက်ခံစားရနိုင်သော အစုအဖွဲ့များအပေါ်တွင် သက်ရောက်မှုများ ရှိနိုင်ပါသည်။ ဘော်တွင်းစီမံကိန်း ဆောက်လုပ်ခြင်းနှင့် သတ္တုရိုင်း တူးဖော်ခြင်းကြား ယာယီ တိုက်ဆိုင်နေစဉ် ဆက်စပ်သက်ရောက်မှုများအား ကြုံတွေ့ခံစားရနိုင်ပါသည်။ အခြားသော အဆိုပြုစီမံကိန်းများ၏ တည်နေရာအရ ဆူညံသံနှင့် တုန်ခါမှုဆိုင်ရာ ဆက်စပ် သက်ရောက်မှုများအား တွေ့ရှိရခြင်း မရှိပါ။

လူမှုစီးပွားဆိုင်ရာ

ဘော်တွင်းလုပ်ကွက်အတွင်း သံသတ္တုရိုင်းများ တူးဖော်ခြင်းကြောင့် ရှုခင်းသာယာမှုကို လျော့နည်းစေပြီး စီမံကိန်းတည်ဆောက်နေစဉ်ကာလအတွင်း လမ်းအသုံးပြုမှုနှင့် ယာဉ်အသွားအလာများ တိုးလာနိုင်ပါသည်။ နမ္မတူရှိ စီမံကိန်းများကြောင့် ဆက်စပ်လူမှုစီးပွားဆိုင်ရာ သက်ရောက်မှုများ ဘော်တွင်းစီမံကိန်းထံ သက်ရောက်နိုင်ပါသည်။ အထူးသဖြင့် ဘော်တွင်းလုပ်ကွက်အတွင်း ကျေးရွာများအား နမ္မတူအနီးတစ်ဝိုက်တွင် ပြန်လည်နေရာချထားမည်ဆိုပါက အခြားစီမံကိန်းများမှ ရွှေ့ပြောင်းဝင်ရောက်လာမှုများရှိနိုင်ပြီး သက်သာလွယ်ကူသော နေထိုင်နိုင်မှုအပေါ် သက်ရောက်မှု

များနှင့် လူမှုပေါင်းစည်းညီညွတ်မှု ပြောင်းလဲခြင်းများ ဖြစ်ပေါ်နိုင်ပါသည်။ ကျန်စီမံကိန်းများ တည်ရှိခြင်းကြောင့် အပြုသဘောဆောင်သော သက်ရောက်မှုအနေဖြင့် ဒေသတွင်း အလုပ်အကိုင် အခွင့်အလမ်းများနှင့် အရောင်းအဝယ်များ တိုးပွားလာနိုင်ပါသည်။

ကျန်းမာရေး

သံသတ္တုရိုင်းများတူးဖော်ခြင်းနှင့် တည်ဆောက်ရေးလုပ်ငန်းများမှ သတ္တုဓါတ်ပါဝင်သော အမှုန်အမွှားများ ရှူရှိုက်မိခြင်းကြောင့် ဆက်စပ်ကျန်းမာရေးသက်ရောက်မှုများ ဖြစ်ပွားနိုင်ပါသည်။ ပြန်လည်နေရာချထားရေး အစီအစဉ်အား လိုက်နာဆောင်ရွက်လျှင် ဒေသခံပြည်သူများသည် ဘော်တွင်းစီမံကိန်းမှ သက်ရောက်မှုများ အား အနည်းငယ်သာ ခံစားရနိုင်ပါသည်။ သို့သော်လည်း နမ္မတူအနီးတစ်ဝိုက်တွင် ပြန်လည်နေရာချထားပါက ဝင်းမြင့်မိုရ်စီမံကိန်းမှ ဆောင်ရွက်သည့် သတ္တုရိုင်းများအပါအဝင် Myanmar Apex သတ္တုတူးဖော်ရေးကုမ္ပဏီ လီမိတက်မှ ဆောင်ရွက်သည့် ဇင့်ထုတ်လုပ်ရေးမှထွက်ရှိသည့် လေထုညစ်ညမ်းမှုအား ခံစားရနိုင်ပေမည် ဖြစ်ပါသည်။

လူထုပူးပေါင်းပါဝင်မှု

စီမံကိန်းဆိုင်ရာအချက်အလက်၊ အကြံပြုချက်၊ စီမံကိန်းအကြောင်း ထုတ်ဖော်ချက်များနှင့် ညှိနှိုင်း တိုင်ပင်ခြင်းတို့အား ဆောင်ရွက်နိုင်ရန် ဝင်းမြင့်မိုရ်စက်မှုလုပ်ငန်းကုမ္ပဏီလီမိတက်မှ လူထုပူးပေါင်း ပါဝင်မှု အစီအစဉ် အနေဖြင့် ပြင်ဆင်ထားရှိပါသည်။

သက်ဆိုင်သူများပါဝင်ပတ်သက်ခြင်း

သက်ဆိုင်သူများ ပါဝင်ပတ်သက်ခြင်းဆိုသည်မှာ စီမံကိန်းတွင် ပါဝင်ပတ်သက်သူများ၊ သက်ဆိုင်သူများနှင့် စိတ်ဝင်စားသူများ ပါဝင်ပတ်သက်ခြင်း ဖြစ်ပါသည်။ သက်ဆိုင်သူများ ပါဝင်ပတ်သက်ခြင်း လုပ်ငန်းစဉ်တွင် တာဝန်ယူခြင်း၊ တာဝန်ခံခြင်းနှင့် စဉ်ဆက်မပြတ် သုံးသပ်အကြံပြုချက်များ ပါဝင်ပါသည်။

စီမံကိန်းနှင့် ပတ်သက်ဆက်နွယ်နေသူများနှင့် စီမံကိန်းကြောင့် ထိခိုက်ခံစားရသူများတွင် အောက်ပါတို့ ပါဝင်ပါသည်။

- ဒေသခံများ
- ရပ်ရွာခေါင်းဆောင်များ
- ဘာသာရေးအဖွဲ့များ
- တိုင်းရင်းသားအဖွဲ့များ
- ထိခိုက်လွယ်သော အုပ်စုများ

- အစိုးရအဖွဲ့အစည်းများ
- အစိုးရမဟုတ်သော အဖွဲ့အစည်းများ
- လက်ရှိလုပ်သားများ
- တိုင်းရင်းသားလက်နက်ကိုင်အဖွဲ့အစည်းများ
- ရထားလမ်းတစ်လျှောက် နေထိုင်သည့်ဒေသခံများ
- ပို့ကုန်လမ်းကြောင်းတစ်လျှောက်ဒေသခံများ
- ကန်ထရိုက်တာများ၊ ထောက်ပံ့သူများနှင့် ဝန်ဆောင်မှုပေးသူများ
- သတင်းဌာနများ
- ပိုင်ရှင်များနှင့် ရင်းနှီးမြှုပ်နှံသူများ

တိုင်ပင်ဆွေးနွေးသော နည်းလမ်းများ

စီမံကိန်းအပေါ် ၎င်းတို့၏ စိတ်ဝင်စားမှုနှင့် နားလည်မှု၊ ထိခိုက်နိုင်သည့် ပုံစံ၊ ဘာသာစကားနှင့် တတ်မြောက်မှု စွမ်းရည်တို့ အပေါ်အခြေခံ၍ အစုအဖွဲ့တစ်ခုစီနှင့်တစ်ခု ထိတွေ့ဆက်ဆံရန် သင့်လျော်မှုရှိသော ဆက်သွယ်ရေးနှင့် ညှိနှိုင်းမှု နည်းလမ်းများကို အသုံးပြုထားသည်။ တိုင်ပင်ဆွေးနွေးခြင်း လုပ်ငန်းများတွင် အများပြည်သူများ၏ အမြင်များ ရှာဖွေခြင်းနှင့် စီမံကိန်းဆိုင်ရာ ယေဘုယျအသိပညာပေးခြင်းများ ပါဝင်ပါသည်။

အများပြည်သူများ၏ အမြင်များ ရှာဖွေခြင်းတွင် အောက်ပါနည်းလမ်းများအား အသုံးပြုပါသည် -

- စီမံကိန်းကြောင့် ထိခိုက်ခံစားရသူများနှင့် သက်ဆိုင်သူများပါဝင်သည့် အများပြည်သူတိုင်ပင်ဆွေးနွေးခြင်းအား သုံးကြိမ်ပြုလုပ်ခြင်း၊
- ဝင်းမြင့်မိုရ်မှ တာဝန်ရှိသူများနှင့် Tiger Camp၊ နမ္မတူနှင့် ဘော်တွင်းမှ ဒေသခံများ ဒေသဆိုင်ရာ သတင်းအချက်အလက်များနှင့် ဖွံ့ဖြိုးရေးလုပ်ငန်းများ ဆွေးနွေးတိုင်ပင်ခြင်း
- Stakeholder အစည်းအဝေးများကျင်းပခြင်းနှင့် တစ်ဦးချင်း ရှင်းလင်းတင်ပြခြင်း။
- ဘော်တွင်းနှင့် ကျားစခန်းရွာရှိ လူထုအကျိုးပြုသတင်းအချက်အလက်စင်တာများ
- လူထုအဖွဲ့အစည်းရှိ ဆက်ဆံရေးအရာရှိ
- ရှင်းလင်းတင်ပြချက်များ၊ သတင်းလွှာများနှင့် အချက်အလက်စာရွက်များ အပါအဝင် လူထု သတင်းလွှာများနှင့် ထုတ်ဝေခြင်းများ

- ပတ်ဝန်းကျင်ရှိ ကျေးရွာများနှင့် ဆွေးနွေးညှိနှိုင်းခြင်း၊ လူထုအစည်းအဝေးများပြုလုပ်ခြင်းနှင့် လူမှုစီးပွားစစ်တမ်းကောက်ယူခြင်း အပါအဝင် ပတ်ဝန်းကျင်ထိခိုက်မှု ဆန်းစစ်ခြင်းဆိုင်ရာ အခြေခံ စစ်တမ်းကောက်ယူခြင်း
- လုပ်ငန်းခွင်ဆိုင်ရာ ရှင်းလင်းတင်ပြချက်များနှင့် အစည်းအဝေးများ
- ယေဘုယျ စီမံကိန်းဆိုင်ရာ အသိပညာပေးခြင်းအတွက် အသုံးပြုသော နည်းလမ်းများတွင် အောက်ပါတို့ ပါဝင်သည်။
- စီမံကိန်းဆိုင်ရာ ဗီဒီယိုများ
- WMM ဝက်ဘ်ဆိုဒ်
- Myanmar Metals ASX ၏ ကြေညာချက်များ
- မီဒီယာ အင်တာဗျူးများ
- လူထုဖွံ့ဖြိုးတိုးတက်မှုဆိုင်ရာ စီမံကိန်းများ

စနစ်တကျ အများပြည်သူနှင့် တိုင်ပင်ဆွေးနွေးခြင်း

ပထမအကြိမ် လူထုပူးပေါင်းပါဝင်ခြင်း၏ တစ်စိတ်အပိုင်းအဖြစ် တိုင်ပင်ဆွေးနွေးခြင်း အစည်းအဝေးကို ပြည်ထောင်စု၊ ရှမ်းပြည်နယ်နှင့် မြို့နယ်အစိုးရများ၊ အစိုးရမဟုတ်သော အဖွဲ့အစည်းများ အပါအဝင် စီမံကိန်း၏ အကျိုးသက်ရောက်မှုကို ခံစားရသော ပြည်သူများနှင့် အခြား သက်ဆိုင်သူများ စသည့် ကဏ္ဍပေါင်းစုံဖြင့် ကျင်းပခဲ့သည်။ အစည်းအဝေးပွဲများကို ၂၀၁၉ ခုနှစ် ဇန်နဝါရီလနှင့် ဖေဖော်ဝါရီလတို့တွင် ကျင်းပခဲ့ပါသည်။ ဤပထမအကြိမ် လူထုပူးပေါင်းပါဝင်ခြင်းသည် စီမံကိန်းကို ဖော်ထုတ်ရန်နှင့် စီမံကိန်းအဆိုပြုချက်အပေါ် မြင့်မားသော သတင်းအချက်အလက်များ ထောက်ပံ့ပေးရန် ရည်ရွယ်ပါသည်။

ဒုတိယအကြိမ် အများပြည်သူနှင့်တွေ့ဆုံဆွေးနွေးခြင်းကို ပြုလုပ်ရာတွင် ကိုဗစ်-၁၉ ရောဂါ ဖြစ်ပွားခြင်းကြောင့် အခက်အခဲများ ကြုံတွေ့ခဲ့ရပါသည်။ ဒုတိယအကြိမ် အများပြည်သူနှင့် တွေ့ဆုံဆွေးနွေးခြင်းကို ကိုဗစ်-၁၉ ကာကွယ်ရေး လမ်းညွှန်ချက်များကို လိုက်နာကာ နမ္မတူ အထွေထွေ အုပ်ချုပ်ရေးဦးစီးဌာနနှင့် ပူးပေါင်း၍ ကျင်းပခဲ့ပါသည်။ ဒုတိယအကြိမ်အစည်းအဝေးပွဲကို ဒေသခံ ပြည်သူများ၊ ပြည်ထောင်စု၊ ပြည်နယ်နှင့် မြို့နယ်အစိုးရအဖွဲ့များ၊ အစိုးရမဟုတ်သော အဖွဲ့အစည်းများ၊ စစ်တပ်အပါအဝင် စီမံကိန်း၏ အကျိုးသက်ရောက်မှုကို ခံစားရသော ပြည်သူများနှင့် အခြား သက်ဆိုင်သူများ စသည့်ကဏ္ဍ ပေါင်းစုံဖြင့် ကျင်းပခဲ့ကြသည်။ သီးခြားအစည်းအဝေးများကို အမျိုးသမီးရေးရာအဖွဲ့ချုပ်၏ စီစဉ်ဆောင်ရွက်မှုဖြင့် အမျိုးသမီးဒေသခံပြည်သူများနှင့်အတူ ကျင်းပခဲ့သည်။ သက်ဆိုင်သူများအား ၎င်းတို့၏ အမြင်များ၊ အကြံပြုချက်များနှင့် ထောက်ခံချက်များကို တင်ပြရန် အခွင့်အရေးများ ပေးခဲ့သည်။

ပထမအကြိမ်နှင့် ဒုတိယအကြိမ် အစည်းအဝေးတစ်ခုစီတိုင်းတွင် ရှင်းလင်းတင်ပြချက်များအတွက် မေးခွန်းမေးမြန်းခြင်းနှင့် ပြန်လည်ဖြေကြားခြင်းများ ပြုလုပ်ခဲ့သည်။ တင်ပြချက် ES.10, ES. 11 နှင့် ES.12 တို့တွင် ဘုန်းတော်ကြီးအဖွဲ့အစည်း၊ ဘော်တွင်းနှင့် နမ္မတူ ဒေသခံပြည်သူများနှင့် ပြုလုပ်သည့် အစည်းအဝေးများကို ဖော်ပြထားပါသည်။

တတိယအကြိမ် လူထုတွေ့ဆုံဆွေးနွေးပွဲပြုလုပ်ရာတွင် ကိုဗစ်-၁၉ ရောဂါပိုး ပျံ့နှံ့နှုန်း သိသိသာသာ မြင့်မားလာပြီး ရန်ကုန်မြို့နယ်အတွင်း ကျန်းမာရေးနှင့်အားကစားဝန်ကြီးဌာန၏ အပြင်မထွက်ရ အမိန့်ကြောင့် အခက်အခဲများ ကြုံတွေ့ခဲ့ရသည်။ တွေ့ဆုံဆွေးနွေးခြင်းကို ဆက်လက်ပြုလုပ်နိုင်ရန် အတွက် ကိုဗစ်-၁၉ ကပ်ရောဂါအတွင်း ပတ်ဝန်းကျင်ထိန်းသိမ်းရေးဦးစီးဌာန၏ တွေ့ဆုံဆွေးနွေးခြင်း ဆိုင်ရာ လမ်းညွှန်ချက်များနှင့်အညီ ဒီဂျစ်တယ်တွေ့ဆုံဆွေးနွေးခြင်းကို ပြုလုပ်ခဲ့ပါသည်။ ဒေသခံ ပြည်သူများထံသို့ တင်ပြရန် စီမံကိန်းဆိုင်ရာ လက်ရှိသတင်းအချက်အလက်များကို ရှင်းလင်း တင်ပြချက် ဗီဒီယိုများ ပြုလုပ်ပြီး ဘော်တွင်းနှင့် နမ္မတူဒေသများသို့ memory stick ဖြင့် ကျယ်ပြန့်စွာ ဖြန့်ဝေခဲ့ပြီး ဝင်းမြင့်မိုရ်စက်မှုလုပ်ငန်း ကုမ္ပဏီလီမိတက်၏ ဝက်ဘ်ဆိုဒ်မှတဆင့်လည်း အခြား သက်ဆိုင်သူများထံသို့ ဖြန့်ဝေခဲ့ပါသည်။ ဒေသခံ ပြည်သူများ၏ မေးခွန်းများကို အိမ်ထောင်စု ခေါင်းဆောင်များမှတဆင့် ပတ်ဝန်းကျင်ထိခိုက်မှု ဆန်းစစ်ခြင်းဆိုင်ရာ အကြံပေးပုဂ္ဂိုလ်များထံသို့ ဆက်သွယ်ပြီး ဝင်းမြင့်မိုရ် မှတဆင့် ဖြေကြားခဲ့ပါသည်။

တွေ့ဆုံပွဲရလဒ်များ

ပထမအကြိမ်

ပထမအကြိမ် ညှိနှိုင်းဆွေးနွေးပွဲတွင် အဓိက စိတ်ဝင်စားမှုနှင့် ကိစ္စရပ်များတွင် ပါဝင်သည့်အရာ များမှာ-

- စွန့်ပစ်ပစ္စည်းစီမံခန့်ခွဲမှု၊ ပြုပြင်ထိန်းသိမ်းမှုနှင့် လေ့လာမှု၏ လက်ရှိအဆင့်နှင့် သက်ဆိုင်သည့် မေးမြန်းချက်များအပါအဝင် စီမံကိန်း ဖွံ့ဖြိုးတိုးတက်မှု၊ အခြေခံအဆောက်အအုံ လိုအပ်ချက်များ၊ အပြင်အဆင်နှင့် စီမံကိန်းရေးဆွဲခြင်း၊
- ပြန်လည်နေရာချထားရေးနှင့် လျော်ကြေးပေးချေခြင်း၊
- ဒေသဆိုင်ရာ ဖွံ့ဖြိုးတိုးတက်မှုနှင့် လူနေမှုအဆင့်အတန်းမြင့်မားလာမှု၊ ပညာရေး၊ ကျန်းမာရေး၊ အခြေခံအဆောက်အအုံနှင့် စီးပွားရေး၊
- အလုပ်အကိုင်အခွင့်အလမ်းများ ရရှိလာမှု၊
- လူထုတွေ့ဆုံဆွေးနွေးပွဲ၏ အရေးပါဝင်မှု၊ နားလည်ရန်လွယ်ကူခြင်း (ဘာသာစကားမျိုးစုံဖြင့် ရရှိ နိုင်ခြင်း) နှင့် လူနည်းစုပါဝင်ခြင်း၊
- ဒေသခံပြည်သူနှင့် မြန်မာနိုင်ငံအတွက် အကျိုးအမြတ်များရရှိနိုင်ခြင်းနှင့် ဒေသဆိုင်ရာဖွံ့ဖြိုး တိုးတက်မှုအတွက် စီမံကိန်း၏အရေးပါမှု၊

- မိုင်း ပိတ်သိမ်းခြင်း၊
- စီမံကိန်းအဆိုပြုသူ၏ နောက်ခံအခြေအနေနှင့် ပိုင်ဆိုင်မှု ပုံစံ၊
- ပွင့်လင်းမြင်သာမှုနှင့် ထုတ်ဖော်ခြင်း၊

ဒုတိယအကြိမ်

ဒုတိယအကြိမ် ညှိနှိုင်းဆွေးနွေးပွဲတွင် အဓိကစိတ်ဝင်စားမှုနှင့် ကိစ္စရပ်များတွင် ပါဝင်သည့်အရာများမှာ-

- တည်နေရာအပါအဝင် ပြန်လည်နေရာချထားရေး၊ ပြည်တွင်းပြောင်းရွှေ့နေထိုင်သူများ၊ လျော်ကြေးငွေ၊ တာဝန်ခံမှု၊ သချိုင်းမြေများ ပံ့ပိုးပေးခြင်းနှင့် ဝန်ဆောင်မှုများ၊ ရပ်ရွာအခြေခံ အဆောက်အအုံများနှင့် မြေယာများ ရရှိနိုင်ရေး၊
- ငြိမ်းချမ်းရေး၊ လုံခြုံရေးနှင့် တိုင်းရင်းသားလက်နက်ကိုင်အဖွဲ့များ (EAO)
- လူနည်းစုများပါဝင်မှု၊ အရေးပါမှုအပါအဝင် လူထုံတွေ့ဆုံဆွေးနွေးပွဲများ၊ ဒေသခံပြည်သူများ၏ လိုအပ်ချက်များကို နားလည်ခြင်းနှင့် EIA တွင် ညှိနှိုင်းမှုတွေ့ရှိချက်များကို ပေါင်းစပ်ထည့်သွင်းခြင်း၊
- ပွင့်လင်းမြင်သာမှုနှင့် ထုတ်ဖော်ခြင်း၊
- အလုပ်အကိုင်အခွင့်အလမ်း၊ ရွှေ့ပြောင်းနေထိုင်မှု၊ ကျွမ်းကျင်မှု/လေ့ကျင့်သင်ကြားမှုနှင့် စားဝတ်နေရေး၊
- စွန့်ပစ်ပစ္စည်းနှင့် ရေစီမံခန့်ခွဲမှု၊ အနာဂတ်သတ္တုတူးဖော်ရေး အစီအစဉ်များ၊ ရပ်ရွာထု၏ အခမဲ့၊ ကြိုတင်အသိပေးသဘောတူညီချက်များ အပါအဝင် စီမံကိန်းဖွံ့ဖြိုးတိုးတက်မှု၊ လက်ရှိဖြစ်ပေါ်နေသော ညစ်ညမ်းမှု၊ အခြားရွေးချယ်စရာများ၊ နယ်ပယ်အတိုင်းအတာ သတ်မှတ်ခြင်း၊ အချိန်ကာလ၊ အခြေခံအဆောက်အအုံ လိုအပ်ချက်များ၊ အပြင်အဆင်နှင့် စီမံကိန်းရေးဆွဲခြင်း၊
- ကျန်းမာရေးဆိုင်ရာ အကျိုးသက်ရောက်မှုများ၊ ဒေသတွင်း စီးပွားရေးလုပ်ငန်းများနှင့် ဒေသဆိုင်ရာ ဖွံ့ဖြိုးတိုးတက်မှု၊
- ဘာသာရေးဆိုင်ရာ ယုံကြည်ချက်နှင့် အလေ့အကျင့်များနှင့်အညီ အဆောက်အအုံများ ဖျက်စီးခံရခြင်းနှင့် ယဉ်ကျေးမှုအမွေအနှစ်များ ထိန်းသိမ်းစောင့်ရှောက်ခြင်း၊
- ပတ်ဝန်းကျင်ရှိ ဒေသခံပြည်သူများအတွက် ပညာရေးနှင့် ကျန်းမာရေးဆိုင်ရာ ဝန်ဆောင်မှုများ ရရှိနိုင်မှု၊
- သဘာဝပတ်ဝန်းကျင်/ရပ်ရွာရန်ပုံငွေ စီမံခန့်ခွဲမှုအတွက် အစိုးရ၏မျှော်မှန်းချက်များကို ရှင်းလင်းစွာ နားလည်နိုင်ရေး၊

တတိယအကြိမ်

မြန်မာနိုင်ငံရှိ နိုင်ငံရေးအခြေအနေနှင့်ဆက်စပ်သော လူထုမငြိမ်မသက်မှုများနှင့် ကိုဗစ်-၁၉ ၏ ကန့်သတ်ချက်များ ကြောင့် တတိယအကြိမ် ပြည်သူလူထုနှင့် ညှိနှိုင်းတွေ့ဆုံဆွေးနွေးခြင်းကို အပြီးသတ်ရန် မဖြစ်နိုင်ပါ။ တတိယအကြိမ် ပြည်သူလူထုနှင့် ညှိနှိုင်းတွေ့ဆုံဆွေးနွေးခြင်းကို စတင်ခဲ့သော်လည်း သက်ရောက် ထိခိုက်မှုဆန်းစစ်ခြင်းဆိုင်ရာ တွေ့ရှိချက်များကို ဖြေရှင်းသည့်အပိုင်းကို အထက်ဖော်ပြပါ အကြောင်းအရင်းများကြောင့် ပေးပို့နိုင်ခြင်းမရှိပါ။

Plate ES.10 ဘော်တွင်း လူထုတွေ့ဆုံဆွေးနွေးပွဲ

Plate ES.11 **နမ္မတူ လူထုတွေ့ဆုံဆွေးနွေးပွဲ**

Plate ES.12 ရွာဦးဘုန်းကြီးအစီအစဉ်ဖြင့် ဒေသခံပြည်သူများနှင့် တွေ့ဆုံဆွေးနွေးခြင်း

သဘာဝပတ်ဝန်းကျင်နှင့် လူမှုရေးဆိုင်ရာ စီမံခန့်ခွဲမှု ဖွဲ့စည်းမှု/မူဘောင် (ESMF)

သဘာဝပတ်ဝန်းကျင်နှင့် လူမှုရေးဆိုင်ရာ စီမံခန့်ခွဲမှု ဖွဲ့စည်းမှု/မူဘောင်

သဘာဝပတ်ဝန်းကျင်နှင့် လူမှုရေးဆိုင်ရာ စီမံခန့်ခွဲမှု မူဘောင်သည် အခန်းကဏ္ဍနှင့် တာဝန်များ၊ စီမံခန့်ခွဲမှုနည်းလမ်းများနှင့် လုပ်ဆောင်မှုရလဒ်များကို သတ်မှတ်ရန်အတွက် ဥပဒေပြုရေး၊ သက်ဆိုင်သူများနှင့် သဘာဝပတ်ဝန်းကျင်နှင့် လူမှုရေးဆိုင်ရာ စီမံခန့်ခွဲမှုအစီအစဉ် (ESMP) တွင် ဖြေရှင်းမည့် ကောင်းမွန်သည့် အလေ့အကျင့်ကောင်းများနှင့် တိုးတက်ဖွံ့ဖြိုးမှုများရှိသည့်နေရာများ တွင် လုပ်ဆောင်မှုများကို ဆက်လက်စောင့်ကြည့်ရန် နည်းလမ်းတစ်ခုဖြင့် စီမံကိန်းကို ထောက်ပံ့ပေး သည်။ မူဘောင်သည် သဘာဝပတ်ဝန်းကျင်နှင့် လူမှုရေးဆိုင်ရာ စီမံခန့်ခွဲမှုအစီအစဉ်ကို လွှမ်းခြုံပြီး အကောင်အထည်ဖော်ဆောင်ရွက်ထားသည်။ (Attachment 4)

သဘာဝပတ်ဝန်းကျင်နှင့် လူမှုရေးဆိုင်ရာ စီမံခန့်ခွဲမှု မူဘောင်သည် စီမံကိန်း၏ အဆင့်အားလုံး- တည်ဆောက်ရေး မစတင်ခင် အဆင့် (အစီအစဉ်ရေးဆွဲခြင်းနှင့် အတည်ပြုချက်ရရှိခြင်း)၊ တည်ဆောက်ရေး အဆင့် (အကောင်အထည်ဖော်ခြင်း)၊ လုပ်ငန်းလည်ပတ်ခြင်းအဆင့် (သတ္တု တူးဖော်ခြင်းနှင့် ထုတ်လုပ်ခြင်း)၊ ဖျက်သိမ်းခြင်းအဆင့်၊ ပိတ်သိမ်းခြင်းအဆင့်နှင့် ပိတ်သိမ်းပြီးသည့် အဆင့် တို့တွင် အသုံးပြုနိုင်သည်။ သဘာဝပတ်ဝန်းကျင်နှင့် လူမှုရေးဆိုင်ရာ စီမံခန့်ခွဲမှု မူဘောင်သည် ဝင်းမြင့်မိုရ်၏ မူဝါဒများနှင့် လုပ်ထုံးလုပ်နည်းများကို မြန်မာနိုင်ငံ၏ ဥပဒေများ၊ လမ်းညွှန်ချက်များနှင့် စံချိန်စံညွှန်းများအပြင် နိုင်ငံတကာဆိုင်ရာ လမ်းညွှန်ချက်များနှင့် စံချိန်စံညွှန်းများကို ပေါင်းစပ်ခြင်း ဖြင့် သဘာဝပတ်ဝန်းကျင်၊ လူမှုရေးနှင့် ယဉ်ကျေးမှုဆိုင်ရာ စီမံခန့်ခွဲမှုများကို အကောင်အထည် ဖော်ရန် လမ်းညွှန်ထားသည်။ သဘာဝပတ်ဝန်းကျင်နှင့် လူမှုရေးဆိုင်ရာ စီမံခန့်ခွဲမှု မူဘောင်(ESMF) နှင့် သဘာဝပတ်ဝန်းကျင်နှင့် လူမှုရေးဆိုင်ရာ စီမံခန့်ခွဲမှုအစီအစဉ် (ESMP) တို့သည် သဘာဝ ပတ်ဝန်းကျင်၊ လူမှုအသိုင်းအဝိုင်းနှင့် ယဉ်ကျေးမှုဆိုင်ရာ အမွေအနှစ်များနှင့်သက်ဆိုင်သည့် စီမံကိန်းပိုင်ရှင်၏ မူဝါဒနှင့် လုပ်ထုံးလုပ်နည်းများနှင့် ကိုက်ညီသည်။

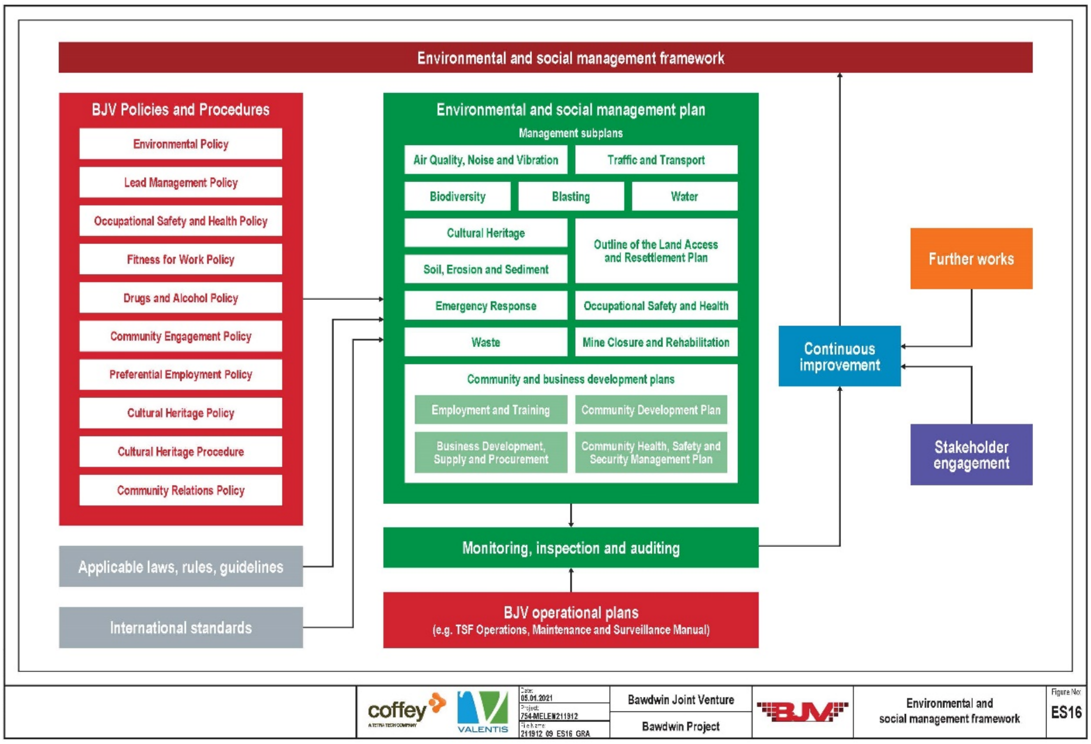
သဘာဝပတ်ဝန်းကျင်နှင့် လူမှုရေးဆိုင်ရာ စီမံခန့်ခွဲမှုအစီအစဉ် (ESMP)

- သဘာဝပတ်ဝန်းကျင်နှင့် လူမှုရေးဆိုင်ရာ စီမံခန့်ခွဲမှုအစီအစဉ် (see Attachment 4) သည် စီမံကိန်း၏ အဆင့်အားလုံးအတွင်း အဓိကကျသော သဘာဝပတ်ဝန်းကျင်ဆိုင်ရာ၊ လူမှုရေး ဆိုင်ရာနှင့် ယဉ်ကျေးမှုဆိုင်ရာရှုထောင့်များအတွက် လိုအပ်ချက်များ၊ ပေါင်းစပ် စီမံခန့်ခွဲခြင်း၊ စောင့်ကြပ်ကြည့်ရှုခြင်း၊ စစ်ဆေးခြင်းနှင့် အစီရင်ခံစာတင်သွင်းခြင်း လုပ်ငန်းစဉ်များ ကို ဖော်ပြထားသည်။ သဘာဝပတ်ဝန်းကျင်နှင့် လူမှုရေးဆိုင်ရာ စီမံခန့်ခွဲမှုအစီအစဉ် (ESMP)တွင် အောက်ပါအချက်များ ပါဝင် သည်။
- စီမံကိန်းအဆင့်များ

- သဘာဝပတ်ဝန်းကျင်ဆိုင်ရာ၊ လူမှုရေးဆိုင်ရာ၊ ကျန်းမာရေးနှင့် ယဉ်ကျေးမှုအမွေအနှစ်ဆိုင်ရာ စီမံခန့်ခွဲမှုအတွက် မူဝါဒနှင့် စည်းမျဉ်းမူဘောင်
- သဘာဝပတ်ဝန်းကျင်နှင့် လူမှုရေးဆိုင်ရာ စီမံခန့်ခွဲမှုအစီအစဉ် (ESMP) ကို အကောင်အထည်ဖော် ဆောင်ရွက်နေသည့် ပုဂ္ဂိုလ်များ၏ တာဝန်များ
- စီမံကိန်းနှင့်သက်ဆိုင်သော သက်ရောက်မှုများနှင့် အန္တရာယ်များ အကျဉ်းချုပ်နှင့် လျော့ချရေး နည်းလမ်းများ
- သဘာဝပတ်ဝန်းကျင်နှင့် လူမှုရေးဆိုင်ရာ စီမံခန့်ခွဲမှုအစီအစဉ် (ESMP) ကို အကောင်အထည်ဖော် ဆောင်ရွက်ခြင်းအတွက် ယေဘုယျ ကုန်ကျစရိတ်
- စောင့်ကြပ်ကြည့်ရှုခြင်းနှင့် အစီရင်ခံစာတင်သွင်းခြင်းစနစ်ကို အကောင်အထည်ဖော်သွားမည်။
- ကွဲပြားခြားနားသော ပတ်ဝန်းကျင်ဆိုင်ရာ၊ လူမှုစီးပွားရေးဆိုင်ရာ၊ ကျန်းမာရေးနှင့် ယဉ်ကျေးမှု အမွေအနှစ်ဆိုင်ရာရှုထောင့်များအတွက် သီးခြားလျော့ပါးသက်သာစေရေးနှင့် စီမံခန့်ခွဲမှု လိုအပ်ချက်များကို ကိုင်တွယ်ဖြေရှင်းမည့် အစီအစဉ်ခွဲများ

ပုံ ES.16 တွင် သဘာဝပတ်ဝန်းကျင်နှင့် လူမှုရေးဆိုင်ရာ စီမံခန့်ခွဲမှုမူဘောင်နှင့် ဆက်စပ်သည့် စီမံခန့်ခွဲမှုဆိုင်ရာအစီအစဉ်များ၏ ခြုံငုံသုံးသပ်ချက်များကို ဖော်ပြထားသည်။

သဘာဝပတ်ဝန်းကျင်ဆိုင်ရာနှင့် လူမှုရေးဆိုင်ရာ စီမံခန့်ခွဲမှု ချဉ်းကပ်မှုတွင် စည်းမျဉ်းစည်းကမ်း၊ ကတိကဝတ်များ နှင့်အညီ လိုက်နာဆောင်ရွက်ခြင်း၊ စောင့်ကြပ်ကြည့်ရှုမှုရလဒ်များကို အစီရင်ခံစာ တင်သွင်းခြင်းနှင့် မှတ်တမ်းတင်ခြင်း၊ စစ်ဆေးခြင်း၊ စောင့်ကြပ်ကြည့်ရှုခြင်းတို့ ပါဝင်ပါသည်။ ခွင့်ပြုမိန့်နှင့် စည်းမျဉ်းစည်းကမ်းများနှင့်အညီ သရုပ်ဖော်ပြသရန်နှင့် စီမံခန့်ခွဲမှုနည်းလမ်း၏ အကျိုး သက်ရောက်မှုများကို ဆုံးဖြတ်ရန်၊ ပတ်ဝန်းကျင်ထိခိုက်မှုဆန်းစစ်ခြင်းတွင် ပြုလုပ်ထားသော ခန့်မှန်းချက်များကို စိစစ်ရန်နှင့် သက်ရောက်မှုများကို တိုင်းတာရန် ဆောင်ရွက်သွားမည်ဖြစ်ပါသည်။



ပုံ ES.16 သဘာဝပတ်ဝန်းကျင်ဆိုင်ရာနှင့် လူမှုရေးဆိုင်ရာ စီမံခန့်ခွဲမှု မူဘောင်

Bawdwin Project

Environmental Impact Assessment
Chapter 1

October 2023

Bawdwin Project

Prepared for

Win Myint Mo Industries Company Limited

Prepared by	Revised by
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Quality information

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v2	EIA Chapter 1	24/12/2020	Michael Sale	Tara Halliday	Tara Halliday
V3	EIA Chapter 1	05/02/2021	Anna Gallagher	Tara Halliday	Tara Halliday
Rev0	EIA Chapter 1	05/02/2021	Anna Gallagher	Tara Halliday	Tara Halliday
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1 Introduction

Win Myint Mo Industries Company Limited (WMM) propose to redevelop the 600-year old Bawdwin mine (termed the 'Bawdwin project'), a lead-zinc-silver mine in northern Shan State, Myanmar. The lead, zinc, copper and silver mineral resource at Bawdwin is estimated at approximately 100 million tonnes (Mt). The existing Bawdwin mine has an open pit, underground workings and associated processing infrastructure. The existing mine has been in care and maintenance, i.e., with no mining taking place, from 2009 up until 2020.

The Bawdwin project will involve expansion of the existing open pit and construction of new mineral processing and supporting infrastructure. The starter open-pit mine has a proposed 13-year mine life and will process ore at a rate of up to 3.0 Mt per annum (Mtpa). Pending further exploration, there is the potential for further expansion of the open pit and the development of an underground mining operation, which would extend the life of the mine up to 50 years.

This Environmental Impact Assessment (EIA) has been prepared in accordance with the Environmental Impact Assessment Procedure (2015) (EIA Procedure) legislated by the Myanmar *Environmental Conservation Law 2012*.

This EIA will be used to inform a decision by the Minister of Natural Resources and Environmental Conservation on whether the Bawdwin project should proceed and if so, under what conditions.

This chapter provides background information on the proponent (WMM), an overview of the project and its history, justification of the project, statutory context and information on the objectives and structure of the EIA.

1.1 History of mining at Bawdwin

The Bawdwin mine is one of the longest operating and most important base metal mines in the world with a history of mining dating back to the beginning of the fifteenth century. The history of the Bawdwin mine can be separated into five broad phases:

- The early discovery and possible working of the ore interpreted from the archaeological record.
- Chinese mining commencing in 1412 and continuing until 1868.
- Limited minor workings by the Kachin and Shan people between 1868 to1901.
- British colonial period and post-colonial period from 1901 until the nationalisation of the mine in 1962.
- Nationalised period of the mine from 1962 to 2009.

Since 31st December 2009, the current production sharing agreement of the mine has been in place between Number 1 Mining Enterprise (ME-1), a State-owned mining enterprise under the Ministry of Natural Resources and Environmental Conservation (MONREC) and WMM. Mining of oxide resource under this agreement by WMM is likely to commence in mid-2021.

A summary of the history of the Bawdwin mine is presented in **Error! Reference source not found.**.

Error! Reference source not found. to **Error! Reference source not found.** depict the existing environment at Bawdwin mine, including the steep terrain and Nam Pangyun valley, the open pit and supporting infrastructure of historic value.

Table 1. 1 Summary of the history of the Bawdwin mine

Period	Description
500 – 1300s	Between the fifth and thirteenth centuries the region in which Bawdwin is located was ruled by the Shan people. Based on historical sources mining at Bawdwin was not undertaken during this period. The area came under Chinese control following an invasion in 1343 A.D.
1400s – 1800s	Based on a stone inscription mining commenced in 1412 A.D., during the Ming Dynasty. Although the ore was rich in lead, the Chinese only focussed on recovering the silver deposits, which once smelted were taken back to China, while the lead-rich slag was left behind. Chinese mined silver by constructing short tunnels into the sides of the Nam Pangyun valley and ER valley. The ore was smelted onsite and slag disposed in dumps which have eroded and dispersed in the Nam Pangyun. Mining and smelting continued for the next 450 years, with some royalties paid to the King of Ava, but the rebellion and civil war in Yunnan in about 1868 lead to the abandonment of the mines. Between 1868 to1880s, there was likely to be limited small scale mining by Kachin/Shan people.
1900 to 1909	The British annexed Upper Burma in 1886, and at the turn of the nineteenth century Bawdwin began to attract attention of mineral explorers, initially due to the lead-rich slag heaps left behind by the Chinese, and later for the ore lodes themselves that still held considerable mineral resources. A succession of companies attempted to re-open and develop the mine, with the notable presence of American Herbert Hoover (later the 31st President of the United States of America). Industrial ore extraction and lead production began in the early 1900s. Construction of a railway down the valley of the Nam Pangyun between Bawdwin and Namtu and then on to the junction with the Burma Railways at Namyao began in 1905. By 1908, 42 miles of the railway were completed and the bridge crossing the Myitnge River at Namtu was half-complete. The first smelting at a furnace at Mandalay took place in February 1909 and the railway was completed by the end of 1909. After two years of operation, the smelters were moved from Mandalay to Namtu, reducing the distance slag and ore needed to be transported. A lead refinery was subsequently added to the Namtu plant in 1909.
1910 to 1938	In 1914, Burma Corporation became the owners of the mine and constructed the Tiger Tunnel into the underground workings (completed in 1918), which allowed efficient access to the massive lead-zinc-silver China Lode orebody, with transport of ore to Namtu for concentration, smelting and refining. The period between 1928 and 1938 were the most stable and productive years of the mine, when production reached its peak of approximately 500,000 tons of ore being processed each year.
1942 to 1950	In 1942, the Japanese invaded and took over the mine. The retreating British attempted to disable vital elements of the mine infrastructure, including the Mansam Falls power station and the processing plant, and further damage was caused by Allied bombing. The Japanese continued to

Period	Description
	operate the mine, but at a reduced production compared to pre-war production. After the end of the war, the Burma Corporation resumed possession of the mine, but production was slow to restart. War damage had to be repaired, and the political situation in the country deteriorated after independence was achieved in 1948.
1950s	In 1951 a new company, the Burma Corporation was created as a joint venture, with the Government of the Union of Burma having a half-share. In 1965 the mine was nationalized. By the 1950s the rich ore lodes were becoming depleted, and several prospecting programmes were undertaken to identify any new ore bodies. While knowledge of the existing bodies was enhanced, no rich new lodes were found.
1980s to 2009	In the 1980s an open pit mine (known as the Gossan Quarry) was started to exploit the low-grade ore halo that surrounded the old Chinaman Lode. A waste rock dump is located southeast of the open pit mine at the head of ER valley. A concentrator plant was constructed at Bawdwin mine about 1980 to enable the low-grade oxide ore to be processed on site. The concentrator plant includes crushing, grinding and flotation separation units. Mineral concentrate was transported by rail to Namtu for smelting to refine lead, antimonial lead, and silver, with copper matte and nickel speiss as by-products. Zinc concentrate was shipped as unrefined product. Tailings from the 1980s concentrator plant were initially disposed to the Nam Pangyun, with later deposition in the Bawdwin underground mine workings. Production at Bawdwin concentrator plant ceased in 2009 with the closure of the open pit operation.
2010 to present	ME-1 is a State-owned mining enterprise under MONREC who oversees the production and marketing of nonferrous metals, such as zinc and lead. ME 1 and WMM entered into a production sharing contract on December 31, 2009. Since that time, the mine and processing facilities have been in care and maintenance. The workforce has been retained under the production sharing permit and contract conditions, and conduct care and maintenance activities. In June 2018, WMM, Myanmar Metals and EAP entered into a contractual agreement to form a joint venture arrangement (BJV) for the purposes of developing the Bawdwin project. In late 2020, WMM commenced construction of a haul road to support a small-scale mining operation to develop the oxide resources of the existing pit ahead of the Bawdwin project development. Oxide mining and crushing by WMM is expected to commence in mid-2021 and will continue until the Bawdwin project commences ore mining. The oxide mining operation is being undertaken under existing licencing and approvals and is outside the scope of this EIA.

1.2 Project proponent

The project proponent is WMM, currently holds the production sharing permit and contract with ME-1 of MONREC to undertake production of lead, zinc and silver at the Bawdwin mine. The contract was entered into on 31st December 2009 and commits WMM to a minimum annual production. The contract and permit details are:

> *Production Sharing Contract on production and processing of Lead and Zinc in Namtu Bawdwin Mine Contract No 59, dated 31 December 2009 as updated and amended on 16 June 2011 and 11 March 2015.*

Since entering into the contract, WMM completed one small exploration drilling campaign in 2010, in which seven holes were drilled using a conventional drilling machine. A larger resource drilling campaign commenced in 2016 when WMM contracted Valentis to produce a resource estimate in accordance with the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves ('the JORC Code')[1]. This resource drilling was continued by Valentis into the Scoping Phase of the project (2017 to 2018)) and then subsequently into feasibility level resource drilling in 2019 and 2020. In 2020, WMM commenced preparatory works for small scale mining of the oxide resource within the existing pit. The preparatory works includes construction of a haul road which largely follows the existing road to the open pit.

The information for the directors of the WMM is shown in Plate 1. 1 Step terrain near Bawdwin

Plate 1. 2 Nam Pangyun valley facing Bawdwin upper village and the open pit

[1] The JORC Code is a professional code of practice that sets minimum standards for Public Reporting of minerals Exploration Results, Mineral Resources and Ore Reserves.

Plate 1. 3 Marmion Shaft headframe and winding house

DIRECTORATE OF INVESTMENT AND COMPANY ADMINISTRATION

Myanmar Companies Online Registry - Company Extract

Company Name (English)
WIN MYINT MO INDUSTRIES COMPANY LIMITED

Company Name (Myanmar)
ဝင်းမြင့်မိုရ် စက်မှုလုပ်ငန်း ကုမ္ပဏီလီမိတက်

Company Information

Registration Number	**Registration Date**	**Status**
112358587	25/03/2008	Registered
Company Type	**Foreign Company**	**Small Company**
Private Company Limited by Shares	No	No
Principal Activity	**Date of Last Annual Return**	**Previous Registration Number**
08 - Other mining and quarrying 09 - Mining support service activities 07 - Mining of metal ores	08/04/2022	1928/2007-2008

Addresses

Registered Office In Union

THEIN PHYU ROAD, NO.36
PAZUNDAUNG TOWNSHIP, YANGON REGION, MYANMAR
Email Address: nihc.document@gmail.com
Telephone Number: (95-1)8610656-59

Officers

Name:	DAW AYE NYEIN THU	Type:	DIRECTOR
Date of Appointment:	16/08/2019	Date of Birth:	10/10/1993
Nationality:	MYANMAR	N.R.C./Passport:	12/THAGAKA(N)181391
Gender:	FEMALE	Business Occupation:	-
Name:	DAW NILAR KYAW	Type:	DIRECTOR
Date of Appointment:	N/A	Date of Birth:	28/08/1974
Nationality:	MYANMAR	N.R.C./Passport:	1/MANYANA(N)000920
Gender:	FEMALE	Business Occupation:	-
Name:	U HLA MYINT	Type:	DIRECTOR
Date of Appointment:	N/A	Date of Birth:	29/12/1952
Nationality:	MYANMAR	N.R.C./Passport:	12/LAMATA(N)019829
Gender:	MALE	Business Occupation:	-
Name:	U KYAW MYINT OO	Type:	DIRECTOR
Date of Appointment:	16/08/2019	Date of Birth:	01/05/1978
Nationality:	MYANMAR	N.R.C./Passport:	12/LAMATA(N)003040
Gender:	MALE	Business Occupation:	-
Name:	U KYAW SE	Type:	DIRECTOR

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DIRECTORATE OF INVESTMENT AND COMPANY ADMINISTRATION

Myanmar Companies Online Registry - Company Extract

Company Name (English)	**Company Name (Myanmar)**
WIN MYINT MO INDUSTRIES COMPANY LIMITED	ဝင်းမြင့်မိုရ် စက်မှုလုပ်ငန်း ကုမ္ပဏီလီမိတက်

Date of Appointment:	N/A	Date of Birth:	12/09/1979
Nationality:	MYANMAR	N.R.C./Passport:	7/PAMANA(N)097931
Gender:	MALE	Business Occupation:	-
Name:	U KYAW SEIN	Type:	DIRECTOR
Date of Appointment:	10/11/2022	Date of Birth:	18/02/1967
Nationality:	MYANMAR	N.R.C./Passport:	9/MAMANA(N)077691
Gender:	MALE	Business Occupation:	-
Name:	U KYAW WIN AUNG	Type:	DIRECTOR
Date of Appointment:	22/12/2021	Date of Birth:	03/07/1983
Nationality:	MYANMAR	N.R.C./Passport:	13/LAYANA(N)100197
Gender:	MALE	Business Occupation:	-
Name:	U MAUNG KYAY@ TEE KAR KWAY	Type:	DIRECTOR
Date of Appointment:	N/A	Date of Birth:	02/04/1954
Nationality:	MYANMAR	N.R.C./Passport:	12/LATHANA(N)018174
Gender:	MALE	Business Occupation:	-
Name:	U SAW LIN	Type:	DIRECTOR
Date of Appointment:	10/11/2022	Date of Birth:	14/05/1980
Nationality:	MYANMAR	N.R.C./Passport:	13/TAYANA(N)023814
Gender:	MALE	Business Occupation:	-
Name:	U SEIN MYINT	Type:	DIRECTOR
Date of Appointment:	10/11/2022	Date of Birth:	24/08/1966
Nationality:	MYANMAR	N.R.C./Passport:	13/KAKHANA(N)009939
Gender:	MALE	Business Occupation:	-
Name:	U THAN MYINT@ KHAW TIN EAIN	Type:	DIRECTOR
Date of Appointment:	N/A	Date of Birth:	11/11/1948
Nationality:	MYANMAR	N.R.C./Passport:	12/LAMATA(N)027772
Gender:	MALE	Business Occupation:	-

Ultimate Holding Company

Name of Ultimate Holding Company	**Jurisdiction of Incorporation**	**Registration Number**
-	-	-

Share Capital Structure

Total Shares Issued by Company	**Currency of Share Capital**
40,817	MMK

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Plate 1. 1 Step terrain near Bawdwin

Plate 1. 2 Nam Pangyun valley facing Bawdwin upper village and the open pit

Plate 1. 3 Marmion Shaft headframe and winding house

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Nationality:	MYANMAR	N.R.C./Passport:	12/LAMATA(N)019829
Gender:	MALE	Business Occupation:	-
Name:	U KYAW MYINT OO	Type:	DIRECTOR
Date of Appointment:	16/08/2019	Date of Birth:	01/05/1978
Nationality:	MYANMAR	N.R.C./Passport:	12/LAMATA(N)003040
Gender:	MALE	Business Occupation:	-
Name:	U KYAW SE	Type:	DIRECTOR

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Name:	U KYAW SEIN	Type:	DIRECTOR
Date of Appointment:	10/11/2022	Date of Birth:	18/02/1967
Nationality:	MYANMAR	N.R.C./Passport:	9/MAMANA(N)077691
Gender:	MALE	Business Occupation:	-
Name:	U KYAW WIN AUNG	Type:	DIRECTOR
Date of Appointment:	22/12/2021	Date of Birth:	03/07/1983
Nationality:	MYANMAR	N.R.C./Passport:	13/LAYANA(N)100197
Gender:	MALE	Business Occupation:	-
Name:	U MAUNG KYAY@ TEE KAR KWAY	Type:	DIRECTOR
Date of Appointment:	N/A	Date of Birth:	02/04/1954
Nationality:	MYANMAR	N.R.C./Passport:	12/LATHANA(N)018174
Gender:	MALE	Business Occupation:	-
Name:	U SAW LIN	Type:	DIRECTOR
Date of Appointment:	10/11/2022	Date of Birth:	14/05/1980
Nationality:	MYANMAR	N.R.C./Passport:	13/TAYANA(N)023814
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Nationality:	MYANMAR	N.R.C./Passport:	12/LAMATA(N)027772
Gender:	MALE	Business Occupation:	-

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Name of Ultimate Holding Company	Jurisdiction of Incorporation	Registration Number
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Share Capital Structure

Total Shares Issued by Company	Currency of Share Capital
40,817	MMK

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Figure 1. 1 Board of Directors of the Win Myin Mo Industries Company Limited

WMM is negotiating with No.1 Mining Enterprise (ME1) to sign a new Production Sharing Agreement for the Bawdwin Mine and approval will be sought from the Myanmar Investment Commission.

In the initial 13-year starter pit mining phase, WMM proposes to redevelop the existing Bawdwin mine and construct a new processing plant. Redevelopment will involve demolition of some existing infrastructure and construction of new infrastructure to support mining and processing activities.

1.2.1 Win Myint Mo Industries Company Limited

Under the current production sharing contract, WMM holds a 38 square kilometre (km^2) mining concession over the Bawdwin mine and concessions over the Namtu smelter complex and associated infrastructure including power stations, transmission lines and railways.

WMM is part of National Infrastructure Holdings Company Limited (NIHC) which is a Myanmar investment group focused on infrastructure-related projects such as highways, energy, retail, logistics, mining, dry port, and construction.

Founded in 2015, NIHC is one of the largest infrastructure conglomerates in Myanmar. Headquartered in Yangon with office locations in Naypyitaw, Mandalay, Lashio, Kyaukme, Muse, and Pathein, NIHC has over 4,000 employees.

The contact details for WMM are:

Name: Win Myint Mo Industries Company Limited
Address: Thein Phyu Road, 36, Yangon, Myanmar
Contact: Aye Nyein Thu, email: anthu@nihcmm.com

Attachment (3)

ကုမ္ပဏီမှတ်ပုံတင်လက်မှတ်

Certificate of Incorporation

ဝင်းမြင့်မိုရ် စက်မှုလုပ်ငန်း ကုမ္ပဏီလီမိတက်

WIN MYINT MO INDUSTRIES COMPANY LIMITED

Company Registration No. 112358587

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This is to certify that

WIN MYINT MO INDUSTRIES COMPANY LIMITED

was incorporated under the Myanmar Companies Act 1914 on 25 March 2008 as a Private Company Limited by Shares.

ကုမ္ပဏီမှတ်ပုံတင်အရာရှိ

Registrar of Companies

ရင်းနှီးမြှုပ်နှံမှုနှင့်ကုမ္ပဏီများညွှန်ကြားမှုဦးစီးဌာန

Directorate of Investment and Company Administration

Former Registration No. 1928/2007-2008

Figure 1. 2 Certificate of Incorporation of Win Myint Mo Industries Co. Ltd.

1.3 Project overview

The existing Bawdwin mine comprises an open pit and associated processing and ancillary infrastructure that have been in care and maintenance from 2009 up to 2020. The mining and processing operations have profoundly shaped the local biophysical and socioeconomic environment and provided a source of employment and physical infrastructure that supports Bawdwin village and parts of Namtu town.

1.3.1 Location

The Bawdwin project is located in northern Shan State approximately 385 km northeast of the capital of Myanmar, Naypyitaw, approximately 170 km northeast of Mandalay and 160 km west from the Chinese border. The mine is approximately 11 km east of Namtu, which is approximately 40 km east of Lashio, the capital of Shan State, as shown in **Error! Reference source not found.**.

The Bawdwin ore bodies lie within a broad northwest-trending zone of mineralization that is approximately 2.5 km long and 200 m wide. The ore deposit consists of three massive bodies of sulfidic high-grade lead-zinc ore bodies: from north to south the Shan Lode, the China Lode, and the Meingtha Lode. A fourth lode, the Chin Lode, is found further to the north and has distinct mineralization.

1.3.2 Project overview

WMM proposes to develop the existing Bawdwin mine into a modern mining operation. The redevelopment will involve the demolition of some of the existing infrastructure and construction of new infrastructure at Bawdwin to support mining and processing activities.

The project will involve open pit mining for an initial 13-year mine life and is expected to process 35.8 Mt of ore to produce lead-silver concentrate and bulk zinc concentrate. The redevelopment will include the expansion of the existing open pit from approximately 54 acres to at least 242.7 acres (21.9 ha to 95.9 ha). The expansion will extract mainly fresh sulphide ore and some transitional ore from the halo zone around the China Lode and if proven feasible will lead to further mining to extract ore in the Shan, Meingtha and potentially Chin lodes.

A new processing plant and run-of-mine ore stockpile will be located 3 km northwest of the open pit. The proposed layout is depicted in **Error! Reference source not found.** and **Error! Reference source not found.**. Run-of-mine ore will be delivered by a front-end loader, which will then discharge to a primary crusher. Processing of the ore will involve crushing and grinding followed by separate lead-silver and bulk zinc flotation circuits. Reagents will be used in the lead-silver and bulk zinc flotation circuits. Tailings produced by the processing plant will be piped to one of three tailings storage facilities. The waste rock will be stored in an engineered waste rock dump within the adjacent Wallah Valley.

WMM will source the workforce for the project from the existing mine communities, supplemented where necessary with experienced personnel from other locations.

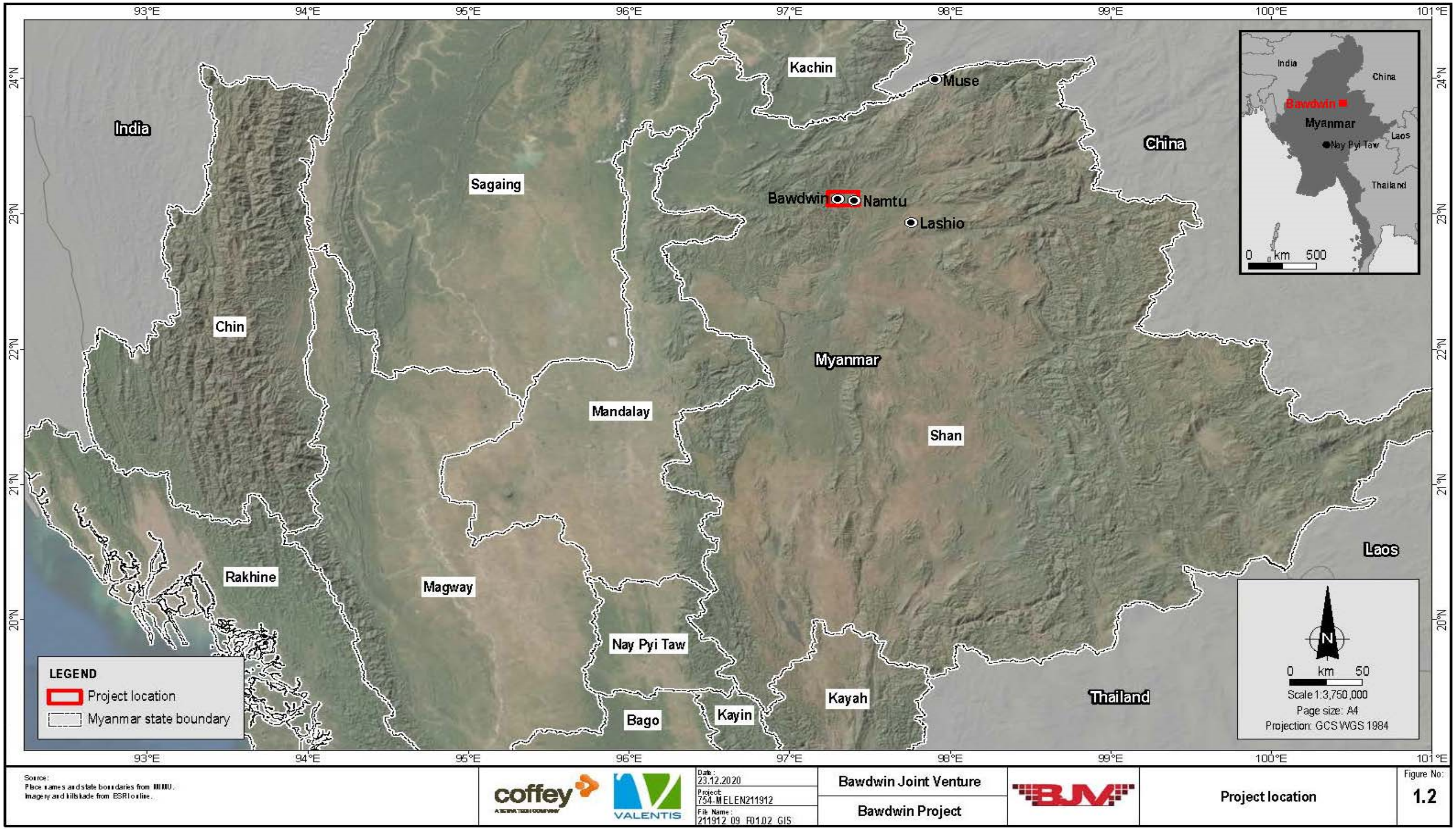

Figure 1. 3 Project location

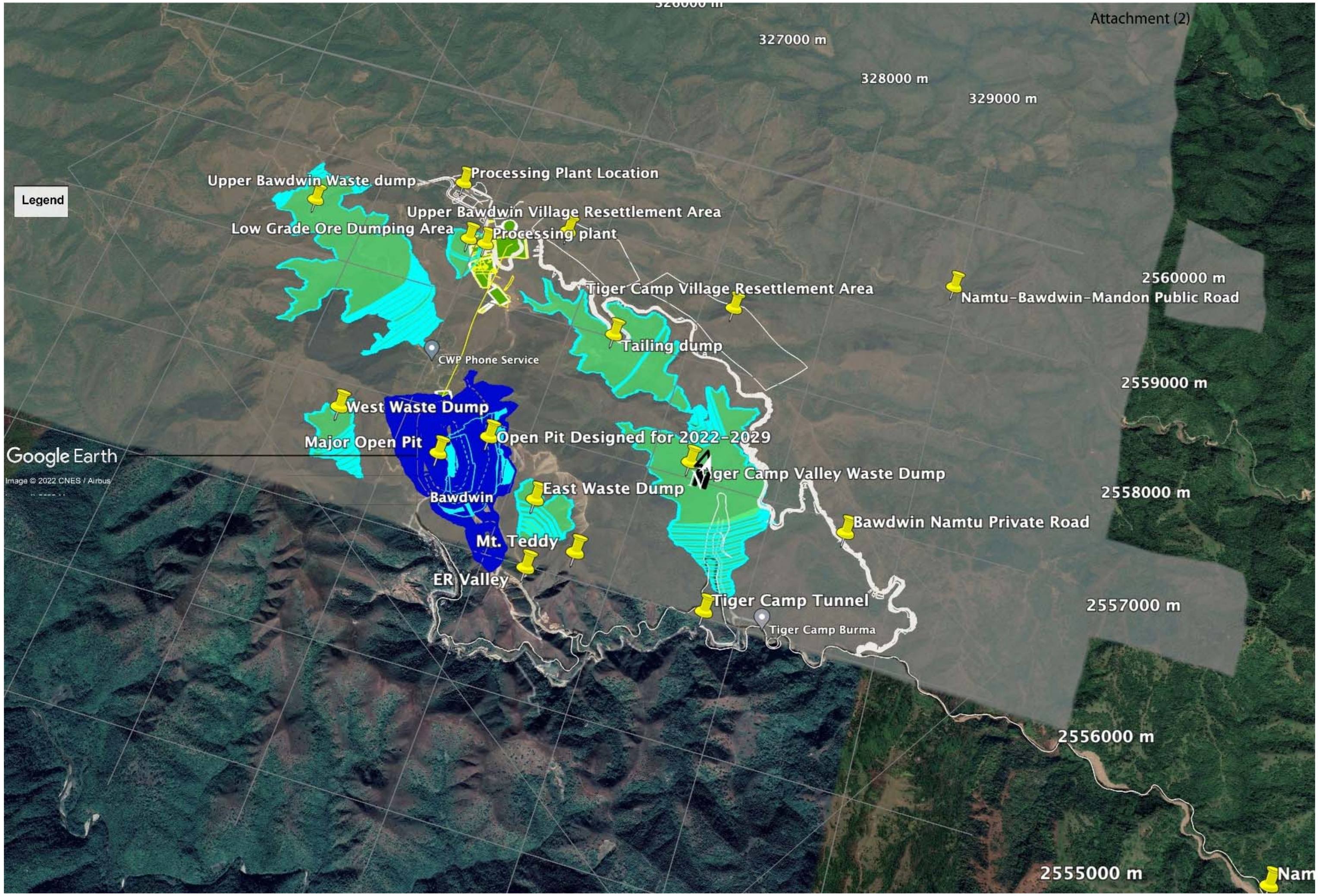

Figure 1. 4 Proposed project layout

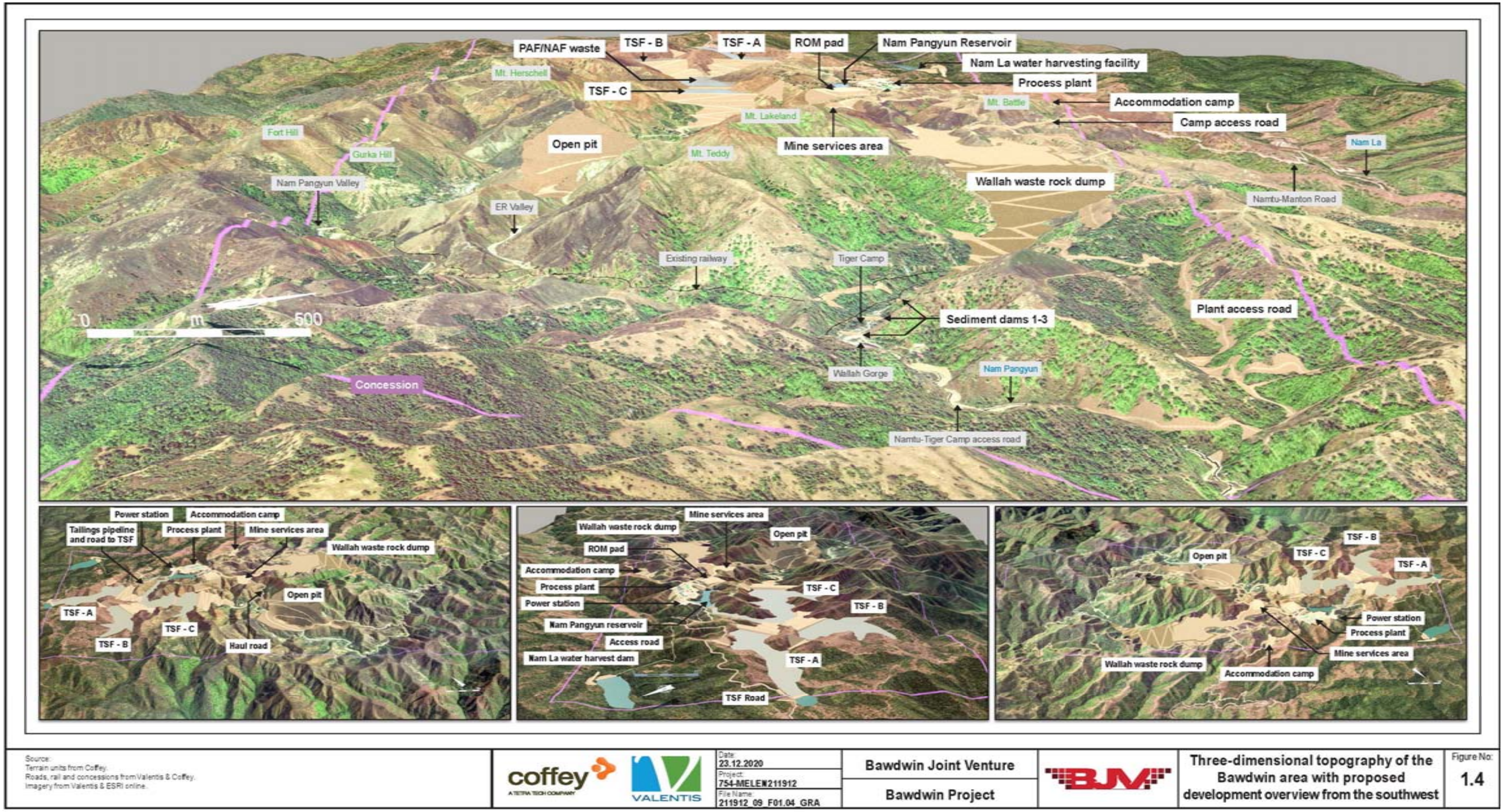

Figure 1. 5 Three-dimensional topography of the Bawdwin area with proposed development from the southwest

On cessation of mining, all surface infrastructure will be dismantled and disposed, with reusable and recyclable materials sold. Mine closure will be conducted in accordance with an approved mine closure plan, with the main objective to ensure long-term physical, chemical and biological stability of the site to minimise potential environmental, health and safety risks.

The key project components are presented in **Error! Reference source not found.**. This EIA is based on the project description in the current feasibility studies which are focussed on open pit mining for a 13-yr period. WMM intend that with further exploration work a much longer mine life of up to 50 years will be feasible.

Table 1. 2 Key project components

Aspect	Description
Mining method	Large-scale conventional open-pit. Open pit mining using drill rigs, excavators and/or front-end loaders and haul trucks. Ore and overburden will be loosened by blasting.
Mining rate	Up to 2 Mtpa ore per annum.
Open-pit dimensions	The existing open pit will be expanded and deepened growing in size from approximately 54 acres to at least 228 acres (21.9 ha to 95.9 ha).
Mine life	13-year starter pit with potential for underground mining to follow that may extend life up to 30 years.
Waste rock	Total of 159 Mt of waste rock that will be either used in construction or stored in a single waste rock dump in the Wallah Valley.
Tailings	Total of 54 Mt of process tailings, the equivalent of 4,600 tonnes per day (t/day) that will be pumped to three valley impoundments, TSF A, TSF B and TSF C.
Processing method	Processing of the ore will involve crushing and grinding followed by separate lead and zinc flotation. The lead and zinc concentrates will be pumped to the concentrate handling facility where it will be thickened, filtered and stockpiled for loading into concentrate containers for transport via truck.
Concentrate production	Lead Concentrate (4,406,600 Tonnes) Zinc Concentrate (2,725,274 Tonnes)
Power	44.2 MW diesel fired power station
Export facilities	A central warehouse and logistics hub for the project will be constructed at either Namtu, or at Lashio. Concentrate containers will be transported to the hub and then loaded onto other trucks for onward transport.
Mine access	A new private road from Namtu to Tiger Camp (Namtu-Tiger Camp access road) will be constructed within the existing rail easement, this road will connect to a new access road between Tiger Camp and the process plant (plant access road). Until the new mine access roads (Namtu-Tiger Camp access road and plant access road) are constructed the existing public Namtu-Manton road will be utilised.

Aspect	Description
Accommodation	An accommodation camp will be constructed for the project capable of accommodating approximately 1,400 people. The accommodation camp will be used during construction and operation of the project. It is expected that the local workforce will reside in their homes and be transported to site daily
Employment	Up to 2,285 people during construction, decreasing to 1,115 people during operations.

1.3.3 Spatial boundaries

This EIA describes the environment and issues and impacts associated with the project in a range of spatial contexts. These include:

- Mine area – includes the open-pit, processing plant, mine infrastructure area, haul roads, waste rock dump, power station and tailing storage facilities (TSFs), accommodation camps and other ancillary infrastructure. It also includes a proposed private mine access road between Tiger Camp and the process plant.
- Mine access corridor – includes the proposed mine access road between Namtu and Tiger Camp along the existing rail corridor.
- Transport route – includes the public road between Namtu and Lashio.

Throughout the EIA, two further key areas are defined. These are:

- Bawdwin Concession – a rectangular area of 24.6 km^2 centred on the Bawdwin mine and including Tiger Camp. It is defined in an existing production sharing contract between ME-1 and WMM.
- Namtu Concession – an irregular polygon of 5.3 km^2 centred on the Namtu smelter complex and associated infrastructure. It is also defined the production sharing contract.

1.3.4 Temporal boundaries

The EIA describes the existing environment at Bawdwin mine based on environmental baseline data collected largely up to the end of 2019 (Appendix C to Appendix H). However, stakeholder engagement, community consultation and collection of socio-economic data from household surveys of farms and villages surrounding Bawdwin were continued up to December 2020.

1.3.5 Project rationale

The rationale, or reason for the Bawdwin project is based on a combination of economic, engineering, environmental and social considerations. The project described in this EIA is based on the current mineral resource and design information. On the basis of this design, it is anticipated that the productive mine life (from mining of the first ore, excluding construction and closure phases) will be 13 years.

This section outlines the justification of the project and its compatibility with Myanmar government strategies.

1.3.6 Feasibility investigations

Detailed feasibility investigations have been undertaken of the Bawdwin project to assess the feasibility of the project: scoping study, pre-feasibility study and definitive feasibility study. The feasibility of the project reflects a combination of economic, engineering, environmental and social considerations that were assessed in these three stages with increasing level of detail at each stage. The purpose of these is to evaluate the various commercial and technical aspects of the project and determine whether the opportunity makes good business sense.

The project scoping study was completed in September 2018, with the objective to understand the extent of the resource that remains in situ at the Bawdwin Mine, despite historic mining. This study considered a large-scale open pit mine operation targeting mainly fresh sulphide mineralisation and found resource estimates to be 100 Mt at 4.0% lead (Pb), 1.9% zinc (Zn), 0.2% copper (Cu) and 97 g/t silver (Ag). Following this, in February 2019, a pre-feasibility study report was prepared which developed further information on the viability of the project.

During the pre-feasibility study between October 2018 and March 2019, the deposit (Indicated and Inferred) was refined to 94 Mt at 4.2% Pb, 2.0% Zn, 0.2% Cu and 107/t Ag with a mine life of 13 years. The pre-feasibility study proposed an open pit operation with an associated processing plant of 2 Mtpa capacity, dry tails storage in an integrated waste landform in the Wallah Valley and an accommodation village. Power was to be supplied from the existing Mansam substation located approximately 28 km away from the site.

During the detailed feasibility study investigations between April 2019 and June 2020 the project was further refined. These changes included expanding the size of the mine pit, increasing the throughput capacity of the process plant to 3 Mtpa, designing three smaller tailing storage facilities to store conventional thickened tailings, constructing new access roads between Namtu and the process plant, and building a standalone power station. These changes also necessitate the relocation of the existing Bawdwin and Tiger Camp villages.

1.3.7 Project viability

WMM intend to deliver a mining operation that is safe and sustainable and delivers value to stakeholders. This will be achieved by constructing and operating an expanded open pit mine and associated ore processing facilities, support services and infrastructure, while managing adverse impacts on environmental, social and cultural heritage values.

The Bawdwin project, if developed, will bring a range of benefits. The viability of the project is underpinned by a range of internal and external factors that include (but are not limited to):

- Proven resource with long track record of operation – the project has strong fundamentals focussing on a proven mineral orebody with a long history of producing valuable minerals.
- Strong demand for lead, silver and zinc – the project will produce products with strong outlook for future demand and proximity to buyer secured markets.
- Favourable macro-economic conditions – recent changes to the regulatory framework in Myanmar provide support for the development and expansion of the mining sector and also to enable foreign investment in the sector.

- Expertise and experience – the project is being developed in a joint venture arrangement that brings international mining expertise combined with local knowledge, understanding and networks.
- Strong expansion potential – further exploration is planned that is expected to greatly extend the life of the Bawdwin project into a long-life mining operation.

WMM's immediate intention is to build and operate a profitable mine that is safe and sustainable and delivers value to stakeholders.

Project fundamentals

The Bawdwin mineral deposit is a world-class deposit in terms of its size and grade.

Exploration conducted by WMM has resulted in an increase in the mineral resource estimate of the Bawdwin deposit and it now ranks among the largest polymetallic resources globally. The total mineral resource estimate is based on more than 24,000 m of reverse circulation (RC) and diamond drilling completed between 2017 and 2019. The estimate is further supported by 56,008 m of historic channel sampling of underground exploration cross-cuts and a 434-sample channel sampling program collected in the open cut in 2016.

Error! Reference source not found. below summarises the mineral resource estimate for the Bawdwin deposit. The resource has been estimated in five domains. In accordance with the JORC Code, mineral resources can be classified as indicated, inferred or measured based on the confidence of estimates of the quantity, grade, density, shape and physical characteristics of the resource, as defined below:

- An Inferred Mineral Resource is one in which available data and geological interpretation are sufficient to imply geological and grade continuity of the mineral resource, but with no verification and low confidence.
- An Indicated Mineral Resource is one in which the data and geological interpretation are sufficient to reasonably estimate the geological and grade continuity of the mineral resource with a greater level of confidence than an Inferred Mineral Resource. An Indicated Mineral Resource can be converted to a Probable Ore Reserve.
- A measured mineral resource has the greatest degree of confidence and can be converted to a Proved Ore Reserve.

Table 1. 3 Ore reserve and mineral resource estimate

Classification	Tonnage (MT)	Pb(%)	Ag (oz/t)	Zn (%)	Cu (%)
Ore Reserves					
Proven	-	-	-	-	-
Probable	18.4	6.4	5.4	3.4	-
Total Ore Reserves	***18.4***	***6.4***	***5.4***	***3.4***	-
Mineral Resources					
Indicated	42.4	4.0	3.2	2.0	0.2
Inferred	58.2	4.1	3.1	1.8	0.2

Classification	Tonnage (MT)	Pb(%)	Ag (oz/t)	Zn (%)	Cu (%)
Total Mineral Resources	***100.6***	***4.0***	***3.1***	***1.9***	***0.2***

[1]Bawdwin Ore Reserves and Mineral Resources, reported in compliance with JORC Code 2012 Edition and as announced on the Australian Stock exchange (ASX) on 6 May 2019 and 13 February 2019
[2]Probable Ore Reserves are included in Indicated Mineral Resources

The project is located suitably to enable reliable export of these concentrates in containers to international destinations, whether by road or road/sea.

As discussed above, there is a long history of mining at Bawdwin dating back to the early 1400s and there is also a long history of mining high grade ore. From the 1.3 M t of ore mined between 1909 and 1979 (excluding 1940 to 1950), approximately 207,658 t of refined lead, 123,131 t of zinc concentrate, and 10.1 M oz of silver was produced. British era production peaked in the late 1920's, and 1930s, with 451,650 t of ore mined between 1930 and 1939, producing approximately 72,802 t of refined lead, 65,116 t of zinc concentrate and 4.8 M ounces of silver (Gardiner et al., 2017).

Strong demand for lead, silver and zinc

The project will produce two products from the process plant: lead-silver concentrate and a zinc concentrate. On current estimates this would make the Bawdwin project the world's third largest producer of lead and ninth largest producer of silver.

The forward outlook for both silver and lead is strong.

Demand for silver is supported by long term growth in electronics and electrical products and more recently rapid growth in the solar industry. Demand for silver coins and bar has also increased recently and demand for use in jewellery has remained strong. Concurrent to the increased demand, existing mine production of silver globally has fallen in each of the past 3 years.

Strong demand also underpins a robust outlook for lead. Lead demand has experienced a compound annual growth rate of 4% per annum for the 20 years to 2017. Growth in demand largely originates from China driven by growth in lead-acid batteries. Lead in this form is the cheapest, most robust and most successfully recycled way to store electricity where weight is not a concern. Continued demand is expected with further growth in cheap, modular and readily accessible lead acid batteries for energy storage.

Macro-economic conditions

As Myanmar pursues political and economic renewal, investment in the mining sector is anticipated to grow dramatically. At the national level there is increased appetite to kick-start development and investment in the minerals sector.

The Myanmar *Investment Law 2016* took effect in 2017 to establish a coherent legal framework for Myanmar and international investors. The Myanmar *Companies Act 2017* took effect from 1 August 2018. The Act simplified company administration and provided a wider framework for Myanmar's businesses.

Since 2011, the Myanmar Government has passed a number of laws and rules to encourage foreign investment in Myanmar. Amendments to the mining laws were passed in December 2015 and in early 2018, Myanmar's Government passed new Mines Rules to provide further clarity to the *Myanmar Mines Law 1994*. The amendments address key issues and will likely encourage foreign investment interest in the sector. The amendments introduce important new concepts designed to "promote the development of investment in respect of mineral resources" (new Section 3(c)). Subsequently, the first Extractive Industries Transparency Initiative (EITI) Report was issued in 2016. Key amendments include increasing the maximum mine life for large scale production projects to 50 years, providing a guaranteed right of production for investors who have carried out prior exploration and feasibility, a reduction in dead rents and the introduction of alternative State participation mechanisms. The World Bank, through the EITI process, has recently funded a project to establish a mining cadastre which will develop a national database and ultimately make data on all exploration and mining permits publicly available. In July 2018, MONREC began accepting mineral license applications, lifting a 2-year mortarium.

Myanmar remains largely unexplored geologically and as such there is great potential for new market entrants to gain first mover advantage in many parts of the country. Myanmar and foreign companies have already started to intensify their activities in securing prospective exploration blocks with a significant increase in on-ground exploration activities in recent years.

According to information from the Directorate of Investment and Company Administration, the total approved foreign direct investment from 1988 to October 2018 amounted to $77.8bn of which 3.7% related to mining projects. This is expected to grow as a result of the reforms listed above. Currently, the Government estimates that contribution from the mining industry to GDP is expected to grow by 7.5% while the broader economy is expected to grow by 7.6%. It is anticipated that once Bawdwin is developed, this will result in a potential significant shift in GDP contribution from the mining industry.

Expertise and experience

Win Myint Mo Industries is a leading private Myanmar conglomerate that employs over 4,000 employees and currently is the operator of the current Bawdwin concession. WMM's experience as a major infrastructure developer in Myanmar brings substantial expertise relevant to the project in areas such as roads, energy, and logistics. They also have a range of existing relationships and supply chains in Myanmar with global leaders.

Strong expansion potential

The Bawdwin project will lay strong foundations for future expansion enabling a long-life mining operation. Following the initial 13-year mine life, the project will target the un-mined mineral resources of the China, Shan and Meingtha Lodes. Broader mine expansion studies will continue in parallel with the construction and operation of the project.

1.3.8 Alignment with Government policies

Section 27 of Myanmar's 2008 Constitution grants the Union Government ultimate ownership of all land and all natural resources within the country's national territory, whether located above-ground, sub-soil or underwater and the ability to legislate for extraction of natural resources. The sector is governed by two sets of laws and regulations; those related to the exploration and mining of minerals and those related to the extraction of gemstones and jade.

The sector is managed by the Ministry of Natural Resources and Environmental Conservation (MONREC). MONREC was created in 2016, through a merger of the Ministry of Mines and the Ministry of Environmental Conservation and Forestry. MONREC has seven departments including the Minister's Office, the Department of Mines, the Department of Geological Survey and Mineral Exploration (DGSE), Mining Enterprise No. 1, Mining Enterprise No. 2, Myanmar Gems Enterprise and the Myanmar Pearl Enterprise. The Department of Mines is in charge of policy and royalties collection, DGSE is responsible for geological exploration and the mining enterprises act as both regulator and joint venture partner for mining investments.

Myanmar Minerals Sector Policy

A similar policy to that of the National Gemstone Policy is being developed for the Minerals sector. . It is anticipated that the policy will deal with important issues in the sector, including:

- The governance and management of mining enterprises.
- The lack of exploration data.
- The permitting process.
- Sector transparency.
- Decentralisation.

Some changes are occurring ahead of the development of the policy. For example, following amendments to Myanmar's constitution, the *2015 Myanmar Mines Law* and 2018 Mines Rules set in motion a shift in how the government manages the sector. States and regions now have the power to issue artisanal and small-scale permits and collect revenue.

Myanmar Sustainable Development Policy

The project presents broad commercial and socio-economic development opportunities for Myanmar and aligns with the country's national development strategy, the Myanmar Sustainable Development Plan (GoM 2018).

The Myanmar Sustainable Development Plan describes the country's long-term strategy and reflects the aspirations of Myanmar. It strives to "strike the right balance between economic and social development, and environmental protection and sustainability" (GoM 2018). Strategy 5.5 of the plan states that the Government of Myanmar is seeking to reform the mining sector in a way that benefits the government and the lives of the people while being sustainable and profitable. The redevelopment of the Bawdwin Mine aligns with these overarching government goals.

Economic Policy of the Union of Myanmar

The Union government released 12 key points that formed their Economic Policy on 29 July 2016. Of these points two are relevant to the project:

- To create job opportunities for all Myanmar citizens who live in Myanmar and who arrived back from foreign countries to Myanmar and to give high priority in the short term to the businesses that can create many job opportunities.
- To improve private sector in accordance with market oriented economy, the government will separately draft and implement policies which allow every citizen to freely operate their desired businesses and promote foreign investments, and the government will put efforts to protect copyrights and rule of law.

The project is consistent with specific aspects of this policy. It will support job growth and encourage Myanmar nationals to seek work in Myanmar rather than overseas. The policy also supports foreign investment.

National Environmental Policy

The Myanmar National Environmental Policy 2019 (GoM 2019) aims to provide long-term guidance for government organisations, civil society, the private sector and development partners to achieve environmental protection and sustainable development objectives in Myanmar (GoM 2019).

The vision of the National Environmental Policy is to achieve:

> *A clean environment, with healthy and functioning ecosystems, that ensures inclusive development and wellbeing for all people in Myanmar.*

The project aligns with this vision by seeking to improve environmental conditions at the site.

1.3.9 Social and economic benefits

WMM has engaged with local communities and other stakeholders as understanding of the project has evolved. This engagement will continue throughout the life of the project and will be guided by the project's public participation plan. Through its resettlement and community development plans, WMM will seek to reduce potential adverse impacts on these communities and to deliver real benefits to local communities based on a range of key initiatives.

If constructed, the project will be one of the largest mines in Myanmar and has the potential to generate significant long-term economic benefits at the local, regional and national level.

WMM estimates the initial capital expenditure to build the project to commercial production will US$ 360 Million with a Life of Mine capital expenditure in the order of US$ 1 Billion.

The project will directly benefit the Myanmar economy in a number of ways. These include:

- Direct financial benefits including:
  - Royalties and dead rent paid to the Union of Myanmar (dead rent is the amount that has to be paid by the lessee to the lessor whether or not he has derived benefit from the asset).
  - Corporate income taxes paid to the Union of Myanmar by WMM.
  - Indirect taxes paid to the Union of Myanmar including, commercial tax; withholding tax; customs duties and personal income tax.

  - An additional profit share tax as governed by the amended PSC agreement.

- Procurement of goods, materials and services from within Shan State and elsewhere in Myanmar, where practicable. This will aim to support, as far as practicable, the establishment of local businesses that are sustainable in the longer term.
- Employment and training to maximise the proportion of Myanmar workers, which are expected to exceed 570 full time positions during operations.
- Wages paid to employees of WMM and contractors.
- Contributions to national mineral export revenue, total export revenue and GDP.
- Strategic community-level investments by WMM in services, infrastructure, local business, and livelihood development.

If the project does not proceed, project-derived benefits (including those benefits listed above) will not occur. Equally, the potential adverse impacts of the project discussed in the subsequent chapters of this EIA will also not occur.

The social benefits of the project are discussed further in Chapter 6.

1.4 Statutory context

The Bawdwin mine lies within the Bawdwin Concession that is currently governed by a production sharing permit and contract between ME-1 and WMM. Redevelopment of the Bawdwin mine requires an extension to the large-scale production permit under the *Myanmar Mines Law 1994* and Myanmar Mines Law Amendment (2015), the issue of a Myanmar Investment Commission permit which sets out foreign investment concessions and an EIA (this report) in accordance with the *Environmental Conservation Law 2012*.

Other associated permits and procedures will also be required after the major approvals have been issued.

1.4.1 Steps of the EIA process

The main steps of the EIA process in Myanmar are scoping, investigation, reporting and approval. These steps are briefly described below, further details can be found in Section 2.1.1 of this report.

- **Scoping:** defines the spatial scope of the project, provides a preliminary assessment of impacts and develops the objectives of the studies that will support the EIA.
- **EIA investigation:** investigates and assesses various aspects that may be impacted by the project and how they will be impacted.
- **EIA reporting:** prepares the EIA report for submission to government, ensuring all relevant investigation and public consultation has taken place.
- **Review and approval process**: reviews the EIA report and invites comments and recommendations from various stakeholder. The Ministry then either rejects the report, or approves it with conditions.

This EIA report has been guided by:

- The Bawdwin Project Terms of Reference outlined in the Bawdwin Project Scoping Report affirmation by the Myanmar Environmental Conservation Department (ECD) of MONREC on 16th June 2020
- Environmental Impact Assessment Procedure (2015).
- Environmental Impact Assessment Guidance for the Mining Sector (2018) with supporting Technical Guidance for Environmental Impact Assessment of Mining (2018).
- Various international standards, guidance documents and procedures.

1.4.2 Objectives of the EIA

The objective of this EIA is to identify potential environmental, social and cultural heritage impacts associated with the project and set out the management measures WMM proposes to address potential adverse impacts. More specifically the EIA provides:

- A basis for affected and interested persons and organisations to understanding the project; the environmental, social, and cultural heritage impacts that may arise from its development; and the avoidance or management measures WMM propose to mitigate potential adverse impacts.
- The means by which the Republic of the Union of Myanmar can assess the project in accordance with statutory processes, whether the Minister should grant approval for the project, and subsequent to that, detail the necessary conditions of construction, operation and closure in the form of an ECC.
- A practical framework for WMM to assist with managing potential project risks and impacts, including the establishment of performance objectives and management measures to be undertaken throughout construction, operation and decommissioning of the project.

1.4.3 Structure of the EIA

This EIA has the following structure:

- Executive Summary. A summary, prepared in English and Myanmar language, of the proposed project, impact assessment and management measures.
- Volume 1 – Main Report. A stand-alone environmental, social and cultural heritage assessment that can generally be understood without reference to the supporting (technical) studies upon which it is based.
- Volume 2 – Attachments. Supplementary material to the main report including a reconciliation of the EIA with Terms of Reference and relevant Myanmar guidelines, as well as environmental, social and cultural heritage management plans.
- Volume 3 – Appendices. A series of technical reports on the various investigations that have informed the EIA Main Report.

The EIA Main Report comprises a glossary and list of abbreviations followed by 11 chapters including figures, tables and plates. A description of the EIA Main Report structure and contents is outlined in **Error! Reference source not found.**.

Table 1. 4 EIA report structure and contents

Report section	Description
Table of contents	Outlines report headings, table and figure titles and page numbers.
Glossary and abbreviations	Explanation of acronyms and essential terms used throughout the report.
Executive summary	Provides an overview of the project and the environmental and social setting, and a summary of key potential impacts, risks and mitigation measures and project commitments.
1. Introduction	Introduces the project, project proponent and provides an overview of the project, its background, history and the engineering feasibility studies. Provides a confirmation and Letter of Undertaking signed by WMM, and confirmation of WMM to provide all necessary financial and human resources to fully implement Environmental and Social Management Plans and provides confirmation of the third-party consultant of the accuracy and completeness of the EIA report.
2. Policy, legal and institutional framework	Provides an overview of the Myanmar legal framework, and relevant international standards and environmental and social agreements. It also presents WMM's corporate environmental and social policies.
3. Assessment of alternatives	Provides a description of each project alternative with prediction and evaluation of all major potential environmental and social impacts and risks. Explains the reason behind the preferred alternative.
4. Project description	Describes the project and its objectives, including the size, installations, technology, infrastructure, production, and use of materials and resources and generation of waste.
5. Existing environment	Describes the administrative, physical, biological, social, economic, cultural and visual characteristics of the study area and highlights sensitive environmental, social, cultural and visual components.
6. Impact assessment	Identifies and assesses the potential environmental and social impacts of the project and describes mitigation measures and residual impacts.
7. Assessment of hazard and risk	Assesses natural and industrial hazards and provides an Emergency Response Plan.
8. Cumulative impact assessment	Assesses and presents a management framework for cumulative impacts.
9. Public consultation and disclosure	Outlines the public participation process and the public engagement undertaken throughout the project. .

Report section	Description
10. Environmental and social management framework	Provides an overview of the environmental and social management framework (ESMF) under which the project will be constructed, operated and decommissioned to manage the environmental, social and cultural impacts associated with the project.
11. References	Complete list of source materials used or consulted in the preparation of the EIA.

1.5 EIA study team

WMM appointed Coffey Myanmar Limited and Valentis Services Limited (Coffey & Valentis) as the lead EIA consultant. Coffey & Valentis, is an experienced international EIA consulting team, supported by local and international subject matter experts. The core EIA project team and their experience is outlined in **Error! Reference source not found.** below along with the EIA technical study leads in **Error! Reference source not found.**. Although Coffey & Valentis prepared EIA report, E Guard Environmental will revise and prepare final EIA report for this project.

Table 1. 5 EIA project team roles and experience (Coffey and Valentis)

Name and qualifications	Role	Experience
Tara Halliday	EIA project director	More than 21 years' experience in environmental and social impact assessment; B. Eng (env) (Hon)
Barton Napier	EIA strategic advisor	Over 25 years' industry experience, with 16 years' experience in environmental and social impact assessment; Ass Dip AppSc, Cert Tech (Survey & mapping)
Lachlan Foy	EIA strategic advisor	15 years' experience in project financing, and project management; B.Com (Hon), CA
Dr Michael Sale	EIA project manager	12 years' experience in environmental and social impact assessment; BSc (Hon), Ph.D (zoology).
Geoff Lowe	EIA project manager	30+ years' experience in exploration and geological studies; BSc (Geology)
Pat Vidler	Social studies and resettlement manager	10 years' experience in social impact assessment and resettlement; BSc Eng, MPH

Name and qualifications	Role	Experience
Than Khin	Technical manager	20+ years' experience in environmental studies; Doctorate of Engineering (Environmental)
Travis Wood	EIA author	12 years' experience in environmental and social impact assessment; BSc (Hon)
Lana Griffin	EIA author	4 years' experience in environmental and social impact assessment; B.EnvEng (Hons), BSc

Table 1. 6 EIA study specialists (Coffey & Valentis)

Name and Qualifications	Role	Experience
Jack Dempsey	Health	30+ years' experience, BSc (Hon)
Karen Teague	Health	20 years' experience in contaminated land and environmental industry
Dr Khin Yupar Kyaw	Health	12 years' experience in health consultations
Dr Myo Sett	Health	11 years' experience as medical officer and public health consultant
Thet Htar Myint	Socio-economic	20+ years' experience; M.Sc.
Angela Reeman	Resettlement	20 years of experience in international resettlement projects, including 5 years working on projects in Myanmar; B. Eng, MSc.
Michael Blackam	Groundwater and surface water	Over 25 years' experience; B.A.Sc. (Hon) (Environmental and Exploration Geology, Hydrogeology)
John Sweeney	Groundwater and surface water	Over 15 years' experience; B.Sc (Hons) (Hydrogeology).
Peter Petchy	Archaeology	25 years' experience in historical and historical mining archaeology; PhD
Dr. Aung Aung	Biodiversity lead	15+ years' experience; Ph. D

Table 1. 7 EIA study team for revision of Main EIA report (E Guard)

Sr.	Name	Position	Transitional Consultant Registration Numbers	Role	Area of Expertise
	E Guard Environmental Services	Third Party EIA Organization	10028		1.Air Pollution Control, 2.Ecology and Biodiversity, 3. Facilitation of Meeting, 4.Geology and Soil, 5.Ground Water and Hydrology, 6.Land Use, 7.Legal Analysis , 8.Modeling for Water Quality, 9.Noise and Vibration , 10. Risk Assessment and Hazard Management, 11.Socio-Economy, 12. Water Pollution Control, 13. Waste Management, 14. Agriculture, RAP, 15. Food Technology, 16. Health Impact Assessment, 17.Marine and Microbiology, Water Quality, 18. RS&GIS, 19.Water Quality
1.	U Tin Aung Moe	Director	00103	Project Leader	1.Facilitation of Meeting, 2.Land Use, 3.Risk Assessment And Hazard Management, 4.RS&GIS
2.	Dr. Myint Oo	Advisor	Applied	Advisor	1.Forestry 2.Environmental Management

Sr.	Name	Position	Transitional Consultant Registration Numbers	Role	Area of Expertise
					3.Resources Assessment
3.	Daw Thein Mwe Khin	Senior Consultant	00104	Team Leader	1. Forestry 2.Socio-Economic
4.	U Aung Myint Myat	Consultant	00099	EQ Team Head	1. Forestry
5.	U Aung Si Thu Thein	Consultant	00281	Team Member	1. Ecology and Biodiversity, 2.GIS, 3.Land Use
6.	U Thaw Tar Htun	Consultant	00267	Water Pollution Control Expert	1.Water Pollution Control
7.	Daw May Thu Win	Assistant Consultant	00380	Legal Analyst	1.Legal Analysis
8.	Daw Shwe Ya Min Bo	Assistant Consultant	00279	Social Impact Analyst	1.Foresty 2.GIS, 3.Ecology and Biodiversity
9.	U Htet Aung	Assistant Consultant	00279	Geologist	1. Geology and Soil
10.	U SiThu Min Naing	Assistant Consultant	00223	Mining Engineer	1.Soil Test 2. Mining Engineer
11.	Daw Moe Cho Thinn	Environmental Specialist	00378	Social Impact Analyst	1. Facilitation of Meeting

1. U Tin Aung Moe (Director/Consultant)

U Tin Aung Moe is a consultant who holds Transitional Consultant Certificate No 0103, described expertise are Facilitation of meeting, Land use, Risk Assessment and Hazard Management, RS and GIS. He is one of the founding members of E Guard. He has been working for Environment Assessment and Environmental technologies development andcapacity building for the Developing countries in Asia and Pacific Region. He is responsible for the policy and institutional linkages and harmonization of E Guard.

2. Dr. Myint Oo (Advisor)

Dr. Myint Oo, Rector (Retired) of University of Forestry and Environmental Science, Yezin, Ministry of Natural Resources and Environmental Conservation, worked for the Ministry for 35 years from 1984 to 2019. He obtained bachelor’s degree in forestry from Yangon University, and also M. Sc. and Ph. D. degrees from Göttingen University, Germany with special reference to tropical forest resources assessment using remotely sensed data and geographic information systems. As a government employee he was involved in forest management planning and implementation, organizing and conducting forestry research studies, training, international relations, administration and teaching of forestry and environment-related subjects at the university. After retirement in 2019 he joined E Guard Environmental Services Co. Ltd. as an advisor and attended the training course on ‘Principles of Environmental Impact Assessment Review’ organized by AIT Center in Vietnam. Since then, he has been involved in the internal review process of EIA studies of the company as well as providing advice to project team members in respect of project implementation and report preparation. He is also responsible for review and revision of existing technical documents relevant to his expertise and providing advice for the improvement of company’s governance policies and procedures when required.

3. Daw Thein Mwe Khin (Senior Consultant)

Daw Thein Mwe Khin is a Senior Consultant, who holds Transitional Consultant Certificate No. 00104, described expertise in Forestry. She received her master’s degree in Regional and Rural Development Planning from Asian Institute of Technology in 2019 and bachelor’s degree in forestry from the University of Forestry in 2013. She worked as a social expert in Yangon Outer Ring Road Construction Project, Hanthawaddy New International Airport Development Project and Wataya Bridge Construction project. She had experience in working as a survey team leader for YCRL Updating Project and Dry Zone Water Supply Project in 2014, 2015 and 2016 respectively. She had her experiences in working as a core team member of the social team who did the preparation of RAP for Construction of Kyarkalay Bypass and 2 Bridges and RAP for Construction of Thaton Bypass and 2 Bridges in 2014. In addition, she has a project leader role in the preparation of four IEE reports for various types of projects, tender preparation, many social surveys, FGDS for various EIA/IEE/EMP projects during around five years of working life in the EIA field. She also studied the socioeconomic impact of rural electrification on the well-being of rural households in central dry zone, Myanmar as her master thesis in 2018. She will be involved as a team leader and social expert in this project.

4. U Thaw Tar Htun (Consultant)

U Thaw Tar Htun is employed as a consultant at E Guard Environmental Services Co., Ltd., where he has been involved in the Environmental Impact Assessment (EIA) project reporting since 2018. He holds a bachelor’s degree in Civil Engineering from Taunggyi

Technological University, obtained in 2011, and a master's degree in Engineering (International Graduate Program in Environmental and Water Resources Engineering) from Mahidol University in Thailand, completed in 2016. Over the course of nine years, he has amassed considerable experience in various environmental fields, including his research conducted during his master's degree program titled "Mathematical Modelling of the Wastewater Collection System in Cha-Am Municipality using PCSWMM." This research was presented at the 3rd International Conference on Civil, Biological, and Environmental Engineering held in Phuket, Thailand.

During his career, he has been actively involved in numerous projects pertaining to Environmental Impact Assessment studies, Impact Identification and Analysis, formulation of mitigation measures, and the development of Environmental Management Plans. From August 2012 to October 2017, he served as a Sub Assistant Engineer in the Engineering Department (Water and Sanitation) at the Naypyitaw Development Committee, Naypyitaw.

Within the team conducting this environmental study, U Thaw Tar Htun's primary contributions include the Identification of Impacts and Analysis, formulation of Mitigation Measures, and the development of an Environmental Management Plan with specific focus on the following areas:

- Prevention and control of air pollution
- Meteorology, air quality assessment, and prediction
- Prevention, control, and impact prediction related to water pollution
- Management of solid and hazardous waste.

-

5. U Aung Myint Myat (Consultant)

U Aung Myint Myat is a Consultant, who holds Transitional Consultant Certificate No. 10099, described expertise is Forestry. He has Bachelor Degree in Forestry from the University of Forestry and Environmental Science in 2014. He also got full time Diploma in Environmental Impact Assessment and Environmental Management System from Yangon Technological University in 2019 and Diploma in GIS&RS form Dagon University. He has more than eight years experiences in conducting environmental site inspection, socio-economic surveys and data interpretation, negotiating with clients, government authorities and local people to conduct stakeholder engagement and public consultation meeting, Environmental Quality measurement and data analysis and also reporting for EMP, IEE & ESIA of various nature of project. For this EIA study, his main responsibility as a support team member are to conduct preparation of socio-economic questionnaires, scoping the study area, environmental quality data analysis, environmental and social impact assessment, biodiversity survey, analysis and reporting. His expertise for this project is Natural Resources Management, Ecosystem and Biodiversity, Air quality analysis, Geological assessment, Risk Assessment, Legal analysis and reporting.

6. U Aung Si Thu Thein (Consultant)

U Aung Si Thu Thein is a Consultant, who holds Transitional Consultant Certificate No. 00281, described expertise in Ecology and Biodiversity, GIS and Land Use. He received his Bachelor Degree in Forestry from the University of Forestry in September, 2015. He also received Post Graduate Diploma in Geographic Information Systems from the Dagon University in February, 2018. Moreover, he pursued his Master of Science Degree in Natural Resources Management from the Asian Institute of Technology, Thailand in May,

2020. He has more than five years-experience in preparation of Environmental Management Plan and Initial Environmental Examination Reports for various development projects as a Lead Consultant and in participation many Environmental Impact Assessment and Resettlement Action Plan projects for development projects in Myanmar. On the other hand, he has two years-experience in research conducting with regards to impacts assessment of natural resources management systems on livelihood of local people. Moreover, he has many experiences in communication with clients, government authorities and local people, stakeholder engagements and public consultation meetings conduction and socio-economic survey. His expertise for this project includes Natural resources management, Ecosystem and biodiversity, Soil conservation and Land use.

7. Daw May Thu Win (Assistant Consultant)

Daw May Thu Win is working as an Assistant Consultant in E-Guard Environmental Services Co., Ltd. who holds Transitional Consultant Certificate No. 00380, described expertise in Legal Analysis. She obtained her bachelor’s degree in law from East Yangon University (Tarwa) in 2018. She is currently assisting in preparing Laws, Rules, Regulations, Policies, Directions and Notifications used for environmental reports, public consultations and information-gathering processes. As a legal expert, she has the responsibility of legal study and analysis of this project. She will mainly contribute to the Policy, Legal and Institutional Framework Chapter of this EIA study.

8. Daw Shwe Ya Min Bo (Assistant Consultant)

Daw Shwe Ya Min Bo is an Assistant Consultant, who holds Transitional Consultant Certificate No. 00279, described expertise in Forestry, Ecology and Biodiversity, and GIS. She received her bachelor’s degree in forestry from the University of Forestry and Environmental Sciences in November 2016. She also received a Post Graduate Diploma in Geographic Information System and Remote Sensing and Post Graduate Diploma in Environmental Studies from University of Yangon in December 2019. She has almost six years-experiences in preparation of Environmental Management Plan and Initial Environmental Examination reports for various development projects and in participation many Environmental Impact Assessment and Resettlement Action Plan projects including Japan’s ODA loan projects. Her main contribution is Natural Resources Management, Socio-economic survey, Ecosystem and Biodiversity, and Land Use for this project.

9. U Htet Aung (Assistant Consultant)

U Htet Aung is an Assistant Consultant, received Master Degree with Petroleum Geology from Yangon University in 2015. He has three years experiences in data collections and report writing. He is currently preparing environmental reports, conducting public consultation and information gathering processes. He was participated in the preparation of Environmental Impacts Assessment (EIA) Report of Yangon Outer Ring Road (YORR) Construction Project and Nyaungdon Bank Protection and Rehabilitation Project. He was working on Data Analysis and Impact Assessment, Stakeholder engagement and Public Consultation Meeting and Technical Report Writing of 40MW Ground Mounted Solar Power Plant and 30MW Belin Solar Power Plant EMP reports. He will be contributed as a geologist in this EIA report.

10. U Si Thu Min Naing (Mining Engineer)

U Si Thu Min Naing is a mining engineer at E Guard Environmental Services. He got his Bachelor Degree in Mining – B.E (Mining) from Mandalay Technology University at 2014.

He has many experiences in conducting data, data interpretation, negotiating with clients, government authorities and local people to conduct stakeholder engagement and public consultation meeting, data analysis and also reporting for EMP, IEE & ESIA reports. In this EIA report, his contribution is as a mining engineer.

11. Daw Moe Cho Thinn (Environmental Specialist)

Daw Moe Cho Thinn is an environmental specialist, who holds Transitional Consultant Certificate No. 00378, described expertise is Facilitation of Meeting. She has Bachelor of Public of Administration from Yangon University of Economics. She also got Diploma in Accounting (UK) in 2019. She had experience in working as a volunteer recycling and upcycling trainer at HER (Heroines to Enable Recycling) project. She worked as a volunteer at media team of U- Report Myanmar Organization from 2019 to 2022. She did a research paper about Yangon Public Bus Transportation for her Bachelor Degree. She is currently working in social data analysis, data reporting, valuation and analysis from an economic perspective at E Guard Environmental Services. Her contribution in this project is social data analysis and valuation and analysis from an economic perspective.

1.6 Third-party consultant confirmation

Following submission of the details of the consultant nominated to conduct environmental assessment, ECD accepted Coffey & Valentis as an acceptable third-party consultant to complete the Bawdwin Project EIA.

On 16 August 2019, on behalf of Director General, Soe Naing (Director) from MONREC's ECD confirmed there was no rejection (objection) on the request that Coffey and Valentis prepare the Environmental Impact Assessment Report for the large-scale lead, zinc mineral production project in the area of 618 acres in Namtu-Bawdwin mine, Namtu Township, Kyaukme Township, Kyaukme District, Shan State (North) presented by Win Myint Mo Industrial Co., Ltd.

On 22nd August 2019, the Executive Director (on behalf of) Khin Maung Kyaw, General Manager from Mining Enterprise (1) confirmed there was no rejection (objection) on the request that Coffey & Valentis prepare the Environmental Impact Assessment Report.

Although Coffey & Valentis started preparation EIA scoping report for Bawdwin project, they can't continue report preparation in current situation. So, the project proponent submits the other third-party selection form that will continue conducting EIA report. In 19th May 2023, the Director on behalf of the Director General (MONREC) approved the third-party application for E Guard Environmental Services to act as the EIA consultants for this project.

The third-party acceptance letters are included as Appendix 1.

1.7 Confirmation of accuracy and ability to fund and implement EIA commitments

The EIA report was prepared by Coffey & Valentis in accordance with the requirements of applicable laws, the Environmental Impact Assessment Procedure (No. 616/2015) and under the guidance of the Ministry MONREC. E Guard Environmental Services will revise EIA report for Bawdwin project of Win Myint Mo Industries Company Limited.

The commitment letters of the proponent and third party are included as Appendix 3 and 4.

Bawdwin Project

Environmental Impact Assessment
Chapter 2

October 2023

Bawdwin Project

Prepared for

Win Myint Mo Industries Company Limited

Prepared by	Revised by
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Quality information

Revision history

Revision	Description	Date	Originator	Reviewer	Approver
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v2	EIA Chapter 1	24/12/2020	Michael Sale	Tara Halliday	Tara Halliday
V3	EIA Chapter 1	5/2/2021	Lana Griffin	Tara Halliday	Tara Halliday
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Rev1	electronic	Word, PDF	Win Myint Mo Industries Co., Ltd.	22/9/2023

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Contents

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2 Policy, legal and institutional framework

This chapter describes the key laws, rules, standards and guidelines relevant to the project, including:

- The legislation and guidelines of Republic of the Union of Myanmar (Myanmar) that apply to the approval and grant of tenure of the project.
- International standards and guidelines that relate to the project design, environmental impact assessment (EIA) document and process and eventual project implementation.
- Bawdwin Joint Venture (BJV) corporate environmental and social policies and commitments.

2.1 Policy, legal and institutional framework

2.1.1 Myanmar legislation and guidelines

The key legislation governing the project, and in particular the approval and tenure for the project, are:

- *Myanmar Mines Law (1994), Mines Law Amendment (2015),* and associated Mines Rules (2018).
- The *Environmental Conservation Law (2012)* (Environmental Conservation Law) and the supporting EIA Procedure.

A description of these two areas of legislation and the principal approvals required by each is provided in the following sections.

In addition, there are a number of national policies and standards and cross-sectoral laws that provide the regulatory framework for Myanmar's mining sector. Finally, other legislation and regulations applicable to the assessment of specific environmental, social and cultural heritage aspects of the project are discussed, as well as an overview of the broader policy framework.

Mining laws and rules

Myanmar's 2008 Constitution grants the Union Government ultimate ownership of all land and natural resources within the country's national territory, whether located above or below ground, and the ability to make laws for extraction of natural resources. The mining sector is regulated by the Ministry of Natural Resources and Environmental Conservation (MONREC) principally through the Department of Mines and Department of Geological Survey and Mineral Exploration (DGSE), along with four mining State-Owned Enterprises, each with a specific mineral focus and all reporting to the Union Minister for Natural Resources and Environmental Conservation. Of most relevance to the project is Number 1 Mining Enterprise (ME-1), which is responsible for mining, production and marketing of antimony, lead, zinc, silver, iron, nickel and copper ores and, limestone. The Department of Mines is responsible for forming mineral policy, enforcing regulations and environmental standards, and collecting royalties. A number of these regulatory functions are undertaken on behalf of the Department of Mines by the mining enterprises.

The ***Myanmar Mines Law (1994)*** **(Mines Law)** is the main piece of legislation governing the mining and minerals sector in the country. This law was amended in 2015 (Mines Law Amendment) to promote the development of investment in respect of mineral resources. It sets out the mine licensing framework, the respective roles and responsibilities of the Union Government and the fiscal regime and royalty rates for minerals, as well as the objectives of mine inspections and penalties for non-compliance.

Myanmar's legal framework establishes classes of mineral exploration and production permits based on the nature and scope of proposed activities. The Mines Law and Mines Law Amendment specify nine classes of permitted activities. Section 11 of the Myanmar Mines Law Amendment prescribes the classifications of mines as either large, medium or small depending on: the life of mine, the spatial extent, capital investment and machinery used.

Under these criteria, the Bawdwin project is classified as a 'large' mine. Details regarding the application and granting of permits and the duties and rights of permit holders are outlined in the Myanmar Mines Rules (2018).

The **Myanmar Mines Rules (1996) (Mines Rules)** provide further detail regarding specific aspects relating to the mining sector. The Mines Rules were recently updated (13 February 2018). The recent amendments to the Myanmar Mines Rules provide further detail relating to licencing, the fiscal regime and environmental management. The **Myanmar Mines Rules (2018)** also address included the addition of environmental management and mine closure.

The Mines Rules outline measures to avoid environmental impacts by mining operations (Chapter 31) and set out a number of conditions that a proponent must meet including testing of pollutants from mineral production, and management of hazardous wastes. In regard to mine closure and rehabilitation (Chapter 30) it requires holders of a large-scale mineral production permit to prepare a mine closure plan in consultation with relevant stakeholders with subsequent review every five years. Additionally, it requires that a fund for mine closure and rehabilitation has been raised and guaranteed before mineral production can commence.

The ***State-Owned Enterprises Law (1989)*** grants the Union Government the 'sole right' to carry out business in certain sectors including exploration, extraction and export of minerals and metals. Private operators and investors may participate in the mining sector through contracts with the Government or by entering joint venture agreements with the relevant state-owned enterprises. Such joint ventures operate on a production sharing basis, whereby the private partner is responsible for raising all capital and production is shared with the relevant mining enterprise in accordance with the terms and conditions set out in a negotiated Production Sharing Contract (PSC).

The right to conduct work and produce mineral products at the Bawdwin concession is currently governed by the PSC on Production and Processing of Lead and Zinc between ME-1 and Win Myint Mo Industries Co., Ltd (WMM). ME-1 and WMM entered into a PSC on 31 December 2009, which has since been amended twice, once on 16 June 2011, and again on 11 March 2015. Annex (a) to the 2009 Contract lists the concessions and leases transferred to WMM. The concessions and leases cover a combined area of 9,490.6 acres (3,840.7 ha) and include the Namtu concession (**Error! Reference source not found.**) and Bawdwin concession (**Error! Reference source not found.**).

The PSC is valid for an operating period of 15 years, with an option to be extended for a further five years. It goes into detail about the general duties of both ME-1 and WMM, and how the transfer of the mine should take place. Section 13 of the contract outlines how production sharing will take place including the share ratio and how the value of concentrates will be determined.

Redevelopment of the Bawdwin mine will require an extension to the large-scale production permit, as it is a significant economic deposit, requires substantial investment in complex technology, and has a mine life of 13 years, with the potential to extend up to 50 years if underground mining is found to be economically feasible.

The ***Myanmar Companies Act 2017*** took effect from 1 August 2019. The Act simplified company administration and provided a wider framework for Myanmar's businesses.

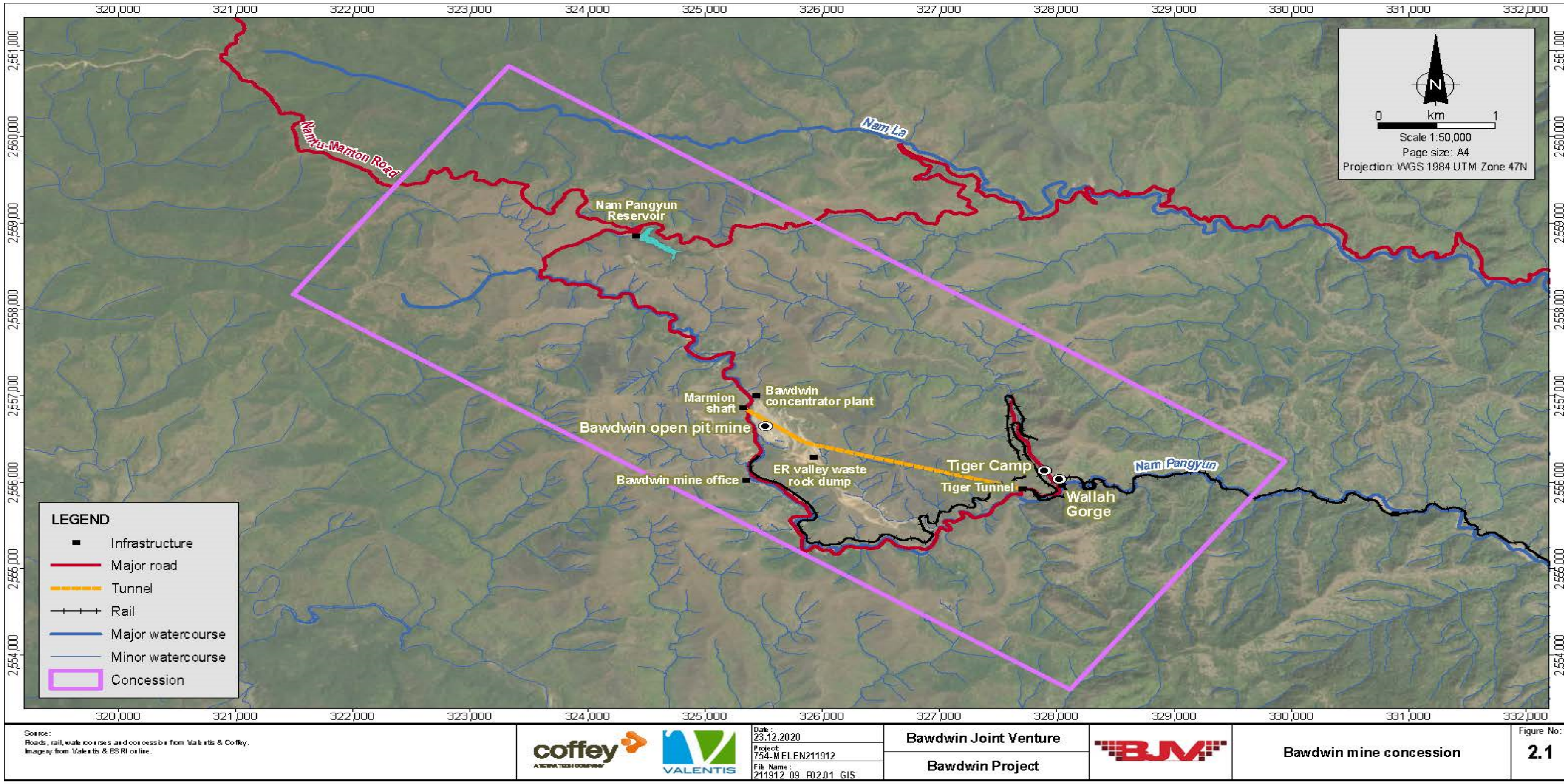

Figure 2.1 Bawdwin mine concession

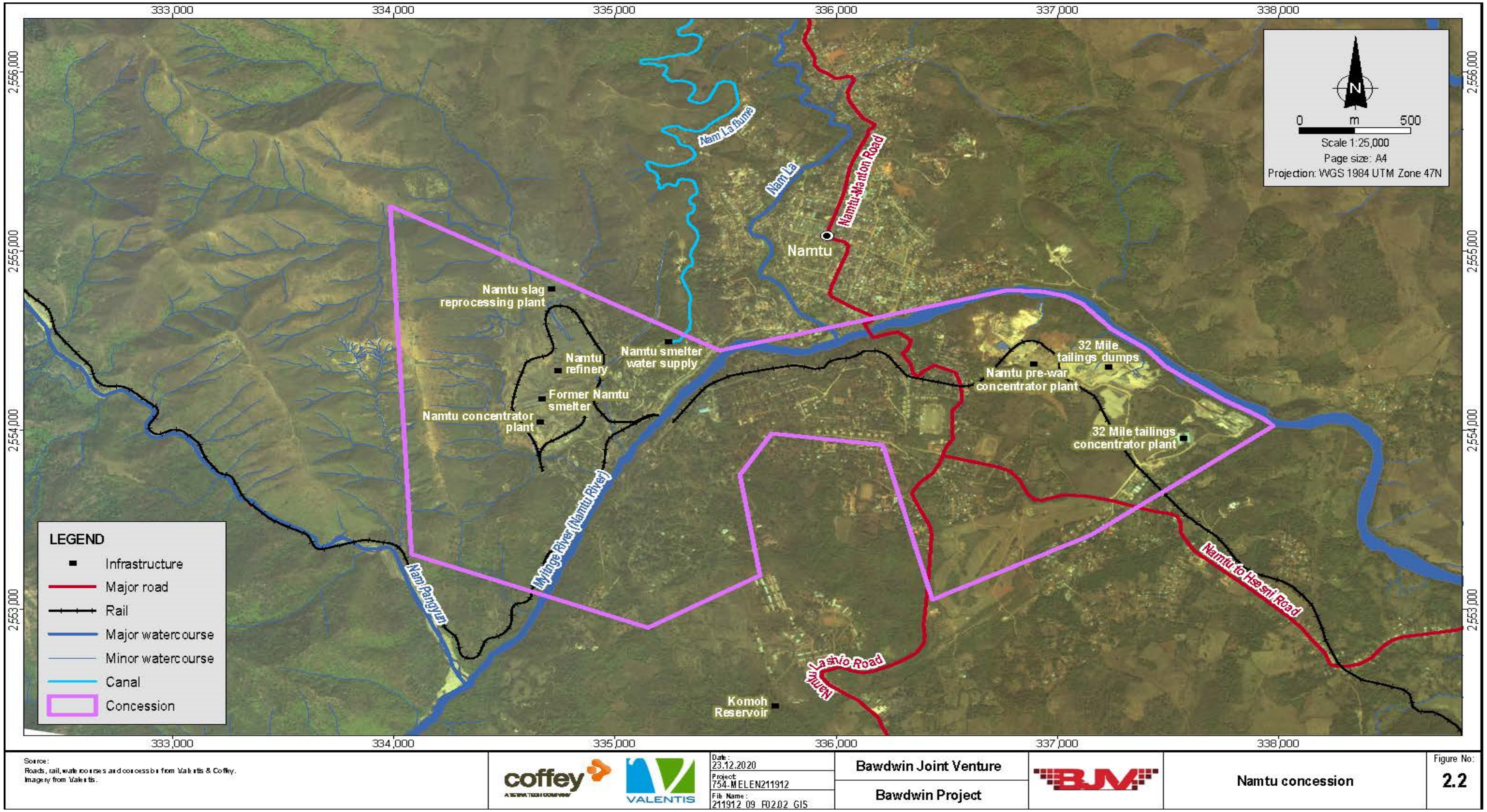

Figure 2.2 Namtu concession

Under the ***Myanmar Investment Law 2016***, major and/or sensitive projects, including proposed large-scale mineral production projects, require prior investment approvals from the Myanmar Investment Commission (MIC), a government body comprised of a number of key government representatives. This includes a requirement for MIC approval of foreign investment in the production project, sought be way of an application based on the financial, technical and related projections of the proposed project. Given the foreign investment, its size and significance of the Bawdwin mine a MIC permit will be required. The permit outlines key project requirements and sets out any investment concessions an investor may receive for a project.

Negotiations are underway to vary this PSC to extend the PSC term and renegotiate the production share terms based on the resource defined in the new feasibility study.

Environmental laws and rules

The Environmental Conservation Law and Environmental Conservation Rules establish a requirement for EIA. In accordance with sub-section (b) of Section 42 of the Environmental Conservation Law, the EIA Procedure was issued in 2015 to provide guidance for environmental impact assessment for the development of projects that may have an adverse impact.

The EIA Procedure outlines the required level of assessment, which depends on the nature and scale of the development. All new projects and project expansions having the potential to cause adverse impacts are required to submit an EIA and obtain approval in the form of an Environmental Compliance Certificate (ECC) which sets out the conditions on which a project is approved.

Section 23 of the EIA Procedure outlines the initial steps for the environmental and social approvals process. The main steps include:

- The project proponent **submits a project proposal** to MONREC for initial screening. The project proposal for the Bawdwin project was submitted by WMM to ME-1 in October 2018 and resubmitted in March 2019 following advice from the Environmental Conservation Department (ECD).
- MONREC (in association with relevant statutory authorities) assesses the project proposal and determines the need for and level of environmental assessment with consideration of EIA Procedure Annex 1 Categorization of Economic Activities for Assessment Purposes.
- The Ministry then designates the project as either an EIA Type Economic Activity, an Initial Environmental Examination report (IEE) Type Economic Activity, or neither and therefore not requiring an EIA. In May 2019, the General Manager on behalf of the Managing Director designated the project as an EIA Type Economic Activity.
- The project proponent submits details of the environmental consultant that will conduct the EIA (third party confirmation from ECD). In August 2019, the Director on behalf of the Director General (MONREC) approved the third-party application for Coffey & Valentis to act as the EIA consultants for the project.

An overview of the approvals process for an EIA Type Economic Activity is shown in **Error! Reference source not found.**.

Chapter V of the EIA Procedure describes the approval process and requirements and can be summarised in four stages, as outlined in Table 2.1.

Section 62 to 63 of the EIA Procedure outline the required content of the EIA Report and the Environmental Management Plan. This report has considered these requirements as well as the 2018 draft Myanmar Mining EIA Guidelines and international standards in developing the EIA and ESMP structure and content.

Table 2.1 Stages of EIA approval process and requirements

Approval process stage	Description
Scoping	The aim of the Scoping stage of the approvals process is to: • Define the spatial scope of the project. • Provide a preliminary assessment of environmental and social impact that will be investigated by the EIA. • Develop objectives and tasks of the proposed technical studies that will support the EIA. • Commence stakeholder engagement and provide an initial opportunity for stakeholder input into the EIA. The conclusion of the scoping stage results in the submission of a Scoping Report and Terms of Reference for the EIA. The Scoping Report for the Bawdwin project was submitted in July 2019. Following feedback from ECD in November 2019 and March 2020, the final Scoping Report was submitted in March 2020. On March 29 2020, the Minister accepted the Scoping Report and Terms of Reference for the Bawdwin project EIA including a number of requirements to be addressed in the EIA.
EIA investigation	The EIA investigation stage: • Investigates and assesses physical, biological, social, legal, economic, health, cultural and visual aspects that may be affected by the project and assesses potential impacts and risks of unplanned events. • Considers applicable national and international standards and considers the views and concerns of stakeholders. A key aspect of the EIA investigation stage is the public participation process including the timely disclosure of all relevant information about the project and its likely impacts (described further in Chapter 9).
EIA reporting	After completing all investigations and public consultation and participation processes, the proponent prepares and submits the EIA Report in accordance with the EIA procedure to the ECD with the required service fee as prescribed by the department.
Review and approval process	During the review and approval process stage: • ECD circulates the EIA Report to a convened EIA Report review body for comment and recommendations. • Relevant stakeholders including government organisations, institutions, civil society organisations, and project affected people (PAP) are invited to comment. • The proponent (or consultant) presents the EIA Report to national, regional, state, and local level governments. • At this point the Ministry may require the proponent to make amendments to the EIA Report. • The Ministry makes a final decision within ninety (90) working days of receipt of the EIA Report. • In the case of complex projects, or if the Ministry requires the EIA Report to be amended, the timeline will be extended accordingly. • The Ministry either approves the EIA Report with the guidance of the review committee, subject to any conditions as may be prescribed, and issues an ECC; or rejects the EIA Report. If the EIA is rejected, an appeal process can be pursued.

Source: Based on Chapter V of the EIA Procedure

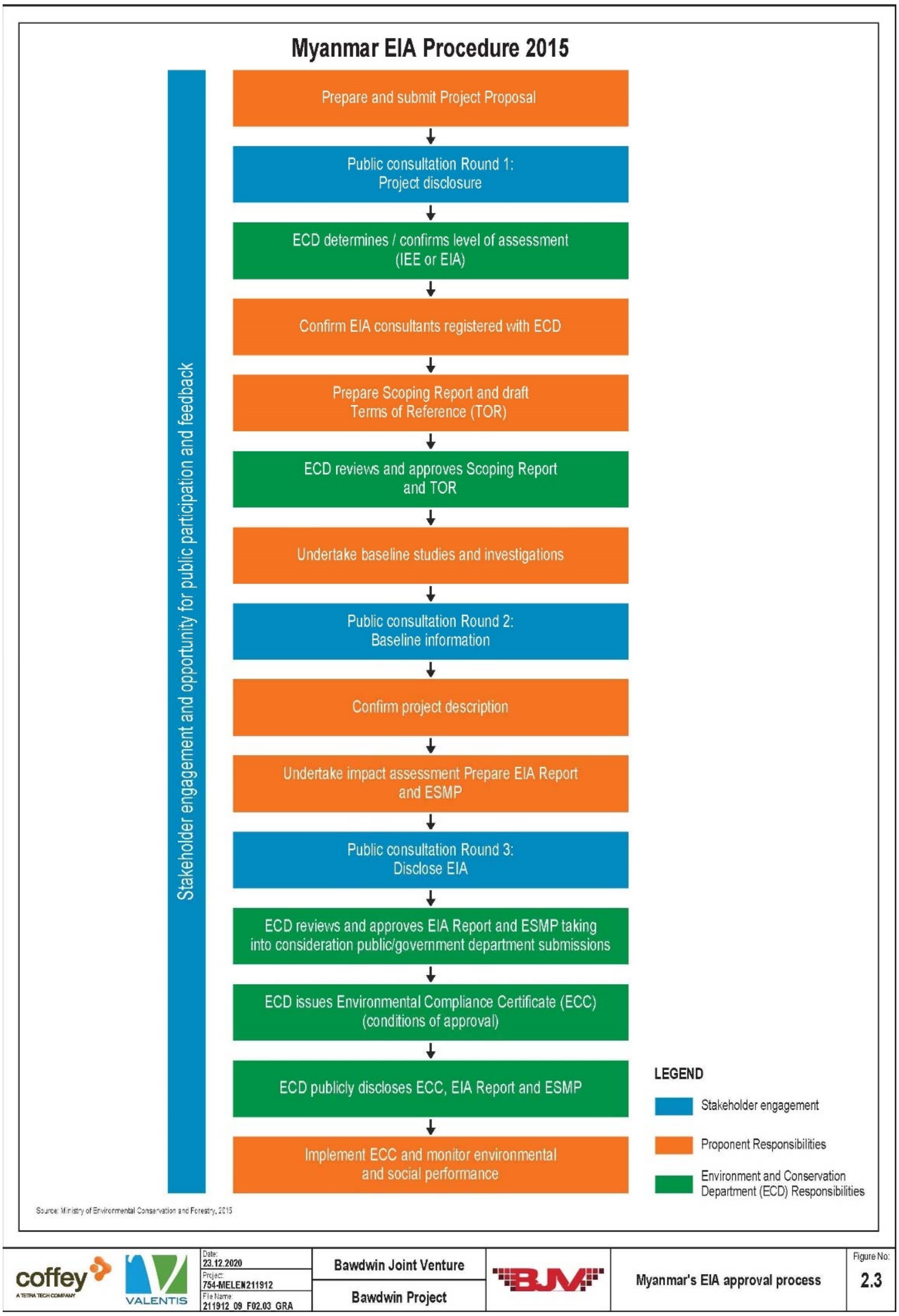

Figure 2.3 Myanmar approvals process

Environmental Impact Assessment Guidelines for the Mining Sector

The 2018 draft Myanmar Mining EIA Guidelines include a set of six guidance documents on preparation and review of environmental approvals documents including EIA, EMP and ECC, specific to the mining sector. The final draft Mining Guidelines for Environmental Impact Assessment (July 2018) have been prepared by external consultants funded by the Asian Development Bank. The draft guidelines generally follow IFC performance standards and provide detailed guidance.

The draft guidelines are to be used to guide project proponents and EIA consultants in the assessment of environmental and social impacts of mining projects of any size. The draft guidelines outline that conduct of the EIA investigation has the following basic steps:

1. Defining the geographic boundaries of the assessment.
2. Defining the time frame for the assessment.
3. Preparing the project description.
4. Analysis of alternatives.
5. Description of the natural and social environment.
6. Assessment of impacts.
7. Designing mitigation measures.
8. Cumulative impact assessment.
9. Designing environmental quality monitoring programs.
10. Risk assessment and emergency response planning.
11. Community engagement and community development planning.
12. Environmental and social management planning.

The draft guidelines are supported by a technical guidance manual, *Technical Guidance for Environmental Impact Assessment of Mining*. This manual provides further guidance as to the expectations of scope, and content of the EIA report and supporting investigations. The manual states that all mines require an Environmental and Social Management Plan (ESMP) to be used throughout the mine life cycle. In general, the ESMP should include:

- Proposed mitigation measures.
- Environmental monitoring and reporting requirements.
- Institutional or organizational arrangements.
- Capacity development and training measures.
- Implementation schedule.
- Cost estimates.

Guideline on Public Participation in EIA Processes

The draft Guideline on Public Participation in EIA Processes (31 May 2017) (referred to as the Public Participation Guideline) describes the public participation processes required under the EIA Procedure to be completed during the EIA process.

Environmental Management Plan for Mining Sector Guideline

The Environmental Management Plan for Mining Sector Guideline (July 2018) presents the format in which each EMP should be set out. As per the guideline, the following sections should be included:

- Executive summary
- Project description
- Maps and layout plan
- Commitments
- Policies and legislation
- Existing environment
- Impacts and mitigations measures
- Emergency plan
- Public disclosure
- Monitoring and budget allocation
- Institution and budget allocation
- Corporate social responsibility
- Mine closure plan

Note these sections differ somewhat from those outlined in the EIA Procedure for the content of the EMP and subplans.

Other applicable laws and rules

Table 2.2 provides a list of other cross-sectoral laws and rules of relevance to the project in addition to the mining and environmental laws described above.

Table 2.2 Other laws and rules applicable to the project

Acts	Objective, scope and purpose	Relevance to the project
Constitution of the of the Republic Union of Myanmar 2008:	The Constitution of the of the Republic Union of Myanmar is the foundational legislation for the Union. It establishes Myanmar as an independent sovereign Nation for multi-national races and the basis for a multi-party democratic system. The legislation includes provisions regarding the protection of the environment in Myanmar. • The Union shall protect and conserve natural environment under section-45 of said law. • Every citizen has the duty to assist the Union carrying out the environmental conservation under sub-section (b) of section 390 of said law.	Articles in the Constitution relevant to environmental protection that may relate to Bawdwin are Articles 37, 42 and 390.
Environment Laws		
National Environmental Policy of Myanmar (2019)	• Mission: To achieve a clean environment, with healthy and functioning ecosystems, that ensures inclusive development and wellbeing for all people in Myanmar. • Vision: To establish national environmental policy principles for guiding environmental protection and sustainable development and for mainstreaming environmental considerations into all policies, laws, regulations, plans, strategies, programs and projects in Myanmar.	

Acts	Objective, scope and purpose	Relevance to the project
The Environmental Conservation Law (2012)	To construct a healthy and clean environment and to conserve natural and cultural heritage for the benefit of present and future generations; to maintain the sustainable development through effective management of natural resources and to enable to promote international, regional and bilateral cooperation in the matters of environmental conservation. • The project proponent has to pay the compensation for damages if the project will cause injuries to environment under sub-section (o) of section 7 of said law. • The project proponent has to purify, emit, dispose and keep the polluted materials in line with the stipulated standards under section 14 of said law. • The project proponent has to install or use the apparatus which can control or help to reduce, manage, control or monitor the impacts on the environment under section 15 of said law. • The project proponent has to allow relevant governmental organization or department to inspect whether performing is conformity with the terms and condition included in prior permission, stipulated by the ministry, or not under section-24 of said law. • The project proponent has to comply with the terms and conditions included in prior permission under section 25 of said law. • The project proponent has to abide by the stipulations included in the rules, regulation, by-law, order, notification and procedure under section 29 of said law.	
The Environmental Conservation Rules (2014)	• The project proponent has to avoid emit, discharge or dispose the materials which can pollute to environment, or hazardous waste or hazardous material prescribed by notification in the place where directly or indirectly injure to public under sub-rule (a) of rule 69 of said law. • The project proponent has to avoid performing to damage to ecosystem and the environment generated by said ecosystem under sub-rule (b) of rule 69 of said law	
The Environmental Impact Assessment Procedure (2015)	• The project proponent has to be liable for all adverse impacts caused by doing or omitting of project owner or contractor, sub-contractor, officer, employee, representative or consultant who is appointed or hired to perform on behalf of project owner under sub-paragraph (a) of paragraph 102 of said law. • The project proponent has to support, after consultation with effected persons by project, relevant government organization, government department and other related persons, to resettlement and rehabilitation for livelihood until the effected persons by the project receiving the stable socio-economy which is not lower than the status in pre-project under sub-paragraph (b) of paragraph 102 of said law.	

Acts	Objective, scope and purpose	Relevance to the project
	• The project proponent has to fully implement all commitments of project and conditions included in EMP. Moreover, the project proponent has to be liable for contractor and sub-contractor who perform on behalf of him/her have to fully abide by the relevant laws, rules, this procedure, EMP and all conditions under paragraph 103 of said law. • The project proponent has to be liable and fully & effectively implement all requirements included in ECC, relevant laws and rules, this procedure and standards under paragraph 104 of said law. • The project proponent has to inform the completed information, after specifying the adverse impacts caused by the project, from time to time under paragraph 105 of said law. • The project proponent has to continuously monitor all adverse impacts in the pre-construction phrase, construction phrase, operation phrase, suspension phrase, closure phrase and post-closure phrase, moreover has to implement the EMP with abiding the all conditions included in ECC, relevant laws & rules and this procedure under paragraph 106 of said law. • The project proponent has to submit, as soon as possible, the failures of his or her responsibility, other implementation, ECC or EMP. If dangerous impact caused by this failure or failure should be known by the Ministry the project proponent has to submit within 24 hours and other than this situation has to submit within 7 days from knowing it under paragraph 107 of said law. • The project proponent has to submit the monitoring report dually or prescribed time by Ministry in line with the schedule of EMP under paragraph 108 of said law. • The project proponent has to prepare the monitoring report under paragraph 109 of said law. • The project proponent has to show this monitoring report in public place such as library, hall and website and office of project for the purpose to know this report by public within 10 days from the date which the report is submitted to the Ministry. Moreover, has to give the copy of this report, by email or other way which way agreed with the asked person, to any asked person or organization under paragraph 110 of said law. • The project proponent has to allow inspector to enter and inspect in working time and if it is needed by Ministry has to allow inspector to enter and inspect in the office and work-place of project and other work-place related to this project in any time under paragraph 113 of said law.	

Acts	Objective, scope and purpose	Relevance to the project
	• The project proponent has to allow inspector to immediately enter and inspect in any time if it is emergency or failure to implement the requirements related to social or environment or caused to it under paragraph 115 of said law. • The project proponent has to allow inspector to inspect the contractor and sub-contractor who implement on behalf of project under paragraph 117 of said law.	
National Environmental Quality (Emission) Guidelines (2015)	The project proponent has to emit, discharge or dispose in line with the standards stipulated in said guideline	
Forest Law (2018)	To implement forest policy and natural resources and environmental conservation policy with the aim of: • forest, natural resources and environment conservation. • climate change and disaster risk reduction with international agreements. • protecting forest cover and biodiversity. • protecting against damage due to forest fire, pest and disease. • establishing forest and firewood plantation and sustainably extracted forest products.	It is not anticipated that significant impact to forested areas will result from the project. • The project proponent has to obtain the permission of Ministry of Natural Resources and Environmental Conservation before starting the work if the project land is forest land or forest covered under sub- section (a) of section 12
Forest Rules 1995 and Amending 1998	Emphasises: • increased formation and protection of reserved forests and protected public forests, • sharing of forest management responsibility with the local communities, • establishment of fast growing plantations on degraded forest lands to conserve soil, water and biodiversity, and • harvesting of timber and other forest products in an environmentally sound manner.	It is not anticipated that significant impact to forested areas will result from the project.
The Protection of Wildlife and Protected Areas Rule 2002	To provide the sustainability of ecosystems, habitats and biodiversity	Limited relevance as this relates primarily to designated protected areas which fall outside of the project area.
Protection of Biodiversity and Protected Areas Laws 2018	Provides for the: • Protection of wildlife • Conservation of protected areas. • Compliance with international conventions and agreements. • Protection of endangered species of flora and fauna and their habitats. • Contribution for the development of research on natural science. • Establishment of gardens for the protection of flora and fauna.	Limited relevance as this relates primarily to designated protected areas which fall outside of the project area. • The project proponent has to avoid entering the prohibited area located in protected area without permission under sub-section (a) of section35 of said law. • The project proponent has to avoid digging on the land or carrying out any activity in protected area under sub-section (c) of section35 of said law. • The project proponent has to avoid extracting, collecting or destroying in any manner, any kind of wild or cultivated plant in

Acts	Objective, scope and purpose	Relevance to the project
		protected area under sub-section (d) of section35 of said law. • The project proponent has to avoid polluting soil, water and air, damaging a water-course or poisoning water, electrification, using chemical or explosive materials in protected area under sub-section (a) of section39 of said law. • The project proponent has to avoid possessing or disposing of toxic objectives or mineral wastes in protected area under sub-section (b) of section39 of said law.
The Conservation of Water Resources and Rivers Law 2006 and Amending Law 2017	Aims to: • Conserve and protect the water resources and rivers system for beneficial utilization by the public. • Provide smooth and safe waterway navigation along rivers and creeks. • Contribute to the development of State economy through improving water resources and river systems. • Protect from environmental impacts.	Bawdwin project will divert channels and may discharge pollutants to waterways. The project will need to demonstrate compliance with the PSC and ECC.
The Conservation of Water Resources and Rivers Rules 2013 and Amending 2015	Aims to: • Conserve and protect the water resources and rivers system for beneficial utilization by the public. • Provide smooth and safe waterway navigation along rivers and creeks. • Contribute to the development of State economy through improving water resources and river systems. • Protect from environmental impact.	Bawdwin project will divert channels and may discharge pollutants to waterways. The project will need to demonstrate compliance with the PSC and ECC. • The project proponent has to avoid any act to damage to the river, any creek and water resource under sub section (a) of section 8 of said law. • The project proponent has to avoid disposing the fuel, chemicals, toxic substances, other substances and explosive substances from the bank to the river under sub section (a) of section 11 of said law. • The project proponent has to avoid disposing any material, which may damage or change the water way, from the bank to the river under section 19 of said law. • The project proponent has to avoid constructing the toilets, which are not suitable, at the bank under sub section (a) of section 21 of said law. • The project proponent has to avoid digging the well or lake and digging the soil without permission of the Directorate

Acts	Objective, scope and purpose	Relevance to the project
		under sub section (b) of section 21 of said law. • The project proponent has to avoid putting the heavy materials in the bank without permission of the Directorate under section 22 of said law. • The project proponent has to avoid the violation of conditions stipulated by the Directorate for prevention of water pollution under sub section (b) of section 24 of said law. • If the project proponent has to build a river-crossing bridge or stream-crossing bridge alongside within the stream territory, river bank territory and strand territory as necessity, present the project scope and project period to the Ministry of Transport and request the agreement contract, in line with the section (20) of said law. • After reviewing the request form in accordance with section 20 and if there is no possible impact on conservation of water resources and rivers, the Ministry of Transport shall define the regulations and give the permission of constructing stream-crossing bridges and river-crossing bridges, in line with the section (21) of said law. • If the permission is given according with section 21, the project proponent has to submit the project scope and monitoring service charges to the department for the construction of the river-crossing bridges and stream-crossing bridges, in line with the section (22) of said law.
Freshwater Fisheries Law 1991	Aims to: • Further develop fisheries. • Prevent the extinction of fish. • Safeguard and prevent the destruction of freshwater fisheries waters. • Obtain duties and fees payable to the State. • Manage the fisheries and take action in accordance with the Law.	Limited relevance to the project.
Underground Water Act 1930	Legislates the extraction of groundwater, requiring a license be obtained beforehand.	Should groundwater extraction be required, licenses will have to be obtained from the water officer.
Investment Laws		

Acts	Objective, scope and purpose	Relevance to the project
Myanmar Investment Law (2016) and Myanmar Investment Rules (March 2017)	Key objectives of the law of relevance to the project are: • to develop responsible investment businesses which do not cause harm to the natural environment and the social environment for the interest of the Union and its citizens (as per the Environmental Conservation Law and EIA Procedure); • to create job opportunities for the people; • to develop various professional fields including infrastructure around the Union; • to enable the citizens to be able to work alongside with the international community; • to develop businesses and investment businesses that meet international standards.	• The project proponent has to submit a proposal to the Commission and invest after receiving the Permit under section 36 of said law. • The project proponent has not to invest in prohibited investment under section 41 of said law. • The project proponent has to register the land lease contract at Registration of Deeds Office in accordance with the Registration of Deeds Law under sub – section (d) of section 50 of said law. • The project proponent has to appoint a qualified person of any citizenship in the investor's investment within the Union as senior manager, technical and operational expert, and advisor in accordance with applicable laws under sub -section (a) of section 51 of said law. • The project proponent has to appoint the nationalities in the various levels of administrative, technical and expert work by the arrangement to develop their expertise under sub- section (b) of section 51 of said law. • The project proponent has to appoint the nationalities only in normal work without expertise under sub – section (c) of section 51 of said law. • The project proponent has to appoint either foreigner or nationality with the appointment agreement in accord with the law under sub – section (d) of section 51 of said law. • The project proponent has to ensure the entitlements and rights contained in applicable labor laws and rules including minimum wages and salary, leave, holiday, overtime fee, damages, workman's compensation, social welfare and other insurance relating to workers by stipulating the rights and duties of employers and employees and other employment terms and conditions contained in the employment contract under sub – section (e) of section 51 of said law. • The project proponent has to settle disputes arising amongst employers, amongst workers,

Acts	Objective, scope and purpose	Relevance to the project
		between employers and workers, between workers and technicians or staff in accordance with applicable laws under sub – section (f) of section 51 of said law. • The project proponent has to respect and comply with the customs, traditions and culture of the national races in the Union under sub – section (a) of section 65 of said law. • The project proponent has to establish and register a company or sole proprietorship or legal entities or branches under the applicable laws in order to invest under sub – section (b) of section 65 of said law. • The project proponent has to abide by the rules and stipulations of special licenses, permits and business operation certificates issued to them including the rules, procedures, notifications, orders and directives issued under applicable laws and this law, terms and conditions of contract and tax obligations under sub – section (c) of section 65 of said law. • The project proponent has to carry out in accordance with the stipulations of department concerned if it is required by the nature of business or other need to obtain any license or permit from the relevant Union Ministries, government bodies and organizations, or to carry out registration under sub – section (d) of section 65 of said law. • The project proponent has to immediate inform to the Commission if natural mineral resources or antique objects and treasure trove, which are not related to the permitted business and not included in original contracts, are found above and under the land on which the investor is entitled to lease or use under sub – section (e) of section 65 of said law. • The project proponent has not made any significant alteration of topography or elevation of the land on which he is entitled to lease or has rights to use, without the approval of the Commission

Acts	Objective, scope and purpose	Relevance to the project
		under sub – section (f) of section 65 of said law. • The project proponent has to comply with the international best practices, existing laws, rules and procedures to not damage, pollute, and injure to environment, cultural heritage and social under sub – section (g) of section 65 of said law. • The project proponent has to prepare and keep proper records of books of account and annual financial statement, and necessary financial matters relating to the investments which are performed by permit or endorsement in accordance with internationally and locally recognized accounting standards under sub – section (h) of section 65 of said law. • The project proponent has to close the project after paying the compensation to the employees in accord with the existing laws if violates the appointment agreement or terminate, transfer or suspend the investment or reduce the number of employees under sub – section (i) of section 65 of said law. • The project proponent has to pay the wages or salary to the employees in accord with the laws, rules, order and procedures in the suspension period under sub – section (j) of section 65 of said law. • The project proponent has to pay the compensation or injured fees to the respected employees or their inheritors if injury in or loss of part of body or death caused by work under sub – section (k) of section 65 of said law. • The project proponent has to stipulate the foreign employees to respect the culture and custom and abide by the existing laws, rules, orders, and directives under sub – section (l) of section 65 of said law. • The project proponent has to abide by labor laws under sub – section (m) of section 65 of said law. • The project proponent has to right to sue and be sued in accordance with laws under sub –

Acts	Objective, scope and purpose	Relevance to the project
		section (n) of section 65 of said law. • The project proponent has to pay the compensation, to the injured person for damages if damage to environment or socio-economy is occurred by misuse of project under sub – section (o) of section 65 of said law. • The project proponent has to inspect in anywhere of project if Myanmar Investment Commission inform to inspect the project under sub – section (p) of section 65 of said law. • The project proponent has to obtain the permission of MIC before EIA process and report back this process to Myanmar Investment Commission under sub – section (q) of section 65 of said law. • The project proponent has to insure the prescribed insurance by rules under section 73 of said law. • The project proponent has to submit confirmation of its compliance with the applicable requirements of the Environmental Conservation Law, rules and environmental impact assessment procedures to undertake, obtain and implement an initial environmental examination, assessment, certificate and management plan as those requirements are met under section 190 of said law. • The project proponent has to comply with the conditions of the permit issued by MIC and applicable laws when making the investment under section 202 of said law. • The project proponent has to fully assist while negotiating with the Authority for settling the grievances of the local community that have been affected due to Investments under section 203 of said law. • If the project proponent is desirous to appoint a foreigner as senior management, technician expert or consultant according to section 51(a) of the Law. The project proponent has to submit

Acts	Objective, scope and purpose	Relevance to the project
		such foreigner's passport, expertise evidence or degree and profile to the Commission Office for approval under section 206 of said law. • The project proponent has to insure the relevant insurance out of the following types of the insurance at any insurance business entitled to carry ort insurance business within the Union based on the nature of the business: (a) Property and Business Interruption Insurance; (b) Engineering Insurance; (c) Professional Liability Insurance; (d) Bodily Injury Insurance; (e) Marine Insurance; or (f) Workmen Compensation Insurance; (g) Life Insurance; (h) Fire Insurance. Under section 212 of said law.
The Myanmar Companies Law (2017)	Essential Requirements of Companies are as follows, • A company registered under the Myanmar Companies Law shall have the following facts: under section-4, sub-section (a) of said law. a) a name; b) a constitution c) at least one share in issue (provided that a company limited by guarantee need not have a share capital) d) at least one member e) subject to sub-section (vi), at least one director who shall be ordinarily resident in the Union; f) if the company is a public company, at least three directions, one of whom shall be a Myanmar citizen who is ordinarily resident in the Union; and g) a registered office address in the Union, under section-4, sub-section (a), sub-section i, ii, iii, iv, v, vi and vii of said law. Capacity and powers of companies are as follows, • A company: under section-5, sub-section (a) of said law. (i) will be a legal entity in its own right separate from its members having full rights, powers, and privileges and continuing in existence until it is removed from the register: under section-5, sub-section (a), sub-section (i) of said law. (ii) subject to this law and any other law, has both with other and outside the Union full legal	• The constitution of a company may contain a provision relating to the capacity, rights, powers, or privileges of the company only if the capacity of the company or those rights, powers and privileges are restricted, under section-5, sub-section (b) of said law. • A company may act as a holding company of another company and incorporate and hold shares in any number of subsidiaries, under section-5, sub-section (c)of said law.

Acts	Objective, scope and purpose	Relevance to the project
	capacity to carry on any business or activity, do any act, or enter into any transaction, including the power to: under section-5, sub-section (a), sub-section (ii) of said law. a) issue shares, debentures or securities which convert into shares in the company; under sub-section (ii), sub-section (aa) of said law. b) grant options to subscribe for shares or debentures in the company: under sub-section (ii), sub-section (bb) of said law. c) grant a security interest over any of its property: under sub-section (ii), sub-section (cc) of said law. d) distribute any of the company's property among the members, in kind or otherwise, under sub-section (ii), sub-section (dd) of said law.	
Myanmar Insurance Law (1993)	Requires that any business that may pollute the environment has compulsory general liability insurance.	• If the project proponent uses the owned vehicles the project owner has to insure the insurance for injured person under section 15 of said law. • The project proponent has to insure the insurance to compensate for general damages because the project may cause the damages to the environment and injury to public under section 16 of said law.
Occupational Health and Safety		
Draft Occupational Health and Safety Law 2019	Aims to implement measures for occupational health and safety across industry and sets out the responsibilities of employers and employees. Was enacted in 2019 and will be enforced following issue of notification by the president.	This will apply to the workforce safety during development and operations. • The project proponent has to- a) Appoint a person in-charge for occupational safety and health according to the type of industries to closely supervise the safety and health of the workers in accordance with the specifications of the Ministry. b) Establish each occupational Safety and Health Committee comprising equal number of employers and workers' representatives according to the types of industry without lessening the number of workers prescribed by the Ministry to be safe and healthy workplace, in accordance with the specifications of the Ministry. In establishing the Committee, occupational safety and health matters for female workers shall be considered according to the nature of work under sub – section (a) and (b) of section 12 of said law.

Acts	Objective, scope and purpose	Relevance to the project
		• The project proponent has to comply with this Law and rules, orders, directives and procedures issued under this Law to be safe and healthy workplace under section 14 of said law. • The inspectors shall inspect the workplace under this Law for occupational safety and health, instruct the respective employer on the facts to be observed, and report to the chief inspector under section 16 of said law. • For the purposes of occupational safety and health in line with the code of conduct, inspectors are entitled to; a) Enter, inspect and examine any workplace applicable to this Law without a warrant by showing their identity cards at any time; b) Inspect and copy all records, books and documents relating to the workplace and process, and seize any of them as exhibits, if necessary; c) Take photographs and video records of the workplace situations and processes which may be harmful to the occupational safety and health; d) Assess and record the amount of impact and time on the workplace environment, due to noise, illumination, temperature, dust, fume and hazardous materials, with the assistance of an expert on the respective subjects, if necessary; e) Inquire any person working at the workplace during working hours about contracting occupational diseases or potential situations with the assistance of a certified doctor; f) Ask the responsible person from hospitals and medical clinics to confidentially send the medical report of a worker who is receiving medical treatment for injuring in a workplace accident or suffering from an occupational disease or information about death or the autopsy report requested with the form prescribed by the Department under section 17 of said law.

Acts	Objective, scope and purpose	Relevance to the project
		• The inspectors shall issue a temporary order to the employer for work stoppage partially or wholly with the approval of the chief inspector and inform the relevant departments, if necessary, if any occupational accident, disease, dangerous occurrence or major accident happens or is likely to happen due to any of the following facts; a) Impropriety to work continuously due to the unsafe workplace conditions, unsafe acts of workers, the existence of hazardous material and machinery at the workplace, or parts of machinery or laying out of machinery at the workplace and working practices; b) Impropriety to work continuously due to violation of or failure to comply with any provision of this Law; c) Assumption to be harmful to workers at the workplace due to any act of negligence and carelessness or omission by any person; d) Necessity to evacuate workers for safety due to the imminent danger situation of the occupational injury under section 18 of said law. • The project proponent has to provide adequate and relevant personal protective equipment to workers free of charge and make them wear it during work so as not to expose workers to any serious occupational diseases or hazards under sub section (e) of section 26 of said law. • The project proponent has to arrange and display occupational safety and health instructions, warning signs, notices, posters, and signboards under sub section (l) of section 26 of said law. • The worker shall wear or use at all times any protective clothes, equipment and tools provided by the employer for the purpose of safety and health under sub section (a) of section 30 of said law. • The worker shall proper and systematic use any equipment and tools, machines, any parts of the

Acts	Objective, scope and purpose	Relevance to the project
		machines, vehicles, electricity and other substances being used at the workplace under sub section (d) of section 30 of said law. • The worker shall take reasonable care for the safety and health of himself/ herself and of other persons who may be affected by his/ her acts or omissions at work under sub section (e) of section 30 of said law.
Prevention of Hazard from Chemical and Related Substances Law (2013)	To ensure to use the hazardous chemical and related substances safely and safety for the employees. Moreover, safety in carrying the hazardous chemical and related substances and storage place of it. If it is needed to train how to use the safety dresses which provided to the employees with free of charges. Insure to compensate for injury to person or damage to environment. The project has to be inspected for safety use of hazardous chemical and related substances before starting the project.	• The project owner has to be inspected for the safety and resistance of the machinery and equipment by the respective Supervisory Board and Board of Inspection before starting the business under sub section (a) of section 15 of said law. • The project owner has to assign the employees, who will serve with the hazardous chemical and substances, to attend the trainings on prevention of hazardous chemical and substances in local or abroad under sub section (b) of section 15 of said law. • The project owner has to abide by the conditions included in the license under sub section (a) of section 16 of said law. • The project owner has to abide by and assign to the employees who serve in this work to abide by the instructions for safety in using the hazardous chemical and related substances under sub section (b) of section 16 of said law. • The project owner has to arrange the enough safety equipment in the work-place and provide the safety dresses to the employees who serve in this work with free of charge under sub-section (c) of section 16 of said law. • The project owner has to train, in work-place my arrangement, the know-how to use the occupational safety equipment, personal protection equipment and safety dresses systemically in the work-place under sub section (d) of section 16 of said law.

Acts	Objective, scope and purpose	Relevance to the project
		• The project owner has to allow the receptive Supervisory Board and Board of Inspection to inspect whether the hazard may be injured to health of human or animal or damaged to environment under sub section (e) of section 16 of said law. • The project owner has to assign the healthy employees who have obtained the recommendation that is fit for this work after taken medical check-up and keep systematically the medical records of employees under sub section (f) of section 16 of said law. • The project owner has to inform the copy of storage permission for hazardous chemical and related substances to the relevant township administrative office under sub section (g) of section 16 of said law. • The project owner has to obtain the approval with instructions of relevant fire force before starting the work if the project will use the fire hazard substances or explosive substances sub section (h) of section 16 of said law. • The project owner has to transport only the limited amount of the chemical and related substance in accord with the prescribed stipulations in local transportation under sub section (i) of section 16 of said law. • The project proponent has to take the permission from the Central Supervisory Board if the chemical and related substance is altered and transferred from one place to any other place which contained in the licence under sub – section (j) section 16 of said law. • The project owner has to insure, in accord with the stipulations, to pay the compensation if the project cause injury to person or animals or damage to environment under section 17 of said law. • The project owner has to abide by the conditions included in the registration certificate. Moreover will abide by the orders

Acts	Objective, scope and purpose	Relevance to the project
		and directives issued by the Central Supervisory Board from time to time under section 22 of said law. • The project owner has to classify the level of hazard to protect it in advance according to the properties of chemical and related substances under sub section (a) of section 27 of said law. • The project proponent has to express the Material Safety Data Sheet and Pictogram under sub – section (b) of section 27 of said law. • The project owner has to provide the safety equipment, personal protection equipment to protect and reduce the accident and assign to attend the training to use the equipment systematically under sub section (c) of section 27 of said law. • The project proponent has to perform in accordance with the stipulations in respect of transporting, possessing, storing, using, discharging the chemical and related substances under sub – section (d) of section 27 of said law.
The Control of Smoking and Consumption of Tobacco Product Law (2006)	To ensure the creation of smoking area and non-smoking area in the power plant area for health and control of smoking.	• The project proponent has to keep the caption and mark referring that is non- smoking area in the project area under sub section (a) of section 9 of said law. • The project proponent has to arrange the specific place for smoking in the project area and keep the caption and mark in accordance with the stipulations under sub section (b) of section 9 of said law. • The project proponent has to supervise and carry out the measures so that no one shall smoke at the non-smoking area under sub section (c) of section 9 of said law. • The project proponent has to allow the inspection of supervisory body in the power plant area sub section (d) of section 9 of said law.
The Vehicle Safety and Motor Vehicle Management Law (2020)	When the construction period and if necessary, in operation and production period for the all vehicles.	• The project proponent has to comply with the restrictions and restrictions on the use of domestic

Acts	Objective, scope and purpose	Relevance to the project
		vehicles by the Ministry of Transport and Communications with the approval of the Union Government under sub section (a) of section 9 of said law. • The project proponent has to comply with safety, environmental regulation, standards and regulations regarding the initial registration of vehicles issued by the Ministry under sub section (c) of section 12 of said law. • The project proponent has to drive at the speed limit set by the Road Transport Directorate to ensure the safe movement of vehicles on public roads under sub section (r) of section 14 of said law. • The project proponent has to maintain the vehicles in accordance with the standards set by the Department so that it can be driven safely under sub section (a) of section 18 of said law. • The project proponent has not to carry or transport hazardous materials in public places in accordance with the regulations under sub section (g) of section 81 of said law.
The Vehicle Safety and Motor Vehicle Management Rules (2022)		• The project proponent has to comply with the Commercial Vehicle Regulations in Chapter (9) and the Motor Vehicle Traffic Regulations in Chapter (10).
Pollution Prevention		
Prevention of Hazard from Chemicals and Related Substances Law (2013)	Establishes the licensing and approval system for the use of chemicals. Prohibits the operation of a chemical substances business without a license and prohibits the use of prohibited and unregistered chemicals or related substances	WMM will be required to obtain permits for the use of chemicals in its processing facilities.
Explosives Act (1884) (repeal), Explosives Substance Act (1908).	Regulates the use of explosive substances.	Transport and storage of explosive substances will be required to meet this legislation for example emulsion and magazine facilities.
The Occupational Explosive Material Law (June 2018)	Requires the: • Systematic use, import, transport and storage of occupational explosive material. • Safeuse of blasting material and related substances at the project site.	Transport and storage of explosive substances will be required to meet this legislation for example emulsion and magazine facilities.

The Industrial Explosive Materials Law (2018)	• (a) To manufacture, import, transfer, store and use industrial explosive materials systematically; • (b) To be safe and secure at workplaces where dynamite and related substances are used; (c) To supervise manufacture and use of industrial explosive materials systematically.	On receipt of the direction from the Ministry under sub – section (b), The project proponent has not refused inspection of the Chief Inspector or and inspector under section 8 of said law. The project proponent, in an unlicensed magazine, has to • Accept to store industrial explosive materials; • Deliver to store industrial explosive materials under section 16 of said law. The project has to- (a) Store industrial explosive materials only in the licensed magazine; (b) Take necessary preventive measures in accord with the specifications to avoid harm in transport, manufacture, use or possession of industrial explosive materials • The project proponent has not refused inspection of the Chief Inspector or and inspector under section 18 of said law. The project proponent has to- (a) Import, transport, store, manufacture, use, possess or transfer industrial explosive materials without permission in accordance with this law; (b) Destroy industrial explosive materials without approval of the Executive Committee of Defence Service Council (c) Fail to act in accordance with the rules, regulations, by-laws, notifications, orders and directives issued under section 19 of said law. The project proponent has not to accept to store industrial explosive materials; The project proponent has not The project proponent has to • Accept to store industrial explosive materials more than the limited amount mentioned in the licence issued by the Ministry; • Fail to inform the nearest police station immediately and to report the Chief Inspector timely if anything mentioned in sub-section (c) of section 15 occurs due to industrial explosive materials;

Acts	Objective, scope and purpose	Relevance to the project
		• Continue to store industrial explosive materials without renewal after expiration of the licence under section 21 of said law.
Health		
Prevention and Control of Communicable Diseases Law (1995), Amending Law 2011	Focuses on preventing the outbreak of communicable diseases through the implementation of various preventative measures and reactive actions.	Many workers will be both living and working in proximity to each other, increasing the chances of illnesses spreading. Compliance with this law will be required for project settlements. The project proponent has to build the housing in line with the health standards, distribute the healthful drinking water & using water and arrange to systematically discharge the garbage & sewage under clause (9) of sub section (a) of section 3 of said law. The project proponent has to abide by any instruction or stipulation by Department of health and Ministry of Health under section 4 of said law. The project proponent has to inform promptly to the nearest health department or hospital if the following are occurred: under section 9 of said law. (a) Mass death of animals included in birds or chicken; (b) Mass death of mouse; (c) Suspense of occurring of communicable disease or occurring of communicable disease; (d) Occurring of communicable disease which must be informed. The project proponent has to allow any inspection, anytime, anywhere if it is need to inspect by health officer under section 11 of said law.
Public Health Law 1972	Focuses on protecting people's health by controlling the quality and cleanliness of food, drugs, environmental sanitation, epidemic diseases and regulation of private clinics.	Any health and sanitation facilities provided due to the Bawdwin project will need to comply with this legislation. • The project proponent has to abide by any instruction or stipulation for public health under section 3 of said law. • The project proponent has to allow any inspection, anytime, anywhere, if necessary, under section 5 of said law.

Acts	Objective, scope and purpose	Relevance to the project
Protection of Ethnic Nationalities and Cultural Property		
The Ethnic Rights Protection Law (2015). Rules under discussion (August 2017)	The purpose of this legislation is to obtain equal citizen's rights for all ethnic groups and to preserve and develop their language, literature, arts, culture, custom, national character and historical heritage. Article 5: The matters of projects shall completely be informed, coordinated and performed with the relevant local ethnic groups in the case of development works, major projects, businesses and extraction of natural resources will be implemented within the area of ethnic groups.	Relevant to engagement and social impact assessment and implementation and operation of the project. The project proponent has to disclose all about the project fully to the residents who are national races. The project proponent has to cooperate with the residents who are national races according to section 5 of said law. The project proponent has to compliance with rule 20 shall be reported to the Ministry in full and submitted to the ministry before the project commences under sub-section (a) of section 21 of said law. After the implementation of the project, the plan must be submitted to the ministry under sub-section (b) of section 21 of said law.
The Protection and Preservation of Cultural Heritage Regions Law 1998	Aims to: • Protect and preserve the cultural heritage regions and the cultural heritage therein. • Promote public awareness of the cultural heritage regions. • Protect cultural heritage regions from destruction.	The project proponent has to apply to get the prior permission of Directorate of Ancient-Research to build the road, bridge or dam in the cultural heritage area under section 13 of said law. When the project proponent wants to carry out any of the following undertakings shall adhere to the provisions of the existing laws. The project proponent has to apply to the Region or State Preservation Committee if it is within the world heritage region or national level cultural heritage region, and apply to the Regional Preservation Committee if it is within the respective cultural heritage region apart from the world heritage region or national level cultural heritage region for obtaining the prior permission that there is no impact on cultural heritages in accordance with the stipulations; In the buffer area; Constructing roads, renovating and extending wharfs, parking lots, rail tracks, railway station, stadium, sports grounds, buildings and bridges; Conducting and erecting pylons, underground works, underground electric power lines, high voltage

Acts	Objective, scope and purpose	Relevance to the project
		power lines, transformer stations, lamp posts and gas pipelines; Arranging the flights of helicopter, hot air balloons and gliders; Constructing theatres such as the entertainment building, accommodation facilities, recreation centers, riding and race camps and infrastructures under sub – section (b) section 21 of said law. The project proponent promises not to build the building which is not in line with the stipulations prescribed by the Ministry of Culture in the cultural heritage area under section 22 of said law.
Protection and Preservation of Ancient Monuments Law (2015)	Provides for the: • Implementation of the policy to protect and preserve the perpetuation of ancient monuments. • Public awareness of the high value of ancient monuments. • Searching and maintenance of ancient monuments.	The Bawdwin Mine has numerous structures built by humans over 100 years ago, classifying them as ancient monuments. Permission to conduct works including surveying, digging and researching places where an ancient monument is located must be granted by the Ministry of Religion and Culture – Department of Archaeology and National Museum. • The project proponent has to report to the village-tract or ward administrators if the project proponent will find any ancient monument under the ground or on the ground or under the water under section 12 of said law. • The project proponent has to obtain the prior permission of Department of Ancient Research Museum if the project area is in the prescribed area of ancient monument under section 15 of said law. • The project proponent has to obtain the prior permission, by written, of Department of Ancient Research and National Museum if the project proponent disposes the chemical and solid waste in the Ancient Monument area under sub section (f) of section 20 of said law.

Acts	Objective, scope and purpose	Relevance to the project
The Protection and Preservation of Antique Objects Law 2015	Provides for the: • Implementation of the policy of protection and preservation of antique objects. • Public awareness of the high value of antique objects.	Any antique objects that are found, including human bones, religious objects, tools and currency must be reported to the relevant Ward or Village Tract Administrator. Mechanisms for reporting and movement of these discoveries must be determined prior to work starting. The project proponent has to inform to the village-tract or ward administrator if any antique objective is found in project area under section 12 of said law.
Land Laws and Land Tenure		
National Land Use Policy (2016)	• To promote sustainable land use management and protection of cultural heritage areas, environment, and natural resources in the interest of all people in the country; • To strengthen land tenure security for the livelihood's improvement and food security of all people in both urban and rural areas of the country; • To recognize and protect customary land tenure rights and procedures of the ethnic nationalities; • To develop transparent, fair, affordable and independent dispute resolution mechanisms in accordance with the rule of law; • To promote people centered development in land resources and accountable land use administration in order to support the equitable economic development of the country; • To develop a National Land Law in order to implement the above objectives of the National Land Use Policy.	WMM needs to abide this law.
Farm Land Law (2012) and Farm Land Rules (August 2012). Currently under revision in Parliament.	Relates to land tenure.	This law may apply to any land that is being used for farming that is required to be utilised for the project.
The Vacant, Fallow, and Virgin Lands Management Law (2012) and Amending Law (2018) and the Vacant, Fallow, and Virgin Lands Management Rules (August 2012)	To ensure the use of Vacant, Fallow and Virgin Lands for economic development and job opportunities for land-less citizens in relation to agriculture, livestock breeding, mining, and government is allowable.	May be relevant for chosen resettlement sites.
Land Acquisition Act (1894) and Amending Law 1954. Currently under revision (draft)	The objectives of the draft law (2017) are: • To provide a legal basis for the acquisition of land, prevention of illegal land acquisition and safeguarding the welfare of those who have had their land acquired; • To ensure that Affected Households and local communities who will be affected by the acquisition of land are transparently provided with information to enable them to freely negotiate and make decisions;	Of relevance if land is to be acquired.

Acts	Objective, scope and purpose	Relevance to the project
	• To ensure that Affected Households receive appropriate and equitable Compensation and damages to provide for Resettlement as a consequence of losses and damages which have resulted from loss of housing and relocation due to the acquisition of land; • To ensure the Restoration of Livelihoods of Affected Households; • To prevent adverse environment and public socio- economic impacts caused by acquisition and use of land.	
The Land Acquisition, Resettlement and Rehabilitation Law 2019	Enables the State to compulsorily acquire land when it is required for public interest. Outlines process for land acquisition and resettlement.	Of relevance if land is to be acquired for resettlement purposes.
Labour Laws		
Minimum Wage Act (2013), (Notification No. 2/2015 (August 2015).	Ensures the essential needs of the workers, and their family, who are working at the commercial, production and services, agricultural and livestock breeding businesses are met and to increase capacity of the workers and for the development of competitiveness.	The project proponent hasn't to pay wage to the worker less than the minimum wage stipulated under this Law. The project proponent has to pay more than the minimum wage stipulated under this Law. The project proponent hasn't not had the right to deduct any other wage except the wage for which it has the right to deduct as stipulated in the notification issued under this Law. The project proponent has to pay the minimum wage to the workers working in the commerce, production business and service in cash. Moreover, if the specific benefits, interests or opportunities are to be paid, it may be paid in cash in accord with the stipulations or jointly in some cash and in some produce prescribed in local price according to the desire of the worker. The project proponent has to pay jointly in some cash and some produce prescribed in local price according to the local custom or desire of the majority of workers or collective agreement in paying the minimum wage to the workers and working in the agriculture and livestock breeding business. Such payment shall be for any personal use and benefit of the worker and his family, and the value shall also be considerable and fair under section 12 of said law. • The project proponent has to notify the prescribed wages obviously in workplace under sub

Acts	Objective, scope and purpose	Relevance to the project
		section (a) of section 13 of said law. • The project proponent has to correctly record the lists, schedules, documents and wages and report these to the relevant department and give if these are asked while inspecting, in accord with the stipulations under sub section (b)(c)(d) of section 13 of said law. • The project proponent has to allow to be inspected by the inspector under sub section (d) and (e) of section 13 and section 18 of said law. • The project proponent has to allow holiday for medical treatment if the employee' health is not fit to work under sub section (f) of section 13 of said law. • The project proponent has to allow holidays without deducting from the wages if one of parents or one of family dies under sub section (g) of section 13 of said law.
The Payment of Wages Law (2016)	To ensure the way of payment and avoiding delay payment to the employees.	• The project proponent has to pay the wages under section 3 and 4 of said law. • The project proponent has to submit with the agreements of employees & reasonable ground to department if it is difficult to pay because of force majeure included in natural disaster under section 5 of said law. • The project proponent has to abide by the provisions of section 7 to 13 in chapter (3) in respect of deduction from wages under section 7 to 13 in chapter (3) of said law. • The project proponent has to pay the overtime fees, prescribed by law, to the employees who work over working hours under section 14 of said law.

Acts	Objective, scope and purpose	Relevance to the project
Labor Organization Law (2011)	Purpose: • To protect the rights of the workers, to have good relations among the workers or between the employer and the worker • To enable to form and carry out the labor organizations systematically and independently.	The project will observe the requirements for establishment of labour organisations and a worker's rights. • The project owner has to allow the labor organization to negotiate and settle with the employer if the workers are unable to obtain and enjoy the rights of the workers contained in the labor laws and to summit demands to the employer and claim in accord with the relevant law if the agreement cannot be reached under section 17 of said law. • The project proponent has to allow the demand for the re-appointment of worker who is dismissed by the employer without the conformity with the labor laws under section 18 of said law. • The project proponent has to send the representatives to the Conciliation Body in settling a dispute between the employer and the worker under section 19 of said law. • The project proponent has to allow the labor organization to participate and discuss in discussing with the government, the employer and the complaining employees in respect of employee's rights or interest contained in the labor laws under section 20 of said law. • The project proponent has to allow the labor organization to participate in solving the collective bargains of the employees in accord with the labor laws under section 21 of said law. • The project proponent has to allow the labor organization to carry out the holding the meetings, going on strike and other collective activities in line with the procedure, regulation, by-law and directive of relevant Chief Labor Organization under section 22 of said law.
Settlement of Labour Dispute Law (2012) and Amending Law (2014)	Purpose: • safeguarding the right of workers • having good relationship between employer and workers and making the workplace peaceful	Relevant to worker compensation arrangements. • The project proponent has to not absent to negotiation within

Acts	Objective, scope and purpose	Relevance to the project
	• obtaining the rights fairly, rightfully and quickly by settling disputes between an employer and worker justly.	the stipulated time for complaint under section 38 of said law. • The project proponent has to not change the existing stipulations for employees within conducting period before tribunal under section 39 of said law. • The project proponent has to not close the work without negotiation, discussion on dispute in accord with this law, decision by tribunal under section 40 of said law. • The project proponent has to pay the compensation decided by Tribunal if violates any act or any omission to damage the interest of labor by reducing of product without efficient cause under section 51 of said law.
Employment and Skills Development Law (2013)	Purpose: • Creation of employment opportunities • Implementing measures to reduce unemployment • Enhance discipline and capacity of the workers • Develop skills of workers • Forming and guiding the Employment and Skills Development Agencies	Project training and development programs should align with legislation. • The project proponent has to appoint employees with the contract under section 5 of said law. • The project proponent has to carry out the training programs with the policy of Skill Development Body to develop the employment skill of employees who is appointed or will be appointed under section 14 of said law. • The project proponent has to monthly pay to the fund, which is fund for development of skill of employees, not less below 0.5 percentage of the total payment to the level of worker supervisor and the workers below such level under sub section (a) of section 30 of said law. • The project proponent has to promise not to deduct from the payment of employees for above mentioned fund under sub section (b) of section 30 of said law.
Social Security Law (2012)	Requires a collective guarantee of the employer, worker and the Union for enabling to fulfil health and social needs of the workers.	Project development programs and work conditions should align with legislation. The project proponent has to create the social security for the employees because the project is the business under the Myanmar Citizen Investment Law. To ensure the social security for employees of

Acts	Objective, scope and purpose	Relevance to the project
		the project, the project owner has to register to the social security offices and to pay the prescribed fund. • The project proponent has to register to the respected social security office under sub section (a) of section 11 of said law. • The project proponent has to pay the social security fund for at least four types of social security included in sub-section (a) of section 15 under section 15 of said law. • The project proponent has to pay the fund which has to be paid myself and together with the fund which has to be paid from their salary by the employees. Moreover, the project owner will pay the cost for paying the above-mentioned fund only myself under sub section (b) of section 18 of said law. • The project proponent has to pay the fund for accidence sub section (b) of section 48 of said law. • The project proponent has to make correctly and submit the list and record provided in section 75 to respected social security office under section 75 of said law.
The Leave and Holiday Act (1951) and amended in 1958, 1963,1964, 2006, and 2014)/ Adopted in 1951 and amended in 1958,1963, 1964,2006, and 2014.	Leave and Holiday for workers	Relevant to worker compensation arrangements. The project proponent has to allow the leaves and holidays in line with the law.
Rights of Persons with Disabilities Law (2015). Rules currently under internal discussion between Ministry of Social Welfare and People with Disabilities groups (2017)	Applies to companies who are required to provide employment opportunities for people with disabilities.	Relevant to employment processes and policies and worker compensation arrangements.
Child Law (1993)	Protection of children from exploitation.	Relevant to employment processes and policies.
Workmen's Compensation Act 1923	Outlines an employer's liability for compensation if personal injury is caused to a worker by accident, arising out of and during the course of their employment.	The project will observe the requirements (e.g., compensation) of workplace injuries and accidents. • The project proponent has to pay the compensation in line with the provisions of said law

Acts	Objective, scope and purpose	Relevance to the project
		base on kind of injury and case by case under section 13 of said law.
Payment of Wages Law 2016	Regulates how an employer must pay its workers, what workers must be paid for and what to do if payment is unable to be made.	Will govern the requirements of the payroll requirements of the project workforce.
Other Laws		
The Electricity Law (2014)	To ensure the compliance with the conditions of permission for productions of electricity, abiding by any stipulation, implementing with the best practices and paying compensation in line with above law. It stipulated the following obligations of the project proponent.	• The project proponent has to implement the project with the best practices to reduce the damages on the environment, health and socio-economy, also will pay compensation for the damages and will pay the fund for environmental conservation under sub section (b) of section 10 of said law. • The project proponent has to take the certificate of electric safety, issued by the chief-inspector, before the commencement of power generation under section 18 of said law. • The project proponent has to abide by the rules, regulations, bye-laws, notifications, orders, directives and procedures issued by the Ministry in carrying out the electrical business contained in the permit under section 20 of said law. • The project proponent has to be liable for damages to any person or enterprise by failure to abide by the quality standards or rules, regulation, by-law, order and directive issued under said law under sub section (a) of section 21 of said law. • The project proponent has to be liable for damages to any person or enterprise by negligence of project owner under sub section (a) of section 22 of said law. • The project proponent has to pay if damages or losses arise to any other electric power user or any electrical business due to negligence of any electric power user, the calculated compensation in accord with the method prescribed by the Ministry for the value of damage or loss under section 24 of said law. • The project proponent has to comply with the permission for electric searching and generation

Acts	Objective, scope and purpose	Relevance to the project
		under sub section (a) and (b) of section 26 of said law. • The project proponent has to inform promptly to chief-inspector and head officer of related office while occurring of accident in electricity generation under section 27 of said law. • The project proponent has to comply with the standards, rules and procedure. Moreover, will allow the inspection by respected governmental department and organization if it is necessary under section 40 of said law. • The project proponent has to pay the compensation to anyone who is injured or caused to death in electric shock or fire caused by the negligence or omitting of the project owner or representative of project owner under section 68 of said law.
Natural Disaster Management Law (2013)	To implement natural disaster management programs and to coordinate with national and international organizations in carrying out natural disaster management activities; to conserve and restore the environment affected by natural disaster and to provide health, education, social and livelihood programs in order to bring about better living conditions for victims;	• The project proponent has to perform preparatory and preventive measures for natural disaster risks reduction before the natural disaster strikes under sub section (a)(i) of section 13 of said law. • The project proponent has to undertake rehabilitation and reconstruction activities for improving better living standard after the natural disaster strikes and conservation of the environment that has been affected by natural disaster under sub section (a)(iii) of section 13 of said law. • The project proponent has to carry out better improvement on early warning system of natural disaster under sub section (b) of section 14 of said law. • The project proponent has to carry out together with the measures of natural disaster risk reduction in development plans of the State under sub section (d) of section 14 of said law. • Whoever if the natural disaster causes or is likely to be caused by any negligent act without examination or by willful action which is known that a disaster is likely to strike, shall be punished with imprisonment for a

Acts	Objective, scope and purpose	Relevance to the project
		term not exceeding three years and may also be liable to fine under section 25 of said law. • Whoever interferes, prevents, prohibits, assaults or coerces the department, organization or person assigned by this law to perform any natural disaster management shall, on conviction, be punished with imprisonment for a term not exceeding two years or with fine or with both under section 26 of said law. • Whoever violates any prohibition contained in rules, notifications and orders issued under this law shall, on conviction, be punished with imprisonment for a term not exceeding one year or with fine or with both under section 29 of said law. • Whoever willful failure to comply with any of the directives of the department, organization or person assigned by this law to perform any natural disaster management shall, on conviction, be punished with imprisonment for a term not exceeding one year or with fine or with both under sub section (a) of section 30 of said law.
Motor Vehicle Law 2015	Focuses on road safety, including driving licenses, and reducing environmental pollution caused by motor vehicles.	Vehicles and project drivers will be required to meet the requirements of the legislation.
The Myanmar Engineering Council Law (2022)	To ensure the safety in technical and engineering work in the project	• The project proponent has to ensure the employees who are engineers abide to the provisions of Myanmar Engineering Council law, prohibitions included in the rules, order and directive issued under said law, conditions included in the registration certificate issued by the Myanmar engineering council, under section 34 of said law. • The project proponent has to appoint the employees, who obtained the registration certificate issued by the Myanmar Engineering Council, in the technical and engineering work, under section 37 of said law.
Myanmar Fire Services Law 2015	To ensure to prevent the fire, to provide the precautionary material and apparatuses, if the fire caused in the project area to be defeated because the project is business in which electricity and any	• The project proponent has to institute the specific fire services under sub section (a) of section 25 of said law.

Acts	Objective, scope and purpose	Relevance to the project
	inflammable materials such as petroleum are used. So, the project owner has to institute the specific fire service in line with the above law.	• The project owner has to provide materials and apparatuses for fire precaution and prevention under sub section (b) of section 25 of said law.
The Petroleum and Petroleum Products Law 2017	Contains provisions on: • import, export, transportation, storage, refinery, distribution, inspection and testing of petroleum and petroleum products • issuance of relevant licenses. The purpose of the Rules is to ensure the project owner's compliance with the stipulations for transportation of oil. The project proponent has to abide by the provisions of chapter (3) for transportation as well as the provisions of chapter (4) for storage.	Petroleum will need to be transported and stored at the Bawdwin site for mine operation. This law is applicable to the project because of the transportation and storage of fuel in all project phases. The obligations of the project proponent are; • To transport the fuel by the vehicle or vessel which is licensed by the Ministry of Transportation and Communication under sub-section (a) of section 9; • To abide by the procedures and conditions specified by the Ministry of Transportation and Communication under sub-section (e) of section 9; • To transport after obtaining the transportation license issued by the Ministry of Natural Resource and Environmental Conservation under sub-section (b) of section 10; • To allow inspection by the Ministry of Natural Resource and Environmental Conservation under sub-section (d) of section 10; • To store the fuel in the tank which is licensed by the Ministry of Natural Resource and Environmental Conservation under sub-section (a) of section 10; and • To show the sign of danger on the tank or container of fuel under section 11.
Criminal Matters		
Penal Code (1861) and Amending Law 2016	Prohibits: • Water pollution, air pollution and discharges of poisonous substances that may harm human health or cause injury • Explosives causing harm. • Public nuisance.	Relevant to project compliance.

Source: Technical Guidance Note, Environmental Impact Assessment of Mining (October 2018)

2.1.2 Institutional framework

Governance, law and order

Myanmar's 2008 Constitution grants the Union Government ultimate ownership of all land and natural resources within the country's national territory and the right to amend relevant laws. In 2015, the Constitution was amended to include additional powers to be provided to the States over land management, small–scale mining, environmental conservation, water–resource development and care of vulnerable groups (children, women, the elderly and those with disabilities). Albeit limited, the changes also include powers relating to basic education, hospitals and clinics. When enacting new laws or regulations, the States must ensure that the changes are in accordance with the law enacted by the Union.

In addition, the Constitution ensures that active–duty military appointees of the Commander in Chief lead both the Border Affairs and Home Affairs ministries at the national level. These ministries have powerful subnational mandates and organizational infrastructure in the form of General Administration Departments (GADs). The Ministry of Home Affairs and the Ministry of Border Affairs have jurisdiction over policing and immigration.

Administration

The Head of the GAD is the Executive Secretary of the Region or State. The Region or State Government Law (2010) established the GAD as the body responsible for administration for the State or Region governments. Below the state and regions, the District Administrator and Township Administrator are both GAD Officers. The Township Administrator provides direction to Village Tract and Ward Administrators. These arrangements ensure that the GAD is central to all efforts to coordinate, communicate among and convene other government actors in subnational governance.

In accordance with the administrative structure, the Namtu Township GAD Officer is the focal contact person to coordinate and communicate with Namtu and Bawdwin Administrators, including Tiger Camp Administrators. The GAD has various key roles, including population registration, land registration, and many forms of tax collection.

At the village level, the Ward or Village Tract Administration Law, first passed in 2012, introduced elections for the appointment of Ward or Village–Tract Administrators (W/VTAs). Previously, no elections were held, and GAD township administrators directly appointed W/VTAs. Since the first round of elections in late 2012, the law has been amended twice (in January 2016 and December 2016), altering the election process. Under the current system, representatives from each household elect a Household Leader which represents 10 households, who in turn elect a Household Leaders to represent 100 households. If there is only one elected Household Leader representing 100 households, he/she will automatically become the W/VTA. Where there are multiple Household Leaders representing 100-households, household representatives vote again to elect a W/VTA. The process is overseen by a Supervisory Board of five elders, appointed by the Township Administrator.

An overview of the Myanmar administrative structure is presented in **Error! Reference source not found.**.

The justice system

Most cases of dispute begin in a Village or at the Ward level and proceed to the Township Court (the lowest level) or District Courts, and decisions of these courts may be appealed to a High Court, also known as the State or Divisional Court, and ultimately to the Supreme Court. The Supreme Court has singular jurisdiction in certain matters as set out in Section 295 of the Myanmar Constitution. The Supreme Court is the highest court of the Union, although this does not impact upon the powers of the Constitutional Tribunal and the Courts-Martial. It is constituted by a Chief Justice and a minimum of seven to a maximum of 10 judges. It has judicial officers who undertake research and assist the Supreme Court judges. In addition, law officers, appointed by the Attorney General’s office, act as public prosecutors in all courts. The Supreme Court is the court of final appeal and has appellate jurisdiction to decide judgments passed by State and Regional High Courts, and judgments of the other courts in accordance with the law.

Ministry of Natural Resources and Environmental Conservation structure

MONREC has a number of departments and enterprises as shown in Figure 2.5 consisting of:

- Union Minister’s office.
- Environmental Conservation Department (ECD).

- Dry Zone Greening Department.
- Forest Department.
- Myanmar Timber Enterprise.
- Geological Survey and Mineral Exploration.
- Department of Mines.

ECD is responsible for administering the EIA process for the Bawdwin project and if approved, regulating operations against the ECC that is issued. Mining operations at Bawdwin will also be regulated by the Department of Mines, Department of Geological Survey and Mineral Exploration (DGSE) and ME-1.

Various ancillary permits and approvals will be required from relevant Myanmar government authorities for specific aspects of the Bawdwin project, such as water usage, upgrading of public roads, building construction and on-site health and safety. A number of these permits will need to be applied for at the local Township government level, being Namtu Township.

2.1.3 National policies and standards

The Myanmar National Environmental Policy (2019) provides long-term guidance for government organisations, civil society, the private sector and development partners to achieve environmental protection and sustainable development objectives in Myanmar. The policy builds on Myanmar's National Environmental Policy (1994).

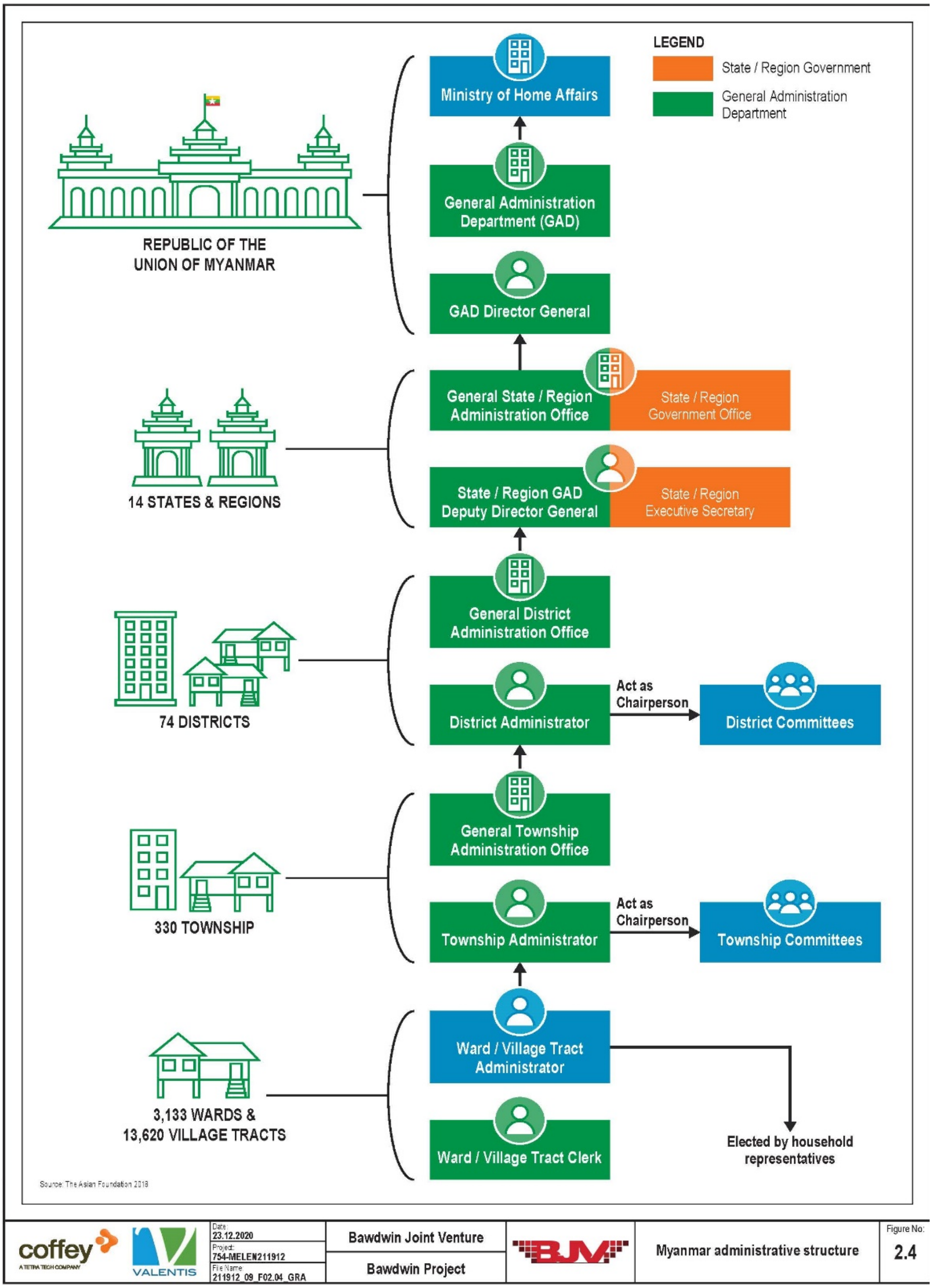

Figure 2.4 Myanmar administrative structure

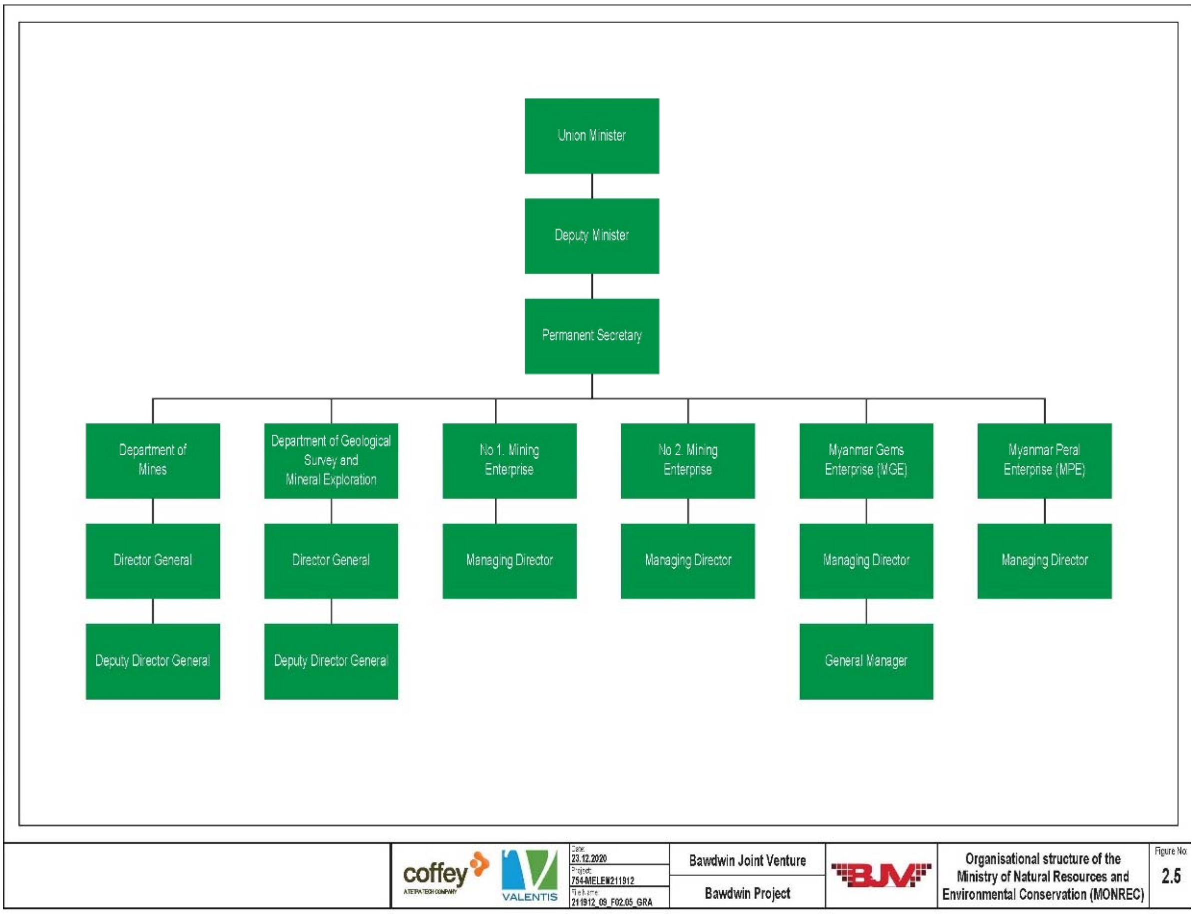

Figure 2.5 Organisational structure of the Ministry of Natural Resources and Environment Conservation (MONREC)

The National Environment Policy outlines 23 principles as the guiding framework for achieving: a clean environment and healthy, functioning ecosystems; sustainable economic and social development; and the mainstreaming of environmental protection and management. It is intended that the policy will be implemented through a series of master plans both at the national levels but also by thematic area and sectors.

National Environmental Quality (Emission) Guidelines

The National Environmental Quality (Emission) Guidelines (16/12/2014) (referred to as NEQ Guidelines) provide the basis for regulation and control of noise and vibration, air emissions, and liquid discharges to prevent pollution to protect human and ecosystem health.

The NEQ Guidelines have been primarily based on the IFC Environmental Health and Safety (EHS) Guidelines, which provide technical guidance on good international industry pollution prevention practice for application in developing countries. The NEQ Guidelines are generally considered to be achievable in new facilities by existing technology at reasonable costs.

General and industry-specific guidelines are set out in Annex 1 – Emissions Guidelines. Section 2.7 of the Annex sets out emissions guidelines for mining, which will apply to effluent discharges from the Bawdwin mine site. Section 1.0 General Guidelines will apply to all other project activities unless they are covered by industry-specific guidelines.

The general and applicable industry-specific guidelines are included in the project environmental management plan (EMP) and ECC and together constitute the project's commitment to manage its discharges to air, land and water.

Other applicable Myanmar policies, plans and strategies

Other Myanmar policies, plans and strategies relevant to the project in addition to those described above are provided in Table 2.3.

Table 2.3 Other Myanmar policies, plans and strategies relevant to the project

Document	Objective, scope and purpose	Relevance to the project
Environmental		
Environmental Policy 1994	Aims to achieve balance between socio-economic, natural resources and environmental aspects through the integration of environmental considerations into the development process.	Relevant to general project design and environmental compliance.
National Environment Policy of Myanmar 2017	Provides guidance for government, civil society, private sector and development partners to achieve environmental protection and sustainable development objectives.	Relevant to general project design, project rationale and environmental compliance.
Myanmar Agenda 21 1997	Provides a blueprint for natural resource management, environmental conservation and activities that contribute to biodiversity conservation.	Relevant to general project design and environmental compliance.
Myanmar Sustainable Development Plan (2018 – 2030)	The Myanmar Sustainable Development Plan (MSDP) outlines a long-term vision of a peaceful, prosperous and democratic country. The MSDP is the integration and distillation of existing plans and priorities.	Relevant to general project design, project rationale and environmental and social standards.
National Sustainable Development Strategy for Myanmar 2009	Supports the goals of sustainable management of natural resources, integrated economic development and sustainable social development.	Relevant to general project design, project rationale and environmental compliance and social standards.

Document	Objective, scope and purpose	Relevance to the project
Environmental Impact Assessment Procedure (2015)	Provides the procedures for environmental screening, scoping, preparation of an IEE, preparation of EIA, preparation of and Environmental Compliance Certificate (ECC). Delineates responsibilities for monitoring compliance with Environmental Management Plans (EMPs) and ECCs.	Details the requirements of an EIA and the approvals process to be followed.
Technical Guidelines for Environmental Impact Assessment (2017)	Provides technical guidance for assessing environmental impacts and preparation of the IEE and EIA reports.	Provides guidance on the preparation of the EIA relating to the project.
National Environmental Quality (Emission) Guidelines (2015)	Provides emission and effluent discharge guideline levels for different sectors and technologies.	As described above.
Forest Policy 1995	To ensures that Myanmar's forest resources and biodiversity are managed sustainably to provide a wide range of social, economic and environmental benefits. Aims to maintain 30% of the country's total land area under Reserved Forest and Public Protected Forest and 5% of total land area as Protected Areas. The 30-year National Forestry Master Plan (2001/02 to 2030/31), prepared in the year 2000, has a goal of expanding PAs to 10% of the country's total land area.	It is not anticipated that significant impact to forested areas will result from the project.
Myanmar Climate Change Policy 2017	Aims to: • Take and promote climate change action on adaptation and mitigation in Myanmar; • Integrate climate change adaptation and mitigation considerations into Myanmar's national priorities and across all levels and sectors in an iterative and progressive manner; and • Take decisions to create and maximise opportunities for sustainable, low-carbon, climate-resilient development, ensuring benefits for all.	Limited relevance to the project with the exception of promoting energy efficiency and minimising GHG emissions.
Myanmar Climate Change Strategy and Action Plan 2016-2030 (draft)	Outlines Myanmar's long-term goal by 2030, Myanmar has achieved climate-resilience and pursued a low-carbon growth pathway to support inclusive and sustainable development.	Limited relevance to the project with the exception of promoting energy efficiency and minimising GHG emissions.
Mining		
Order for Permit Holder to comply with prevention of Detrimental Effects on the Environment due to Mining Operations (2004)	The order is issued under the Mining Law Article 39 (b) This is the order for the Mining Permit holder to systematically discharge the waste rock and tailing from mining process to prevent pollution of river water and the watershed area	Relevant to project planning and operations.

Source: Adapted from Technical Guidance Note, Environmental Impact Assessment of Mining (October 2018)

International agreements ratified in Myanmar

Table 2.4 summarises the international agreements including treaties, conventions and protocols relevant to the project and its implementation, and to which the government of Myanmar has ratified.

Table 2.4 International conventions ratified by Myanmar

Sector	International conventions
Environment, climate and heritage	Plant Protection Agreement for the Southeast Asia and Pacific Region, Rome 1956
	Montreal Protocol on Substances that Deplete the Ozone Layer, Montreal 1987
	London Amendment to the Montreal Protocol on Substance that Deplete the Ozone Layer, London 1990
	United Nations Framework Convention on Climate Change, New York 1992
	United Nations Paris Agreement, Paris 2015
	Convention on Biological Diversity, Rio de Janeiro 1992
	The Convention Concerning the Protection of the World Cultural and Natural Heritage, Paris 1972
	Convention on the Means of Prohibiting and Preventing Illicit Import, Export and Transfer of Ownership of Cultural Property 1970
	Convention on International Trade in Endangered Species of Wild Fauna and Flora, Washington DC 1973 and amended in Bonn, Germany 1979
	Convention on the Safeguarding of the Intangible Cultural Heritage
	UNESCO World Heritage Convention Concerning the Protection of the World Cultural and Natural Heritage
	ASEAN Agreement on Conservation of Nature and Natural Resources, Kuala Lumpur, 1985
	Kyoto Protocol to the Convention on Climate Change, Kyoto 1997
	ASEAN Agreement on Trans-boundary Haze Pollution
	Establishment of ASEAN Regional Centre for Biodiversity
	Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and their Destruction, Paris 1993
Health, Labour and Social	Universal Declaration of Human Rights
	Convention on the Rights of the Child, 1991
	Convention on Elimination of All Forms of Discrimination against Woman
	Relevant Myanmar International Labour Organisation Conventions Hours of Work in Industry Weekly Rest in Industry Workmen's Compensation of Accidents Equality of Treatment on Accident Compensation Minimum Wage Fixing Machinery Freedom of Association and Protection of the Right to Organise Workmen's Compensation of Occupational Diseases Holidays with Pay Forced Labour Convention

2.1.4 International standards and guidelines

Various international standards and guidelines exist in relation to the construction, operation and closure of mines. International standards and guidelines that are relevant to preparation of the EIA include:

- The World Bank Environmental and Social Framework (The World Bank 2018) – which sets out the World Bank's commitment to sustainable development, through a Bank Policy and a set of Environmental and Social Standards that aim to end extreme poverty and promote shared prosperity.
- The Equator Principles III (EPFI 2020) – consists of ten principles including (but not limited to) environmental and social assessment, stakeholder engagement, and reporting.
- IFC Performance Standards on Environmental and Sustainability (IFC 2012) – provides guidance on how to identify risks and impacts, and are designed to help avoid, mitigate, and manage risks and impacts as a way of doing business in a sustainable way, including stakeholder engagement and disclosure obligations of the client in relation to project-level activities.
- IFC Stakeholder engagement: a good practice handbook for companies doing business in emerging markets (IFC 2007a) – provides guidance on conducting effective stakeholder engagement.
- World Bank Group Guidelines:
  - Environmental, Health and Safety General Guidelines (IFC 2007b) – technical reference document describing examples of Good International Industry Practice, and addressing matters such as environmental, occupational health and safety, community health and safety, and construction and decommissioning, as well as sector-specific issues.
  - Environmental, Health and Safety Guidelines for Mining (IFC 2007c) – technical reference that provides guidance on environmental, health and safety issues potentially applicable to mining projects.
- IFC Stakeholder Engagement: A Good Practice Handbook for Companies Doing Business in Emerging Markets (2007).
- IFC Handbook for preparing a resettlement action plan (IFC 2002) – provides guidance in the planning and execution of involuntary resettlement for private sector projects.
- International Labour Organization standards – consist of standards, instruments and codes of practice covering topics related to labour including child labour, employment security, migrant workers, indigenous and tribal peoples, working time, and occupational safety and health.
- International Organization for Standardization standards including ISO 14000, which outlines standards related to environmental management to minimise impacts on the environment and to promote continuous improvement.
- Leading best practice guidelines published by the Australian Government – technical guidance on leading practice sustainable development management covering a range of aspects relating to mining including (but not limited to): tailings management, managing acid and metalliferous drainage, mine closure and completion, stewardship, and community engagement and development.
- International Council of Mining and Metals (ICMM) – technical guidance and guidelines on leading practice sustainable development management covering a range of aspects relating to mining including (but not limited to) tailings management, environmental management, social performance, community health, mine closure, community relations, health and safety, resettlement and biodiversity aspects.

2.2 Corporate policies

BJV has a number of corporate policies relevant to the project including:

- Occupational Safety and Health Policy.
- Fitness for Work Policy.
- Drugs and Alcohol Policy.
- Environmental Policy.
- Community Engagement Policy.
- Lead Management policy.
- Preferential Employment Policy.
- Cultural Heritage Policy.

BJV is committed to high standards of environmental performance, community cooperation and the principles of sustainable development. The environmental and socio-economic assessments for the project have been developed to comply with corporate policies and standards, and to align with relevant international standards.

Sustainability is a core principle of BJV. Operating sustainably with strong governance achieves lasting benefits for stakeholders and the environment. BJV commits to:

- Act ethically and transparently with stakeholders.
- Ensure a safe and healthy workplace.
- Be responsible custodians of the environment.
- Respect human rights and the customs of stakeholders.
- Be gender inclusive.
- Engage with local communities to provide employment opportunities and improve essential infrastructure and services.
- Comply with all laws and regulations as they apply to the business.
- Employ best mining practises to maximise the value realised for all stakeholders.

BJV is committed to developing short, medium and long-term strategies to address the community's desire and need for employment. BJV will provide education and training and invest in social programmes, including offering opportunities for small businesses to build local supply chains for the mine and develop infrastructure that can improve community livelihoods while also serving the project.

2.3 Environmental guidelines adopted for the EIA

BJV intend to meet all Myanmar laws and rules as well as appropriate international standards. Where Myanmar laws and rules are silent or set a lower standard of environmental and social performance the IFC Performance Standards and Environmental, Health and Safety General guidelines have been adopted as the key default standards. Where relevant other international standards referred to above have also been adopted.

BJV will align the project with identified guidelines for various environmental and social aspects of the mine redevelopment. General and specific guidelines are set out in Annex 1 – Emissions Guidelines – of the NEQ

Guidelines. Section 2.7 of these guidelines refer specifically to the mining sector, however, only provide requirements for effluent discharge from the mine site.

As such, general NEQ Guidelines have been be applied when possible and relevant external guidelines have been considered in addition to these, as described below.

2.3.1 Water quality

Discharges to water in Myanmar are regulated through the ECC. Should an ECC for the project be granted, the operation will need to comply with a number of conditions, one of which will be the prescribed water quality standards at the downstream limit of a site-specific mixing zone. The ECC will also contain conditions allowing the abstraction of surface water for use in the project.

The NEQ Guidelines provide indicative guidelines for sanitary sewer discharges. The project-specific requirement is that the final effluent quality for secondary treatment of sewage will be in accordance with NEQ Guidelines, the IFC's general EHS guidelines (IFC 2007b).

In addition to the NEQ Guidelines, the IFC Environmental, Health and Safety Guidelines for Mining (IFC 2007c) provide water quality guidelines for discharge of effluent from open-pit mining and milling operations. The specified limits are applicable to effluent discharged to receiving waters from tailing impoundments, mine drainage, sedimentation basins, sewage systems, and stormwater drainage. These levels should be achieved (without dilution) at least 95% of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours. These guidelines also state that discharges to surface water should not result in contaminant concentrations in excess of local ambient water quality criteria outside a scientifically established mixing zone (IFC 2007c).

Notwithstanding the statutory need to meet the requirements of the NEQ Guidelines, additional standards and guidelines for ambient water quality considered in this EIA include the Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Governments and Australian state and territory governments (ANZG 2018). Additionally, water intended for human consumption and use shall be treated (if required) to meet Myanmar's proposed national drinking water quality standards (NWRC, 2014).

2.3.2 Air quality

The NEQ Guidelines state that projects with significant sources of air emissions should ensure that ambient air quality guidelines are not exceeded. The Myanmar Mining EIA Guidelines (Myanmar Mining EIA Guidelines Working Group, 2018) outline ambient air quality standards for sulfur dioxide, nitrogen dioxide, particulate matter and ozone. In the absence of additional criteria, the NEQ Guidelines default to the WHO air quality guidelines (WHO 2000).

A set of ambient air quality criteria was developed specifically for the Bawdwin project, primarily from a combination of the following guidelines:

- The Myanmar Mining EIA Guidelines (Myanmar Mining EIA Guidelines Working Group, 2018).
- WHO air quality guidelines for Europe (WHO 2000).
- Ontario Ministry of the Environment and Climate Change's Ontario Ambient Air Quality Criteria (OMECC 2019).
- National Institute for Occupational Safety and Health Registry of Toxic Effects of Chemical Substances (NIOSH 2017).
- Texas Commission on Environmental Quality, Texas Air Monitoring Information System (TAMIS) database (TCEQ 2019).
- Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (NSW EPA 2017).

- United States Environmental Protection Authority National Ambient Air Quality Standards (USEPA 2010).

The NEQ Guidelines stipulate air emission standards for power station emissions (sulfur dioxide, nitrogen dioxide and particulate matter) at the point of discharge.

2.3.3 Noise

The NEQ Guidelines specify noise levels that should not be exceeded during daytime and night time. Additional guidance on noise criteria has been considered including:

- Myanmar draft National Environmental (Emission) Quality Guidelines (2014).
- IFC environmental health and safety guidelines for noise (IFC 2007b).

2.3.4 Biodiversity

Terrestrial and aquatic biodiversity assessments were carried out with consideration of:

- The International Union for Conservation of Nature (IUCN) Red List which is the world's most comprehensive information source on the global conservation status of wild species and the links to livelihood.
- IFC Performance Standard 6 (PS-6) which addresses how proponents can sustainably manage and mitigate impacts to biodiversity and ecosystems serviced throughout the project's lifestyle (IFC 2012c).
- Myanmar's National Biodiversity Strategy and Action Plan which integrates conservation and the sustainable use of biodiversity (GoM 2011).

2.3.5 Cultural heritage

Myanmar is a 'State Party' to the UNESCO World Heritage Convention Concerning the Protection of the World Cultural and Natural Heritage. As a State Party, Myanmar has a duty to ensure the identification, protection, conservation, presentation and transmission to future generations of the country's cultural heritage.

As no Myanmar specific guidelines exist for cultural heritage assessment, the guidelines in the Burra Charter, established by the International Council on Monuments and Sites (ICOMOS), were used in conjunction with legislation outlined in Table 2.2. ICOMOS is a global, non-government organisation which works for the conservation and protection of heritage places (ICOMOS 2017). The Burra Charter emphasises that the policy for managing a place must be based on an understanding of its cultural significance. Significance is defined as "aesthetic, historical, scientific, social or spiritual value for the past, present or future generations" (ICOMOS 2013).

In addition, IFC Performance Standard 8 (Cultural Heritage) (IFC, 2012) has been considered, which provides guidance in minimising adverse impacts to cultural heritage from project activities and supporting its preservation.

The International Committee for the Conservation of the Industrial Heritage (TICCIH) TICCIH's Nizhny Tagil Charter for the Industrial Heritage (TICCIH, 2003) was also considered regarding technological significance criteria. TICCIH is the international society which focuses on the study, protection, promotion and interpretation of industrial heritage around the world.

2.3.6 Socioeconomic

The assessment for the Bawdwin project's socioeconomic component has been guided by the Myanmar Mining EIA Guidelines (2018). These define an environmental impact as "any change in an environmental and social component brought about by project activity". Other guidance has been considered including:

- World Bank's Environmental and Social Framework (WB 2017).

- The Equator Principles (EPFI, 2020).
- International Council on Mining and Metals (ICMM) Sustainable Development Framework (ICMM, 2012).

2.3.7 Resettlement

The main international guide adopted for approach to resettlement is IFC Performance Standard 5 (Land Acquisition and Involuntary Resettlement), which is one of the key international standards regarding resettlement and livelihood replacement. Adherence to Performance Standard 5 is supported by the draft IFC Good Practice Handbook: Land Acquisition and Resettlement (2019 draft). Whilst still in preliminary draft form for review and discussion, the handbook provides good practice guidance regarding design and implementation of a resettlement program. Myanmar land and land tenue laws, including the *Land Acquisition, Resettlement and Rehabilitation Law 2019*, were also considered.

Other international guidelines considered included:

- The World Bank Environmental and Social Framework (The World Bank, 2017).
- The Asian Development Bank Environment and Social Safeguards, in particular Safeguard 2.
- The Equator Principles (EPFI, 2013).
- International Council on Mining and Metals (ICMM) Sustainable Development Framework (ICMM, 2012).

Bawdwin Project

Environmental Impact Assessment
Chapter 3

October 2023

Bawdwin Project

Prepared for

Win Myint Mo Industries Company Limited

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3 Assessment of alternatives

This chapter presents the assessment of options analysis for key components of the Bawdwin project. A number of options have been identified for the development of the Bawdwin mine. These include options for mining, processing, site access, ore transportation, water and power supply, and tailings storage facilities.

The rationale for the Bawdwin project is based on a combination of economic, engineering, environmental and social considerations. WMM intends to deliver a mining operation that is safe and sustainable, and which delivers value to stakeholders. This will be achieved by constructing and operating an expanded open pit mine and building a range of new infrastructure components including an ore processing plant, waste rock and tailing storage facilities, accommodation facilities and power station. The assessment of alternatives has been progressively refined over the duration of scoping, pre-feasibility and feasibility studies.

3.1 Method of analysis of alternatives

Key constraints considered in the assessment of alternative development options are:

- Economic constraints that are driven by factors including the characteristics of the mineral deposits, project development expenditure, and the need for the proponent to be in a position to extract and process the ore in a profitable manner.
- Physical constraints including the location of the mineral deposits, a lack of enabling infrastructure and the climatic, topographic and geotechnical constraints imposed by the landscape.
- Environmental constraints including prevailing environmental conditions and sensitivities of the project’s setting focussing on water (surface water and groundwater), land (including biodiversity and soils) and air.
- Social constraints including economic, social, health and cultural heritage components, and the location of existing communities.

Consideration, modification and refinement of the project has included evaluation of a range of alternatives. These include:

- Alternative mining and ore processing methods.
- Alternative mine size and rate of processing.
- Design and location of mine waste storages.
- Alternative locations of project infrastructure.

The assessment of project alternatives was an iterative process that has been developed in each feasibility stage, whereby the level of accuracy and detail has been progressively improved. The main project evolution stages were:

1. Scoping assessment completed in September 2018. This assessed a wide range of alternative cases and recommended a large-scale open pit mine operation targeting mainly fresh sulphide mineralisation with a small amount of near surface oxide and transitional mineralisation with a 13-year mine life at a processing at a throughput of 1.8 Mt per year.

2. Pre-feasibility study completed in May 2019. This expanded the proposed mine pit and developed the concept for an integrated waste landform (for dry tailings and waste rock). The mineral processing throughput capacity was 2 million tonnes per annum (2 Mtpa) of ore over a 13-year mine life.

3. Definitive feasibility study completed in Quarter 4 2020, which featured a number of significant changes, reflecting improved geological understanding of the orebody and mineral processing characteristics. These key changes were as follows:

   - The proposed pit size and shape was refined.
   - The mineral processing rate was increased to 3 Mtpa.
   - The overall project infrastructure configuration was changed, with the processing plant moving to the north of the concession.
   - The concept of an integrated waste landform was replaced by three thickened tailings storage facilities and a separate waste rock dump.
   - There were also changes to the site access route, water supply, electrical power supply and accommodation camp location.

Available options were first assessed in isolation for specific Project elements. Some were then combined, and the analysis was re-run to confirm the preferred option.

3.2 No project alternative

An important option to consider is whether or not to proceed with the project. If the project is not developed by WMM the existing environmental, social and health conditions at the site will largely remain. The project area is, however, a current mining concession and one of the obligations of this concession is for lead-zinc ore extraction and processing. If WMM were not to develop the project the concession would need to be relinquished to ME1 and it is not known what the outcome of this may be. The concession may be released to another party for development, or it could sit undeveloped, but this may result in the current local employees tied to the operation being made redundant and the current benefits of low rent housing and electricity also being withdrawn.

Benefits and disadvantages of the no project alternative were considered and are described below.

3.2.1 Benefits

Potential benefits of the project not being developed, i.e., the ‘no project’ alternative (assuming the concession area remains as is) include:

- There will be no resettlement of the Bawdwin and Tiger Camp communities.
- Alternative land use options may become available for the concession area (e.g., development of mine/rail related tourism).
- The amenity levels of the communities will largely remain as is with no increases in dust, noise or vibration impacts.
- The cultural heritage value of the area will not be affected (natural deterioration of structures and sites may occur over time).
- Communities and residents along the roads and rail corridor will not experience any impacts due to amenity issues, road construction, displacement, or safety risks associated with increased traffic.
- The Nam La catchment will not be subject to any project related adverse effects to water quality or water quantity.
- There will be no increase to the existing mine footprint and no new tailing storage or waste rock dumps will be introduced to the area, thereby avoiding related vegetation clearance, sediment/water quality issues and long-term stability risks.

3.2.2 Disadvantages

Disadvantages of the project not being developed (i.e., no project) include loss of the project-derived social and economic benefits and loss of the potential to resolve or reduce the current environmental and health legacy issues.

If constructed, the project will be one of the largest mines in Myanmar and has the potential to generate significant economic benefits at the local, regional and national level. If the project does not proceed, the following direct and indirect benefits to the Myanmar economy would not occur:

- Direct financial benefits including:
  - Royalties and dead rent paid to the Union of Myanmar (the amount that has to be paid by the lessee to the lessor whether or not he has derived benefit from the asset).
  - Corporate income taxes paid to the Union of Myanmar by the WMM.
  - Indirect taxes paid to the Union of Myanmar including, commercial tax; withholding tax; and personal income tax.
  - An additional profit share tax as governed by the amended Production Sharing Contract or agreement.
- Support to local businesses (existing and new) through preferential procurement policies for local goods and services.
- Employment, training and capacity building of Myanmar workers.
- Wages paid to employees of WMM and contractors.
- Contributions to national mineral export revenue, total export revenue and GDP.
- Strategic community-level investments by the WMM in services, infrastructure, local business and livelihood development.

The long history of mining and processing in the Bawdwin mine area has resulted in existing environmental degradation and legacy issues, which in turn present health risks to the local population. The existing degradation includes:

- Poor water quality of the watercourses draining the area, with high levels of heavy metals, high nutrient loads and mine-related sedimentation. This is due to historical and current discharges from the mine, contact with natural mineralisation and historical mine wastes, current waste and sewage disposal practices, sedimentation from the waste rock dump and stream-bed mining.
- Degraded aquatic ecosystems due to physical impacts to stream beds and the poor water quality. While the aquatic ecosystem has been heavily impacted it still supports some aquatic life such as fish.
- Biodiversity loss due to historical deforestation and human pressures associated with the mine populations.
- Heavily modified landscape and landform due to historical mining activities, which include the open cut and mine related infrastructure.

The levels of lead measured in environmental media in Bawdwin indicate that residents are potentially exposed to elevated lead (and other metals) via multiple media and exposure pathways. The existing exposures may pose a serious health risk to the population in this area. There is an opportunity for the project to improve community health in the Bawdwin communities by resettling communities away from these hazardous locations to lower risk locations. Resettlement may also provide additional benefits in the form of improved access to essential services (clean water, electricity, sanitation) and housing conditions.

If the project does not proceed, the legacy mining contamination and exposure to hazards affecting human health will not be addressed and opportunities to improve land capability during rehabilitation will be forgone.

Other beneficial outcomes from resettlement such as improved quality of housing and improved access to resources will also not be realised.

3.3 Alternatives considered

A high-level overview of the alternatives considered for key elements of the Project is provided in Table 3.1. The following sections (Table 3.2 to Table 3.8) further describe the assessment rationale for each of the key aspects, which include alternatives for:

- Mining method.
- Options for mineral processing.
- Tailings management and storage.
- Waste rock storage.
- Project water supply.
- Power supply.
- Site access and supply/export route.

Table 3.1 Overview of alternatives investigated and preliminary assessment

Aspect	Alternatives Investigated (preferred option in bold)	Constraints			
		Engineering	Cost	Environment	Social
Mining method	**Expand the existing open pit mine**	Low	Moderate	Moderate	Moderate
	Expanded the existing open pit plus develop new satellite pits	Low	Moderate	Moderate	Moderate
	Develop an underground mine	Moderate	High	Low	Low
Mineral processing infrastructure	**Construct a new concentrator plant at Bawdwin and export mineral concentrate(s)**	Low	High	Low	Moderate
	Upgrade current processing infrastructure at Bawdwin (concentrator plant) and Namtu (smelter and refinery). Concentrate minerals at Bawdwin and then transport concentrates for smelting and refining at Namtu, to produce metal products	Moderate	Moderate	Moderate	Moderate
	Construct a new concentrator plant at Bawdwin and a smelter and refinery (multiple locations considered).	High	High	Moderate	Moderate
Location and type of tailings storage facility (TSF)	**Construct a complex of interconnected TSFs within the Bawdwin concession, using conventional thickened tailings**	High	Moderate	High	Moderate
	Construct a single TSF outside the Bawdwin concession, using conventional thickened tailings	High	Moderate	High	Moderate
	Construct a TSF within the Bawdwin concession, by dry-stacking filtered tailings	High	High	Moderate	Moderate
Location of waste rock dump	Construct multiple waste rock dumps around the open pit	Moderate	Low	Moderate	Moderate
	Construct waste rock dump(s) outside the Bawdwin Concession	High	High	Moderate	Moderate
	Construct a single waste rock dump in Wallah Valley	Moderate	Moderate	Low	Moderate
Process water supply	**Construct a reservoir to harvest and store water from the Nam La stream, and also abstract water from the Nam Pangyun stream**	Low	Low	Moderate	Moderate
	Pump groundwater from the underground workings via the Marmion shaft .	High	High	Low	Low
	Construct a new pipeline to abstract water from the Namtu River and pump it to Bawdwin	Moderate	Moderate	Moderate	Moderate

Aspect	Alternatives Investigated (preferred option in bold)	Constraints			
		Engineering	Cost	Environment	Social
	Re-use return water from the tailings storage facility and/or concentrate filter plant	Moderate	Moderate	Low	Low
Power supply	Connect to the existing hydropower station at Mansam Falls	High	High	Low	Low
	Connect to the national grid	Low	Low	Low	Low
	Construct a dedicated on-site power station	Low	Moderate	Low	Low
Site access (goods and service supply options)	**Construct an access road between Tiger Camp and Namtu along the existing railway corridor and a second access road between Tiger Camp and the process plant**	Moderate	Moderate	Low	High
	Use the existing public road between Manton and Namtu	High	High	Low	Moderate
	Use the existing railway between Tiger Camp and Namtu and construct an access road between Tiger Camp and the process plant	Moderate	Moderate	Low	Low

Table 3.2 Assessment of alternatives for mining method

Aspect	**Selected Option**		**Alternative 1**		**Alternative 2**	
Mining method	**Expanded open pit mine**		**Expanded open pit plus new satellite deposits**		**Underground mine**	
	Advantage	**Disadvantage**	**Advantage**	**Disadvantage**	**Advantage**	**Disadvantage**
Feasibility (economic, engineering, constructability)	• Lower overall cost in comparison to underground mining. • Greater ability to increase mining rate compared to underground mining. • Simpler mining method to execute compared to underground mining. • Safer mining technique as underground mining within the existing underground workings is difficult and poses elevated safety risks to personnel.	• Requires larger waste rock dumps compared to more selective mining such as underground mining.	• Lower overall cost in comparison to underground mining • Ability to increase mining rate compared to underground mining, • Increased Mining Reserve due to multiple sources of ore available.	• Higher costs of mining compared to a single open pit. • Requires larger waste rock dumps compared to more selective mining such as underground mining.	• Lower waste rock movement than for open pit mining options • Higher ore grade.	• The nature of the Bawdwin ore body is such that most of the resource cannot be accessed via underground mining methods. • Higher cost of mining compared to open pit mining for an orebody like Bawdwin. • Lower annual production rates compared to an open pit operation. • Less able to increase mining rate compared to open pit mining. • Insufficient knowledge of the orebody at depth due to limits on drilling depth from surface, and hence limited confidence in return on high investment for underground development. • Existing historical workings and underground tailings placement impose a range of engineering and safety constraints.

Aspect	Selected Option		Alternative 1		Alternative 2	
Mining method	Expanded open pit mine		Expanded open pit plus new satellite deposits		Underground mine	
	Advantage	Disadvantage	Advantage	Disadvantage	Advantage	Disadvantage
Environmental (land, water, air, biodiversity)	• Potentially less interaction with groundwater than underground mining.	• Larger surface area disturbance compared to underground mining. • Large area required for waste rock dump/s. • River diversion required. • Mineralised material stored at surface with potential for metalliferous drainage issues if not properly managed. • More landforms to rehabilitate and close and hence higher closure cost liabilities compared to underground mining option. • Higher emissions to environment (e.g., dust and sediment)	• Potentially less interaction with groundwater aquifers than underground mining.	• Larger surface area disturbance compared to underground mining. • Large area required for waste rock dump/s. • River diversion required. • Mineralised material stored at surface with potential for metalliferous drainage issues if not properly managed. • More landforms to rehabilitate and close and hence higher closure cost liabilities compared to underground mining option. • Higher emissions to environment (e.g., dust and sediment) compared to	• Low surface area disturbance. • River diversion less likely to be required compared to open pit option. • Low mine storage requirements and lower issues associated with drainage and surface water management compared to open pit options. • Lower closure liability issues compared to open pit mining options. • Less emissions to environment (e.g., dust and sediment) compared to open pit mining. • Reduced water consumption compared to underground mining operations.	• Potentially greater interaction with groundwater. • Possibly greater dewatering requirement to keep deeper underground workings dry compared to surface mining, and hence greater discharges to Nam Pangyun.

Aspect	Selected Option		Alternative 1		Alternative 2	
Mining method	**Expanded open pit mine**		**Expanded open pit plus new satellite deposits**		**Underground mine**	
	Advantage	**Disadvantage**	**Advantage**	**Disadvantage**	**Advantage**	**Disadvantage**
Social (safety, community, health, cultural heritage)	• Safer for mine workforce than underground mining.	• Displacement of Bawdwin villagers (requiring resettlement). • Removal of some historic mine infrastructure with associated impacts to some cultural heritage. • Higher visual and amenity (e.g., noise and dust) impacts	• Safer for mine workforce than underground mining.	• Displacement of Bawdwin villagers (requiring resettlement). • Removal of some historic mine infrastructure with associated impacts to some cultural heritage. • Higher visual and amenity (e.g., noise [illegible]	• Potentially less displacement of communities due to underground mining, although some may be required for surface infrastructure and TSFs. • Less removal of historic mine infrastructure. • Likely lower dust and noise emissions. • [illegible]	• Higher safety risk to mine workforce.
Chosen method and reason for selecting	The topography and location of the Bawdwin mineral resource constrains options for extraction of the ore. The nature of the Bawdwin ore body, constraints imposed by historical underground mining and the higher costs associated with developing and operating an underground mine means that underground mining is the least preferred option. Feasibility studies have been conducted to determine the details of the mine such as the size of the open pit expansion. The scale of the mine will be determined based on several factors including the location of the orebody, the topography of the area, groundwater levels, operating costs versus recovery of ore, and the ability to safely transport ore and waste rock out of the mine.					

Table 3.3 Assessment of alternatives for mineral processing

Aspect	Selected Option		Alternative 1		Alternative 2	
Mineral processing	**Construct a new concentrator plant at Bawdwin and export mineral concentrate(s)**		**Upgrade current processing infrastructure at Bawdwin (concentrator plant) and Namtu (smelter and refinery). Concentrate minerals at Bawdwin and then transport concentrates for smelting and refining at Namtu, to produce metal products**		**Construct a new concentrator plant at Bawdwin and a new smelter and refinery (multiple locations considered)**	
	Advantage	**Disadvantage**	**Advantage**	**Disadvantage**	**Advantage**	**Disadvantage**
Feasibility (economic, engineering, constructability)	• Greater certainty in project design, schedule and cost by using well understood and new plant infrastructure compared to refurbishing existing infrastructure. • Higher throughput and profitability compared to Alternative 1.	• High capital cost, but lower operating costs compared to Alternative 2. • Limited suitable (i.e., flat) land available due to topography • Public road must be diverted to free up land for the process plant.	• Makes use of existing infrastructure.	• High capital costs for infrastructure upgrades with a high degree of uncertainty. • Detailed investigation of existing infrastructure required before finalising design and commencing upgrades. • Infrastructure requires significant upgrades and maintenance, which may not be feasible. The current infrastructure is not designed for the current throughput and fine grinding requirements. • Greater effort required to adapt existing plant and incorporate new units, compared to	• Reduced road transportation of final products and reduced transport cost. • Final products for transportation are lead and other metal products in solid form, rather than concentrates • Higher overall profitability compared to other options.	• High capital and operating costs, which would make it difficult to raise upfront finance • More complex project dependent on stable energy supply that cannot be supplied by a modular diesel-fired power plant. • Insufficient suitable land at Bawdwin for smelter and refinery complex, plus waste product disposal. • High water requirements for cooling and other processes, which cannot be met by local water sources. Piped water from Namtu River may be required.

Aspect	Selected Option		Alternative 1		Alternative 2	
Mineral processing	**Construct a new concentrator plant at Bawdwin and export mineral concentrate(s)**		**Upgrade current processing infrastructure at Bawdwin (concentrator plant) and Namtu (smelter and refinery). Concentrate minerals at Bawdwin and then transport concentrates for smelting and refining at Namtu, to produce metal products**		**Construct a new concentrator plant at Bawdwin and a new smelter and refinery (multiple locations considered)**	
	Advantage	**Disadvantage**	**Advantage**	**Disadvantage**	**Advantage**	**Disadvantage**
				constructing entirely new infrastructure. • Lower profitability due to lower throughput compared to constructing new infrastructure with greater capacity. • Greater uncertainty about the operability and longevity of using existing infrastructure. • Smelter complex is currently being used by a third party for a zinc fuming operation.		

Aspect	Selected Option		Alternative 1		Alternative 2	
Mineral processing	**Construct a new concentrator plant at Bawdwin and export mineral concentrate(s)**		**Upgrade current processing infrastructure at Bawdwin (concentrator plant) and Namtu (smelter and refinery). Concentrate minerals at Bawdwin and then transport concentrates for smelting and refining at Namtu, to produce metal products**		**Construct a new concentrator plant at Bawdwin and a new smelter and refinery (multiple locations considered)**	
	Advantage	**Disadvantage**	**Advantage**	**Disadvantage**	**Advantage**	**Disadvantage**
Environmental (land, water, air, biodiversity)	• Lower in-situ power requirements compared to on-site smelting options. • The use of newly constructed infrastructure would be less susceptible to leaks and spills. • Higher emission control using new infrastructure compared to upgrading existing infrastructure. • Can easily incorporate environmental monitoring technology in design	• New ground disturbance. • Introduces the risk of concentrate spillage during transport to smelter.	• Less surface area disturbance compared to other options.	• Higher rate of gaseous emissions (and lower emission control) compared to use of newly constructed infrastructure due to older and less efficient infrastructure • Older infrastructure more susceptible to leaks and spills compared to use of newly constructed infrastructure • High power requirements, as smelting requires substantial energy	• The use of newly constructed infrastructure would be less susceptible to leaks and spills. • Higher emission control using new infrastructure compared to upgrading existing infrastructure. • Less transport emissions due to transport of metals rather than concentrate. • Can easily incorporate environmental monitoring	• More complex project with more environmental management considerations with onsite smelting. • High power requirements, as smelting requires substantial energy. • High water requirements, potentially requiring a new water source such as the Myitnge River.

Aspect	Selected Option		Alternative 1		Alternative 2	
Mineral processing	**Construct a new concentrator plant at Bawdwin and export mineral concentrate(s)**		**Upgrade current processing infrastructure at Bawdwin (concentrator plant) and Namtu (smelter and refinery). Concentrate minerals at Bawdwin and then transport concentrates for smelting and refining at Namtu, to produce metal products**		**Construct a new concentrator plant at Bawdwin and a new smelter and refinery (multiple locations considered)**	
	Advantage	**Disadvantage**	**Advantage**	**Disadvantage**	**Advantage**	**Disadvantage**
Social (community, health, cultural heritage)	• Higher health and safety standards and safeguards for newly constructed concentrator.	• Increased truck traffic compared to smelting options due to concentrate trucking outside Namtu district (and associated public hazards and traffic air and noise emissions). • Less socio-economic benefits (e.g., employment, supplier contracts) or value-adding from	• Reduced export traffic on public roads adjacent to villages and townships and associated public impacts and hazards due to reduced volume of exported goods compared to producing mineral concentrates for export. • Increased economic benefit by creating	• Potential for health impacts from smelter emissions due to proximity to residents (i.e., Namtu). • Lower health and safety standards using existing infrastructure	• Increased employment and economic benefit by creating higher value product compared to producing concentrate only. • Reduced export traffic and associated public impacts and hazards due to reduced volume of exported goods compared to producing	• Potential for health impacts from smelter emissions if located in proximity to residents.
Chosen method and reason for selecting	The preferred option is to process ore in a new process plant located to the northeast of the open pit, producing lead and zinc concentrates for export. It is proposed that the produced concentrate will be transported by road to third-party smelters located outside Myanmar. Due to economic and topographical constraints it is not feasible to develop new smelting and refining facilities on site. The use of existing mineral processing infrastructure (concentrator at Bawdwin and smelter/refinery at Namtu) was ruled out due to the poor condition of existing infrastructure, outdated technology and little potential to substantially increase throughput/production. In addition, the Namtu smelter complex is currently being used by a third party unrelated to WMM via an agreement with ME-1 to process zinc.					

Table 3.4 Assessment of alternatives for tailings management and storage

Aspect	Selected option		Alternative 1		Alternative 2	
Tailings storage facility location and type	**Construct a complex of interconnected tailings storage facilities within the current Bawdwin Concession, using conventional thickened tailings**		**Construct a tailings storage facility outside the Bawdwin Concession, using conventional thickened tailings**		**Construct a tailings storage facility within the Bawdwin Concession, by dry-stacking filtered tailings**	
	Advantage	**Disadvantage**	**Advantage**	**Disadvantage**	**Advantage**	**Disadvantage**
Feasibility (economic, engineering, constructability)	• Topography within the concession is suitable to construct smaller valley dams. • Lower risk of dam failure ,compared to a single TSF with a high embankment, due to reduced embankment heights. • No land acquisition is required. TSF locations are within the concession area. • Greater certainty about land access/tenure due to the TSF being located within the concession, compared to outside the concession.	• Suitable locations are extremely constrained by the topography within the concession. • Higher overall costs to construct multiple TSFs and manage/maintain them post closure than a single facility. • Requires a larger volume of low permeability material to construct the cores of multiple embankments, compared to a single TSF with a high embankment. • Greater combined footprint of disturbance of three dams, compared to a single TSF with a high embankment.	• More location options, giving the ability to select more favourable topography and increased storage capacity. Potential for low height embankments in wider valleys, reducing construction, operation and closure risks.	• Land acquisition required and associated risk of schedule delay. • Increased security risk of access hinderance being located off concession. • Greater pumping requirements to transport tailings greater distances and subsequent higher pumping costs.	• Dry stacked tailings have inherently lower failure risk compared to conventional thickened tailings. • In the unlikely event of an embankment failure, dry stacked tailings have less potential to flow and would have a smaller area of downstream impact. • Dry stacked tailings require smaller low-permeability cores in embankments due to lower moisture content, reducing the volume of construction material (e.g., low	• High capital and operating costs. • Uncertainty of the feasibility of dry stacked tailings management in the Bawdwin climate. • Uncertainty of likely tailings characteristics and filtering efficiency over the life of the operation. Variability in physical and mineralogical characteristics may affect the feasibility of dry stacking, whereas conventional tailings can accommodate variability. • Operational disruption when tailings do not meet discharge specification, i.e.

					permeability material) needed. • Water recovered during filtering of tailings could be used for site water requirements. • Less seepage water will be produced by dry stacked tailings and less potential to seep into groundwater.	moisture content is too high.

Aspect	Selected option		Alternative 1		Alternative 2	
Tailings storage facility location and	**Construct a complex of interconnected tailings storage facilities within the current Bawdwin Concession, using conventional thickened tailings**		**Construct a single tailings storage facility outside the Bawdwin Concession, using conventional thickened tailings**		**Construct a tailings storage facility within the Bawdwin Concession, by dry-stacking filtered tailings**	
	Advantage	**Disadvantage**	**Advantage**	**Disadvantage**	**Advantage**	**Disadvantage**
Environmental (land, water, air, biodiversity)	• Lower risk of dam failure and subsequent impacts to downstream ecosystems, compared to single high wall facility	• Highest disturbance footprint. • Increased number of potential contaminant sources (e.g., seepage to groundwater or surface water). • Lower water recovery than paste or filtered tailings. • Post closure, surface run-off water from two of the three TSFs will be discharged to the Nam La catchment, i.e., discharges from closed mine infrastructure will flow to two catchments, with potential long-term	• Less surface area disturbance than multiple TSFs. • More favourable topography may minimise construction impacts (e.g., downstream sedimentation) and minimise dam failure risk.	• New ground disturbance beyond the Bawdwin Concession. • More power intensive compared to onsite TSF(s) due to from pumping requirements although lower than filtered tailings). • Lower water recovery than paste or filtered tailings • Potentially higher environmental risks from seepage and discharges because the area of impact is	• Water recovery from filtered tailings could be used for site water requirements. • Reduced surface area of disturbance compared to conventional thickened tailings also reducing closure liability. • Can progressively close sections of the TSF, thereby reducing closure liabilities. • Less potential for contamination of	• Filtering tailings is power intensive. • Ability to use dry stacking during the wet season may not be possible. • Increased risk of dust generated from dry TSF surface.

Aspect	Selected option		Alternative 1		Alternative 2	
Tailings storage facility location and	**Construct a complex of interconnected tailings storage facilities within the current Bawdwin Concession, using conventional thickened tailings**		**Construct a single tailings storage facility outside the Bawdwin Concession, using conventional thickened tailings**		**Construct a tailings storage facility within the Bawdwin Concession, by dry-stacking filtered tailings**	
Social (community, health, cultural heritage)		• TSF locations will require resettlement of the Bawdwin village, due to: – The location of the TSF complex partially overlies the upper Bawdwin village – Risk of inundation of the remainder of Bawdwin village in the unlikely event of embankment failure. • Impacts to cultural heritage through direct disturbance and indirect	• Ability to select location to avoid inundating Bawdwin village. • Less impact to existing access road.	• Hazard to public safety if located near existing villages. • Potential loss of productive land and/or resettlement depending on the location.	• Less impact to cultural heritage values, due to reduced footprint and different location. • Less impact to existing access road.	• Some displacement of Bawdwin villagers (requiring resettlement) but less than selected option.
Chosen method and reason for selecting	The preferred option is to construct three tailing storage facilities all with modest dam heights thereby minimising dam break risks compared to a single large facility. The use of established technology that has been proven to be safe in seismically active regions. Due to concerns regarding the reliability and proven feasibility of using filtered tailings in a climate such as experienced in the Bawdwin site, and economic constraints, conventional thickened tailings are the preferred tailings management system. The lack of proven underground capacity rules out consideration of depositing paste tailings in mined-out underground voids. Suitable locations for a single TSF are all outside the Bawdwin concession. Such a facility could accommodate the total tonnage tailings in the current production plan and any subsequent extensions to the mine life and would be much more efficient with a lower risk profile than the selected option. However, due to lack of certainty regarding					

Table 3.5 Assessment of alternatives for waste rock storage

Aspect	**Selected option**		**Alternative 1**		**Alternative 2**	
Waste rock dump location and type	**Construct a single waste rock dump within the Bawdwin Concession in Wallah Valley**		**Construct multiple waste rock dumps adjacent to the open pit within the Bawdwin Concession**		**Construct waste rock dump(s) outside the Bawdwin Concession**	
	Advantage	**Disadvantage**	**Advantage**	**Disadvantage**	**Advantage**	**Disadvantage**
Feasibility (economic, engineering, constructability)	• Easier to construct and manage one dump rather than multiple dumps (including during operations and after closure). • Advantageous valley topography and ground conditions result in low geotechnical failure risks. • Larger capacity compared to near-pit waste dump options.	• Towards the end of the life of the open pit, when rock is being deposited at the ultimate extent of the dump, the haul distance is relatively long, resulting in increased haulage costs.	• Reduced distance from open pit resulting in reduced haulage costs.	• Limited capacity due to constrained topography (i.e., limited flat land near open pit). • More difficult to construct and manage multiple dumps (including during operations and after closure) compared to a single dump. • Possibly sterilises ground and constrains future development in a highly prospective area for minerals. • Little potential for future expansion of dumps if required.	• Ability to select favourable topography. • Ability to expand in the future, if required.	• Land acquisition required and associated risk of schedule delay. • Increased security risk of access hinderance being located off concession. • High haulage costs.

Environmental (land, water, air, biodiversity)	• All waste rock contained in one footprint within the concession area confines environmental impact to one area. • Topography (narrow valley and relatively steep gradient of the valley bottom) makes collection and management of any	• Location in a valley with steep gradient makes surface water management difficult (i.e., surface flows concentrated towards waste dump). Surface water runoff may require treatment prior to discharge. • Groundwater seepage from beneath the waste	• Centralises disturbance and environmental impacts near the open pit.	• Environmental impact spread across multiple areas. • Larger footprint/disturbance compared to a single waste dump. • Groundwater seepage from beneath the waste rock dump likely to require treatment	• If located in favourable topography may reduce hazards (e.g., dust generation) and improve feasibility of surface water management	• New ground disturbance beyond the Bawdwin concession. • Potentially higher environmental risks from seepage and discharges due to the environment.

Aspect	Selected option		Alternative 1		Alternative 2	
Waste rock dump location and type	Construct a single waste rock dump within the Bawdwin Concession in Wallah Valley		Construct multiple waste rock dumps adjacent to the open pit within the Bawdwin Concession		Construct waste rock dump(s) outside the Bawdwin Concession	
	Advantage	Disadvantage	Advantage	Disadvantage	Advantage	Disadvantage
Social (community, health, cultural heritage)	• Valley fill waste dump results in minimal visual impact.	• Toe of waste rock dump lies immediately upstream of Wallah Gorge village when the dump reaches its ultimate footprint, posing operational safety and health risks during construction. • Seepage collection ponds and final discharge point also lie immediately upstream of Tiger Camp village. Final discharge will be to the Wallah stream that flows through the village.	• Lower dumps, likely with lower visual impact.	• Visual and land use impacts spread across multiple areas	• Reduced hazards e.g., dust generation if located away from existing villages.	• Hazards e.g., dust generation if located near existing villages. • Potentially visible to the public. • Potentially loss of productive land resettlement depending on the location.
Chosen method and reason for selecting	Constructing a single waste rock dump within the Bawdwin concession in Wallah Valley was selected as the preferred option for the project. This location is in proximity to the open pit and provides suitable topography, simplified haulage routes, and simpler ongoing management compared to multiple smaller waste dumps around the open pit or a waste dump(s) located outside the Bawdwin concession.					

Table 3.6 Assessment of alternatives for project water supply

Aspect	Selected option		Alternative 1		Alternative 2		Alternative 3	
Process water supply	**Construct a reservoir to harvest and store water from the Nam La stream, and also abstract water from the Nam**		**Pump groundwater from the underground workings via the Marmion shafts**		**Construct a new pipeline to abstract water from the Namtu River and pump it to Bawdwin**		**Re-use return water from the tailings storage facility and/or concentrate filter plant**	
	Advantage	**Disadvantage**	**Advantage**	**Disadvantage**	**Advantage**	**Disadvantage**	**Advantage**	**Disadvantage**
Feasibility (economic, engineering, constructability)	• Proximity to process plant. • Suitable quality for process plant and unlikely to require treatment. • Able to provide all process plant requirements. • Lower risk of running out of water by storing water from two river sources.	• Requires construction of an embankment and supporting access road.	• Proximity to process plant. • Does not require construction of a new water reservoir.	• Unsuitable quality for process plant and potentially other uses. • Insufficient volumes to provide process plant requirements. • Will require some water treatment. • Would likely be low engineering feasibility / difficult to construct and operate. • Will likely be expensive to construct and operate (i.e., to treat water quality to required levels).	• Suitable quality for process plant and unlikely to require treatment. • Does not require construction of dam.	• High capital cost to install piping • High operating costs to pump water to the process plant.	• Does not require construction of storage dam	• Unsuitable quality for process plant • Will require some water treatment. • Unable to provide all process plant requirements. • Greater risk of running out of water if TSF supernatant levels are low.

Environmental (land, water, air, biodiversity)	• More likely to enable sufficient availability of water during dry season. • No chemicals required for water treatment • No waste stream generated by water treatment (i.e., no wastewater	• Impact on downstream aquatic and riparian ecosystems from altered flows and water quality impacts during construction of dam wall. • Seasonal alteration of flows in the tributary during operation. • Approximately	• Increased efficiency of water use (i.e., lower net water demand). • May remove contamination loads discharging to environment. • Low impact on downstream aquatic and riparian ecosystems.	• Potential to contribute to localised groundwater drawdown. • Waste stream generated by water treatment (i.e., wastewater effluent).	• No chemicals required for water treatment. • No waste stream generated by water treatment (i.e., no wastewater effluent).	• Impact on downstream aquatic and riparian ecosystems from altered flows. • Higher power demand due to long distance pumping.	• Increased efficiency of water use (i.e., lower net water demand).	• Potential spills/leaks of chemicals required for water treatment.

Aspect	Selected option		Alternative 1		Alternative 2		Alternative 3	
Process water supply	**Construct a reservoir to harvest and store water from the Nam La stream, and also abstract water from the Nam**		**Pump groundwater from the underground workings via the Marmion shafts**		**Construct a new pipeline to abstract water from the Namtu River and pump it to Bawdwin**		**Re-use return water from the tailings storage facility and/or concentrate filter plant**	
	Advantage	**Disadvantage**	**Advantage**	**Disadvantage**	**Advantage**	**Disadvantage**	**Advantage**	**Disadvantage**
Social (community, health, cultural heritage)	• More likely to enable sufficient availability of water during the dry season to use for dust suppression and manage amenity and health impacts to nearby communities.	• Impact on downstream users (communities) from altered flows and water quality impacts during construction of dam wall in the Nam La catchment. • Reduction of 10% of catchment area of the Nam La Flume, which supplies potable	• No impact on downstream users (communities).	• Potential to contribute to localised groundwater drawdown.	• None identified.	• Water security risk from pipeline or pumping failure or interruption. • Potential impact (albeit low) on existing water users (communities) from altered flows during low-flow conditions.	• No impact on downstream users (communities). • Reduced risk of tailings dam failure due to lower volume of stored water.	• Greater risk of running out of water required for dust suppression and management of amenity and health impacts to nearby communities.
Chosen method and reason for selecting	The main water supply options are upgrading and maintaining the existing supply system, using groundwater from the underground workings via Marmion shaft, using water Namtu River and Nam La stream with pump stations and using return water from the tailings storage facility depending on the chosen tailings management and storage option selected, including location of tailings dam(s). The preferred option for water supply is to use a combination of stream flow from the Nam Pangyun and Nam La streams primarily in the wet season and storing in water holding dams; recycling decant water from the TSFs and using water extracted from the Marmion shaft for dust suppression. The use of a combination of water sources would limit potential environmental and social impacts associated with the reliance of water extraction from existing watercourses only. It also provides increased water							

Table 3.7 Assessment of alternatives for power supply

Aspect	**Selected option**		**Alternative 1**		**Alternative 2**	
Power Supply	**Construct a dedicated on-site power station**		**Connect to the national grid**		**Connect to the existing hydropower station at Mansam Falls**	
	Advantage	**Disadvantage**	**Advantage**	**Disadvantage**	**Advantage**	**Disadvantage**
Feasibility (economic, engineering, constructability)	• Guaranteed supply of power to the process plant	• High capital cost to construct new power supply. • Moderate operating costs requiring diesel imported from Yangon. • Security of fuel delivery required.	• Low cost for overhead power line.	• Access to land for transmission line difficult and time consuming to negotiate and acquire. • Lower security of power supply due to EAO security threats. • Difficult to access power line corridor for maintenance due to EAO threats. • Potential for blackouts or power cuts. • Unreliable power supply and dependent on hydroelectric dams that are affected seasonally.	• Low operational/supply cost	• Insufficient power generation capacity based on current configuration. • High cost to upgrade existing facilities. • Lower security of power supply due to EAO threats. • Difficult to access power line corridor for maintenance due to EAO threats. • Potential for blackouts or power cuts. • Unreliable power supply and dependent on hydroelectric dams that are affected seasonally.

Environmental (land, water, air, biodiversity)	• None identified.	• Non-renewable energy source. • Significant greenhouse gas emissions. • Air and noise emissions impacting nearby fauna. • Potential spills in the	• No local air or noise emissions	• A proportion of national grid energy is supplied by non-renewable sources. • Land disturbance for overhead power line connection to grid.	• Renewable energy source. • No environmental impacts from construction of new facilities (e.g., less surface disturbance). • No direct air or noise emissions.	• Upgrades likely to involve land disturbance.
Social (community, health, cultural heritage)	• Located on existing concession therefore no land acquisition required	• Reduced amenity from air and noise emissions. • Increased truck traffic on public roads due to the	• No local air or noise emissions • New grid connection could have social use post mine closure.	• Land acquisition and approval required for transmission line from grid.	• Located on existing easements therefore no land acquisition required. • Upgrade of infrastructure could	• None identified.
Chosen method and reason for selecting	Capital and operating costs, greenhouse gas emissions, noise levels, ability to supply enough power to meet project demands, and the potential to provide a positive long-term power source for the region, are a few of the main factors that were assessed when deciding which power supply option will be the most feasible for the project. A standalone diesel fired power station is the preferred option as this will guarantee power supply, which is critical to successful operations (Alternative 3). This option provides the best guarantee for power supply. A broader assessment of the application of renewable energy sources has not been undertaken.					

Table 3.8 Assessment of alternatives for site access/route

Aspect	Selected Option		Alternative 1		Alternative 2	
Site access	**Construct a new access road between Tiger Camp and Namtu along the existing railway corridor and a second new access road between Tiger Camp and the process plant**		**Use the existing public road between Manton and Namtu**		**Use the existing railway between Tiger Camp and Namtu and construct an access road between Tiger Camp and the process plant**	
	Advantage	**Disadvantage**	**Advantage**	**Disadvantage**	**Advantage**	**Disadvantage**
Feasibility (economic, engineering, constructability)	• Rail bed and embankments already exist as the start point for road construction. • New road will be designed to accommodate larger construction and operation trucks. • Located within existing rail easement. • Lower construction costs. • Private road that can be managed by WMM and less mine/public vehicle interaction.	• Requires removal of existing rail line. • Requires construction of a new access road between Tiger Camp and process plant, which may directly displace some land users.	• Road requires upgrade rather than new construction.	• Current road is narrow with, sharp corners steep ascents and steep drops. It would require substantial upgrading to accommodate project vehicles, including significant earthworks, straightening, installation of drainage culverts and bridges, and blasting. The steep topography makes this challenging, expensive and time consuming • Delivery of oversize loads of construction material and equipment is not feasible prior to completion of the above works in priority areas. • Significant WMM/Public traffic interaction.	• Existing rail could be used by the community or potentially other industrial/commercial ventures (e.g., tourism) after upgrades.	• High capital costs to upgrade and maintain the railway. • Increased complexity of logistics involving both road and rail handling. • 100% rail access provides less flexibility. • Trans-shipment systems and infrastructure for loading/unloading rail wagons would be required at both Namtu and Tiger Camp. • Requires construction of a new access road between Tiger Camp and process plant, which may directly displace

						some existing land users. • Some company road traffic would likely still have to use the existing public road between Manton and Namtu.
Environmental (land, water, air, biodiversity)	• Located within a previously disturbed corridor.	• Requires new construction materials rather than re-using existing infrastructure (i.e., railway) • Disturbance to landforms and soils if regrading is required	• Located within a previously disturbed corridor • No native vegetation clearance required • Upgrade to existing infrastructure rather than new construction	• Environmental impacts from accidents involving concentrate vehicles could result in concentrate entering the Nam La stream system. Recovery or containment of spills would be difficult in steep terrain. • Environmental impacts from accidents involving concentrate vehicles would be more difficult to recover/mitigate as the	• Located within a previously disturbed corridor • Would minimise construction impacts along the rail corridor.	• The option still requires new road construction between Tiger Camp and the process plant with associated environmental impacts. • Trans-shipment facility at Tiger Camp would require additional land.

Aspect	Selected Option		Alternative 1		Alternative 2	
Site access	**Construct a new access road between Tiger Camp and Namtu along the existing railway corridor and a second new access road between Tiger Camp and the process plant**		**Use the existing public road between Manton and Namtu**		**Use the existing railway between Tiger Camp and Namtu and construct an access road between Tiger Camp and the process plant**	
	Advantage	**Disadvantage**	**Advantage**	**Disadvantage**	**Advantage**	**Disadvantage**
Social (community, health, cultural heritage)	• Gentle gradient so less potential for traffic accidents. • Lower safety risks due to limited interface with public and ability to control access. • Potential for use as a public road/access route after closure.	• Loss of the existing Namtu to Bawdwin railway and its cultural heritage values • Potential temporary impacts on artisanal miners in the Nam Pangyun riverbed. • Impacts to landholders along corridor (e.g. no longer able to use for access to river, safety risks, amenity impacts). • Access and amenity impacts to Tiger Camp village during construction, as the area would be used as a staging base for	• Avoids disturbance of the Namtu to Bawdwin rail, thereby reducing impacts to cultural heritage. • Improvement of public road infrastructure and benefits to existing road users. • Reduces displacement and socio-economic impacts along rail corridor and at Tiger Camp and Wallah gorge	• Substantial risks of vehicle accidents and collisions,	• Preservation of the cultural heritage value of the existing rail. • Post closure opportunities (e.g., tourism) for use of rail. • Lower safety risks compared to road transport (note road connection from Namtu to smelter would still be required).	• Would likely result in some displacement and socio-economic impacts along rail corridor, at Tiger Camp and Wallah gorge, and at existing farms along the route of the access road between Tiger Camp and the process plant • Access and amenity impacts to Tiger Camp village during construction

Chosen method and reason for selecting	The steep topography of the area permits only two practical access corridors from Namtu to Bawdwin, via the Nam La and Nam Pangyun valleys. These two corridors are used by the existing road and rail access routes to Bawdwin. Road safety, environmental impacts (such from road construction and upgrades), displacement impacts, amenity impacts (noise and visual amenity of nearby sensitive receptors), costs to construct, upgrade and maintain roads, and travel efficiency have all be considered when determined the preferred site access option. The preferred option is constructing a new dedicated road between Tiger Camp and Namtu. The difference in cost between constructing a dedicated private access road or upgrading the existing public road is not significant and the new dedicated road would have shorter travel time to and from the process plant and controlled access, while use of the existing road has higher safety concerns from interaction with the public.

Bawdwin Project

Environmental Impact Assessment
Chapter 4 – Project description

October 2023

Bawdwin Project

Prepared for

Win Myint Mo Industries Company Limited

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4 Project description

4.1 Project overview

WMM proposes to redevelop the existing Bawdwin mine into a larger, modern mining operation. The redevelopment will involve demolition of much of the existing infrastructure and construction of new infrastructure to support mining and processing activities.

Table 4.1 presents key project components and the conceptual layout of the project is presented in Figure 1.2. A three-dimensional view of the project layout is shown in

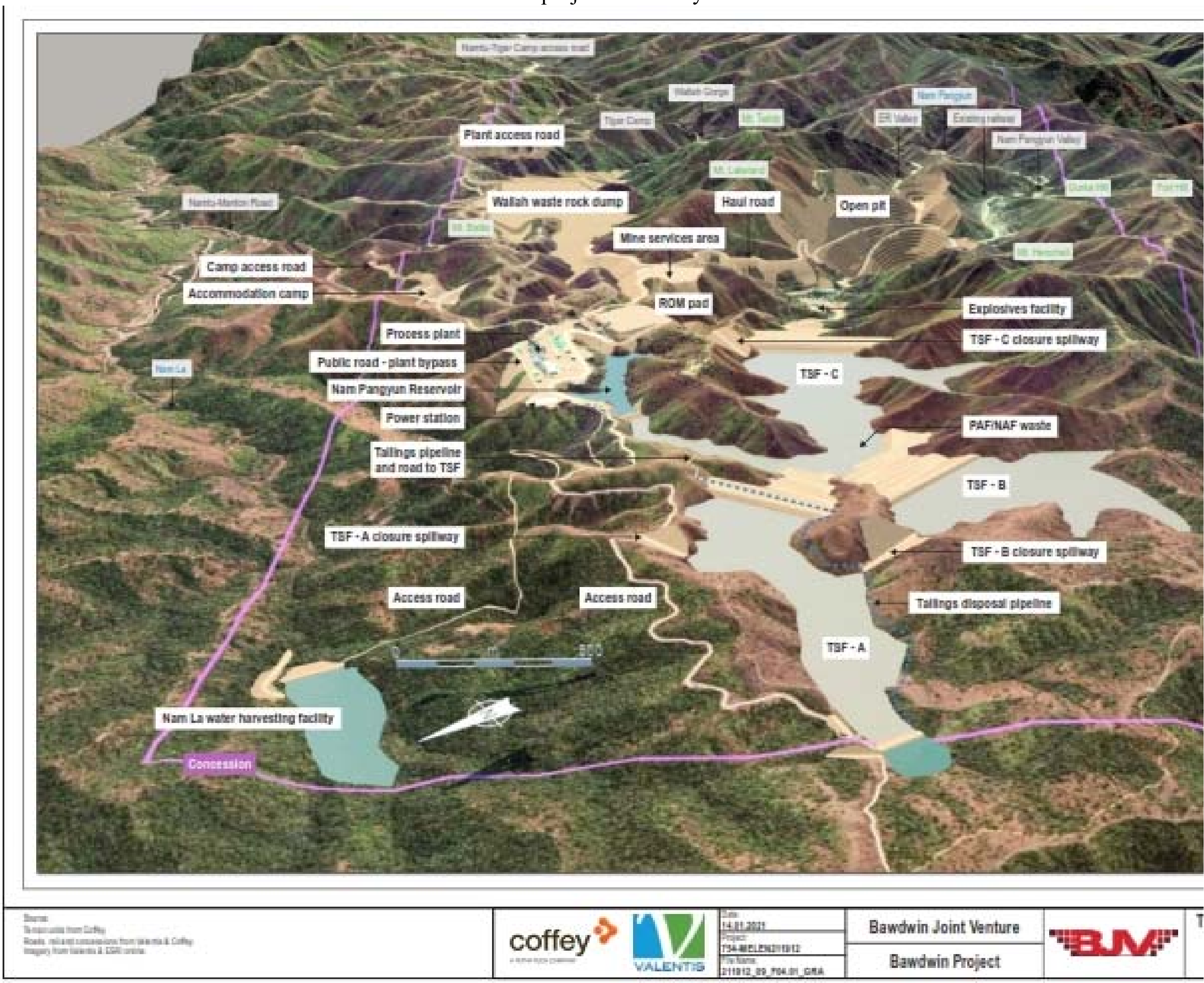


Figure 4.1.

Table 4.1 Key project components

Component	Description
Mining method	Large-scale conventional open-pit. Open pit mining will be done using drill rigs, excavators and/or front-end loaders and articulated haul trucks. Ore and overburden will be loosened by blasting.

Component	Description
Open-pit dimensions	The existing open pit will be expanded and deepened, growing in size from approximately 54.0 acres to at least 242.7 acres (21.9 hectares (ha) to 98.2 ha).
Construction timeframe	The design, construction and commissioning timeframe is 22 months.
Mine life	The planned expansion of the open pit will result in a 30-year mine life. Exploration is proposed and has the potential to extend the life of the mine for up to 50 years.
Mine waste rock management	329.22 million tonne (Mt) of waste rock will be produced by the project and will be disposed in a waste rock dump to be constructed in the Wallah Valley. This will be an engineered structure(s) comprising benches and embankments. A series of three sediment basins will be constructed downstream of the waste rock dump to collect seepage and run off and allow water treatment prior to discharge if required.
Processing method	A new process plant will be constructed in the Bawdwin concession. Ore will be processed at a rate up to 2 Mt per annum (Mtpa). Processing of the ore will involve crushing and grinding followed by separate lead-sliver and zinc flotation. The lead-silver and zinc concentrates will be thickened, filtered and stockpiled for loading into concentrate containers for export.
Tailing management	54 Mt of tailings will be produced by the process plant. It will be transported via a pipeline to one of three tailings storage facilities (TSFs).
Concentrate production	Approximately 138 ktpa of lead-silver concentrate. Approximately 85 ktpa of zinc concentrate.
Processing infrastructure	Processing infrastructure will include construction of a new process plant and associated infrastructure including laboratory, reagents storage, water supply, workshop, warehouse and TSFs.
Export route and facilities	Concentrate will be exported from Bawdwin via new private access roads to Namtu. From there trucks will travel to Lashio on public roads and then onwards for export to international markets. A central warehouse and logistics hub for the project will be constructed in Lashio. Concentrate containers will be transported to the hub and then loaded onto trucks for onward transport.
Mine access	The public Namtu-Manton Road currently provides access to Bawdwin, but will not provide the main access for the project. This road will be used to a limited extent during construction. A new access road from Namtu to Tiger Camp is proposed to be constructed within the existing rail easement (referred to as Namtu-Tiger Camp access road). Access to this road will be provided to residents of Tiger Camp village and Bawdwin lower village, prior to their resettlement. A new road from Tiger Camp to the process plant (referred to as plant access road) is proposed to provide site access. Other new access roads will provide access to project components including the accommodation camp, TSFs and Nam La water harvesting facility. A new double lane haul road will connect the open pit to the process plant and waste rock dump.
Accommodation	An accommodation camp will be constructed for the project capable of accommodating approximately 1,400 people. The accommodation camp will be used during construction and operation of the project. It is expected that the local workforce will reside in their homes and be transported to site daily.
Employment	Up to 2,285 people during construction, decreasing to 1,115 people during operations.

The project infrastructure footprint areas are provided in Table 4.2. The total footprint area is 469.1 ha (1,157.9 acres). The majority (>95%) of project infrastructure will be located on land already disturbed by historical mining mineral processing activities within the 2,458 ha Bawdwin concession.

Table 4.2 Project infrastructure footprint areas

Project component	Infrastructure footprint (ha)	Infrastructure footprint (acres)
Open pit	98.2	242.7

TSFs including embankments, diversion dam and closure spillways	149.0	368.2
Waste rock dump including sediment dams	107.2	264.9
Access roads (Namtu to process plant)	44.4	108.7
Haul roads	14.8	36.6
ROM pad	9.2	22.7
Water dams including embankments, access road and reservoirs	24.2	59.8
Process plant	10.3	25.5
Mine services area	4.4	10.9
Accommodation village and access road	6.8	16.8
Explosives facility	0.4	1.0
Power station	0.3	0.7
Total	**469.1**	**1,157.9**

4.2 Project schedule

The project schedule will consist of six main stages:

- Planning and approvals.
- Works prior to execution.
- Resettlement.
- Implementation including design, construction and commissioning.
- Operation.
- Closure.

The timeframe for redevelopment of the Bawdwin mine is set out in

Figure 4.2 and is described in more detail below.

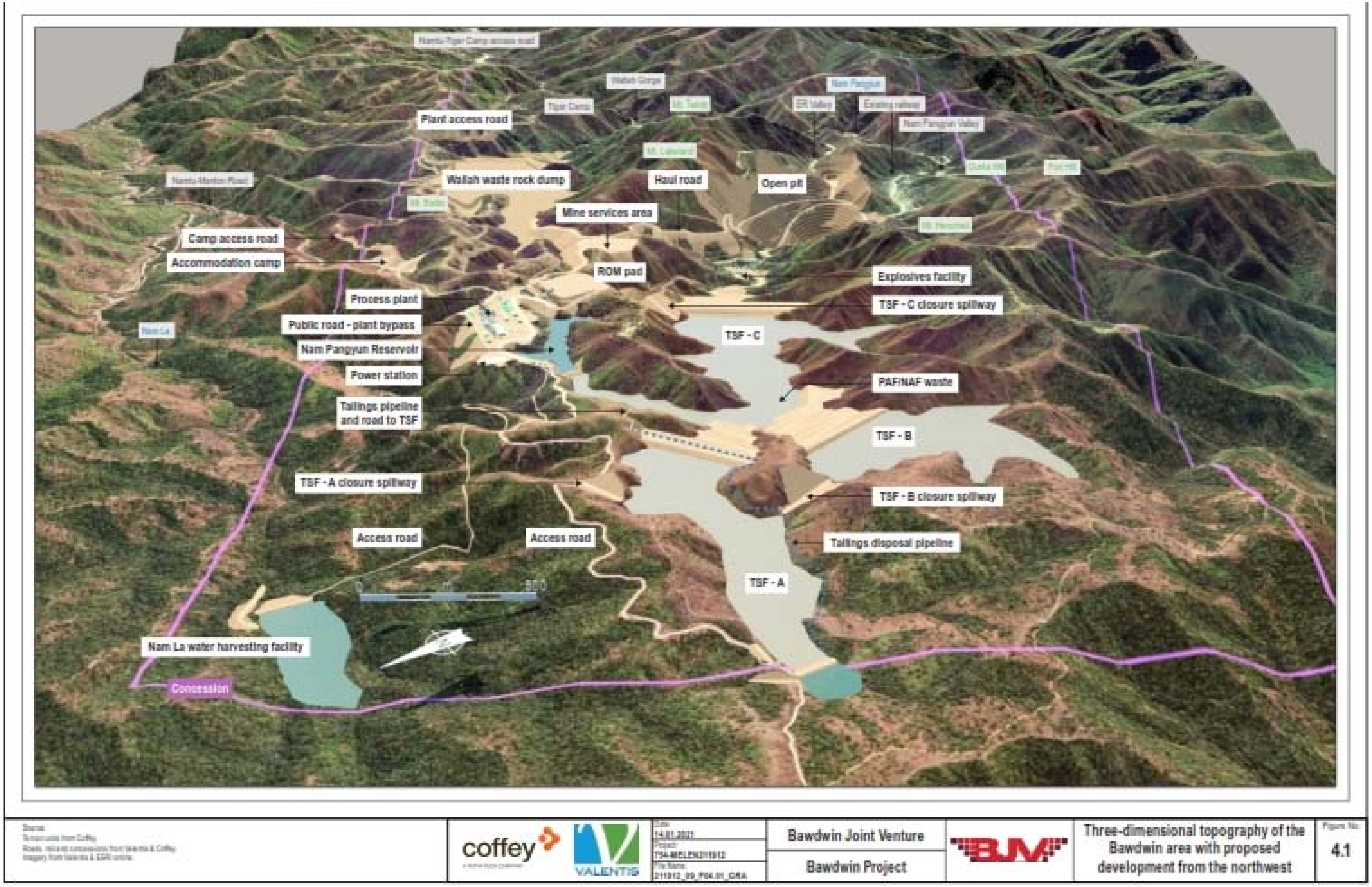


Figure 4.1 Three-dimensional topography of the Bawdwin area with proposed development from the northwest

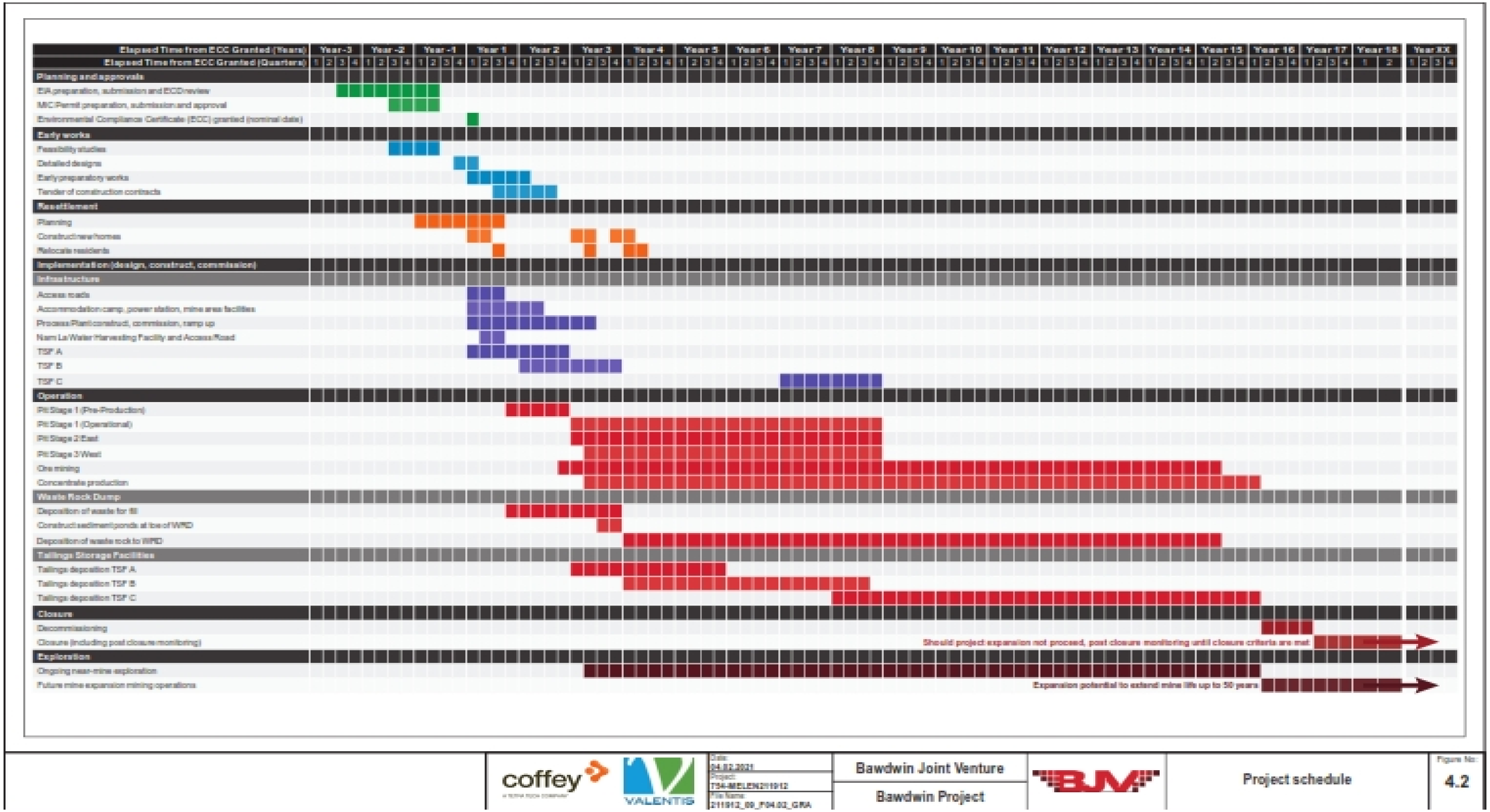


Figure 4.2 Project schedule

4.2.1 Planning and approvals

Following the submission of this EIA to the Environmental Conservation Department (ECD) of the Ministry of Natural Resources and Environmental Conservation (MONREC), the formal EIA review process will commence. This will involve detailed review and comment by ECD and by an independent review team that ECD establishes. The independent review team is likely to include members of other ministries and departments. It is expected that this formal assessment process will take between three and six months. Another round of stakeholder consultation and engagement will also be conducted to seek input and comments from potentially affected people and other stakeholders. The outcome of a successful review and update of the EIA report would be granting of the Environmental Compliance Certificate (ECC).

Under the Myanmar *Investment Law 2016*, major and/or sensitive projects, including proposed large-scale mineral production projects, require prior investment approvals from the Myanmar Investment Commission (MIC). In the case of large-scale mineral production, this includes a requirement for MIC approval of foreign investment in the production project. MIC approval for the project is being sought and an MIC permit application has been submitted summarising the financial, technical and related projections of the project.

A range of secondary approvals and consents will be required in addition to the ECC and MIC permit. These include but are not limited to approvals for construction of plant infrastructure, buildings, roads, power generation infrastructure, water abstraction, and use of explosives and restricted chemicals.

4.2.2 Works prior to execution phase

Following granting of the MIC application and ECC, a range of early works are planned prior to project funding approval and award of the main contract for the process plant. These early works include:

- Design of access roads (i.e., Namtu-Tiger Camp access road, plant access road, camp access road).
- Design of accommodation camp bulk earthworks and camp road.
- Design activities to support the procurement of long-lead equipment.
- Bulk earthworks design and construction of critical site enabling works.
- Acquisition of land for resettlement.
- Preparation and tender of the accommodation camp and associated services and utilities.
- Preparation and tender of resettlement housing contracts.
- Preparation and tender of construction contracts.

4.2.3 Resettlement

Due to the proximity of the Bawdwin and Tiger Camp villages to proposed project components (i.e., the open pit, waste rock dump and access roads), there will be a need for resettlement of these communities in their entirety.

Resettlement planning is a sequential process with steps that needs to be completed in succession before physical relocation can take place. No physical relocation of people will occur until the resettlement site is constructed and commissioned. This will include a series of progressively more detailed planning steps covering:

- Preparation of a Resettlement Policy Framework, which documents the objectives for resettlement, commitments and principles that will be applied in assessing the needs of groups and individuals, entitlements of each group and individual in terms of housing, compensation, and livelihood restoration.
- Development of a Land Access and Resettlement Plan that will guide the assessment, planning and community approval process and will include but is not limited to the establishment of resettlement

committees, asset identification and declaration of cut-off, a draft eligibility and compensation framework, and options for the type and delivery of livelihood restoration support.

- Preparation of detailed Resettlement Action Plan(s) including detailed asset surveys, documentation of agreed compensation and livelihood restoration assistance, detailed schedule and arrangements for physical relocation.

The timing of resettlement is highly dependent on required government approvals and reaching an agreeable outcome from these communities. It is currently proposed that resettlement will be completed over three stages, reflecting the geographical layout of the various village clusters within the Bawdwin concession area, their proximity to the proposed development areas and the proposed development schedule for the project. These stages are:

- Stage 1 – Bawdwin upper village, Nam La farms and other residents located near proposed access roads (nominally commencing 7 months following granting of the MIC application and ECC (i.e., project commencement).
- Stage 2 – Tiger Camp village (nominally commencing 29 months after project commencement).
- Stage 3 – Bawdwin lower village and associated farms and remaining farms above Tiger Camp (nominally commencing 40 months after project commencement).

Details of the resettlement program are provided within the resettlement management plan (Appendix 4).

4.2.4 Implementation (design, construction and commissioning)

The project implementation program is based on a 22-month design, construction, and commissioning timeframe, with the objective of achieving first concentrate production in Year 3. The commencement of the project implementation phase assumes all project approvals are obtained and financing is in place by Year 1.

The proposed execution methodology for the design, engineering, construction and commissioning of the process plant and infrastructure is an engineering, procurement and construction management (EPCM) delivery model. EPCM is a professional services appointment whereby the EPCM contractor is responsible for the basic and detailed design and engineering phases; establishing, implementing and managing tendering processes for procurement of all equipment and materials and awarding and managing works package contracts; and the overall project management and administration of work package contracts, including during warranty periods.

All construction activities for the project will be undertaken in accordance with a detailed Construction Management Plan to be developed by the EPCM contractor in-conjunction with WMM and relevant environmental and social management plans. Specific construction requirements of the project will include:

- Defining construction organisation roles and responsibilities and reporting lines.
- Human resourcing to ensure appropriate construction workforce.
- Site scheduling activities.
- Site establishment.
- Constructing temporary facilities required to support construction including construction site offices, compounds and accommodation facilities.
- Construction management, project controls and progress reporting.
- Equipment and materials management.
- Site security of the project works.
- Construction contractor management including construction works inspection in accordance with agreed hold points, visual inspections, testing and compliance reporting.
- Commissioning activities.
- Practical completion and handover.

- Construction as-built documentation.

Details of construction including the type and locations of temporary construction infrastructure and facilities, the sources of construction materials (such as aggregate); and details of construction methodology will be developed during the detailed design stage of the project. However, temporary construction facilities will be preferentially positioned within the footprint of proposed permanent infrastructure locations to avoid additional environmental impacts.

4.2.5 Operation

The life of the mine based on the proposed open pit mining operation is 13 years. Details of operations covering mining, ore processing, through to final concentrate export are described in the following sections.

Exploration through operations will improve knowledge of the resource and may extend the mine life. Based on the inferred resource, mining could continue for more than 50 years.

4.2.6 Decommissioning and closure

The main objective of mine closure will be to ensure the long-term physical, chemical, and biological stability of the site to minimise potential environmental, health and safety risks. The post-closure site will be designed to require minimal active maintenance and monitoring. A mine closure plan has been developed (see Attachment 4) and will be submitted to the Department of Mines for approval in accordance with the Myanmar Mines Law (1994) and the Myanmar Mines Rules (2018).

Further details regarding mine closure are outlined in Section 4.18.

On cessation of mining and processing all surface infrastructure will be dismantled and disposed, with reusable and recyclable materials sold. Non-hazardous waste will be disposed in suitable locations. Rehabilitation of land will then be completed where required and may include landform contouring, contamination management, soil management, erosion and sediment control works, and revegetation. Personnel will comprise a smaller contractor-oriented workforce shutting down the facility, under the oversight of WMM. Closure monitoring will be implemented during decommissioning. It is expected that decommissioning will last for up to 24 months and rehabilitation works up to 36 months.

Following decommissioning and rehabilitation there will be a period of post closure monitoring and maintenance. This involves evaluating monitoring data and other evidence, in consultation with ECD and relevant stakeholders, to determine if the objectives and closure criteria have been met. Some ongoing rehabilitation works and maintenance will also occur. Post closure monitoring and maintenance is expected to occur until completion criteria are met.

When monitoring has provided evidence that the objectives and closure criteria have been met to the satisfaction of ECD, the WMM will be formally released from all obligations with respect to associated concession, with a third-party assuming responsibility.

4.3 Mineral resource estimate

The Bawdwin orebody consists of a series of lodes (Shan, China and Meingtha) running in a northwest to southeast direction. A lode is defined as a deposit of metalliferous ore that fills or is embedded in a fissure (or crack) in a rock formation or a vein of ore that is deposited or embedded between layers of rock.

The Bawdwin mineral resource has been assigned to the indicated and inferred classifications, as defined under the Australasian Joint Ore Reserves Committee (JORC) Code 2012 classifications. Inferred mineral resource classification have been applied where available drillhole and channel sampling data and geological interpretation are sufficient to imply but not verify geological and grade continuity. Areas with denser drilling and robust continuation of the modelled mineralised zones are classified as indicated.

The open pit mapping, reverse circulation drilling (or RC drilling) and diamond drilling have been conducted in accordance with modern industry best practice standards and have quality assurance and quality control data to support the assay data. The overall structure of the major lodes is well understood from the underground data and open pit mapping.

The resource estimation for the project involved the construction of a resource model from available data in the form of a block model. The block model is created using geostatistics and the geological data gathered through channel sampling and drilling of the ore zone(s). The block model is a set of specifically sized "blocks" in the shape of the mineralized orebody. Although the blocks all have the same size, the characteristics of each block differ. The grade, density, rock type and confidence are all unique to each block within the entire block model.

The resource block model was spatially divided into five domains based on mineralisation cut-off grades. The domains are shown in

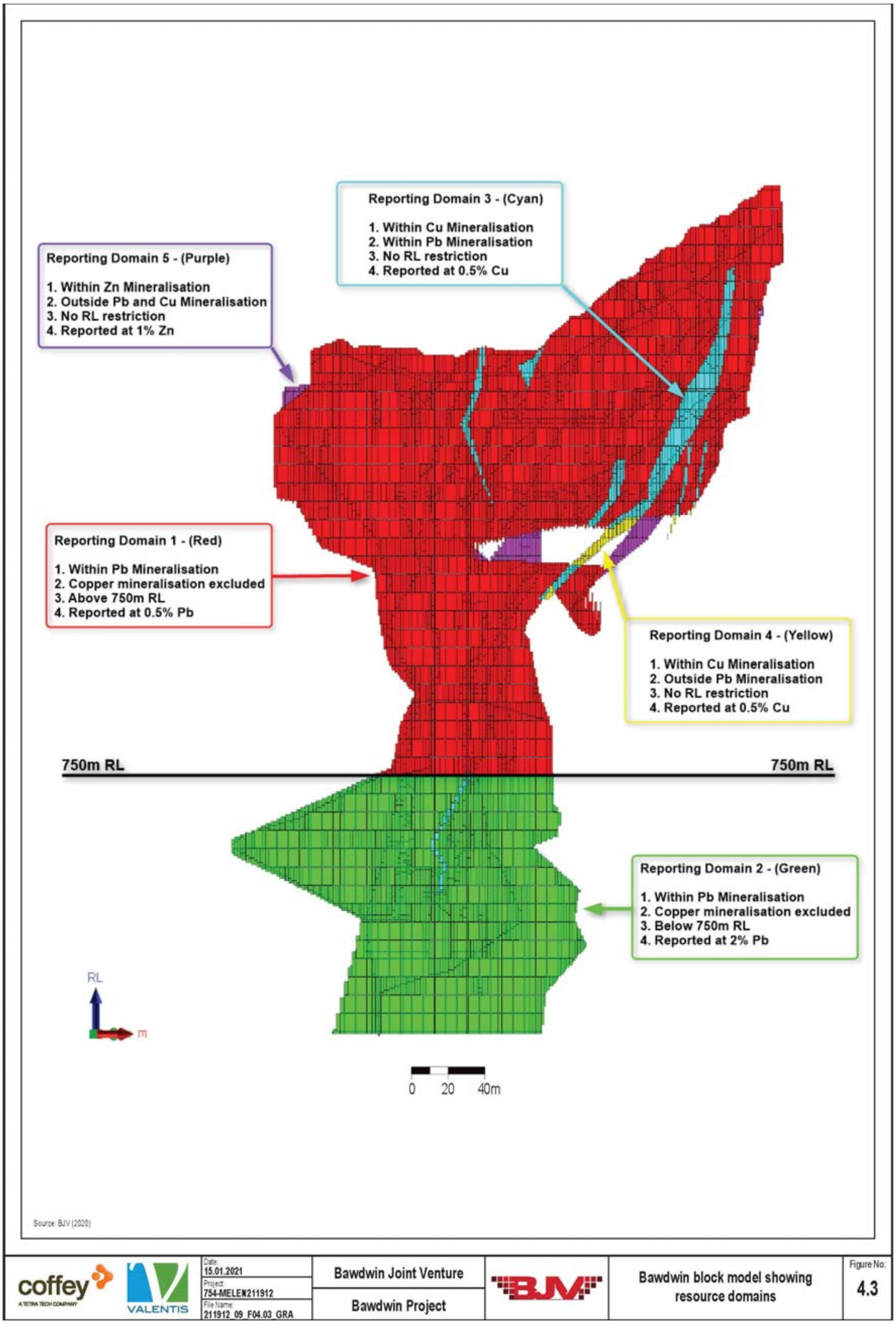


Figure 4.3 and consist of the following:

- Resources above the 750 m RL using a 0.5% Pb cut-off grade.

- Resources below 750 m RL using a 2% Pb cut-off grade.
- Cu mineralisation within Pb Halo using a 0.5% Cu cut-off grade.
- Cu mineralisation outside Pb Halo using a 0.5% Cu cut-off grade.
- Zn mineralisation outside Pb Halo using a 1.0% Zn cut-off grade.

The Bawdwin mineral resource estimate was also classified according to the degree of oxidation and defined as either: fresh, transitional, deep transitional and oxide. Total oxidation (oxide) mainly occurs at the top of the Meingtha Lode. Transitional zones represent partial oxidation and occur as a shallow blanket zone at the top of the mineralised zones and as deep transitional zones that that extend to significant depth. The deep transitional zones are interpreted to be focused in faulted and fractured zones and are of relatively limited extent. Transitional zones have been modelled using a combination of geological observations from drill-core logging, an estimation of sulphur deficit relative to lead, zinc and copper from assay data, and sulphur speciation data based on analysis of sulphide sulphur.

The mineral resource estimate for the Bawdwin project is presented in Table 4.3.

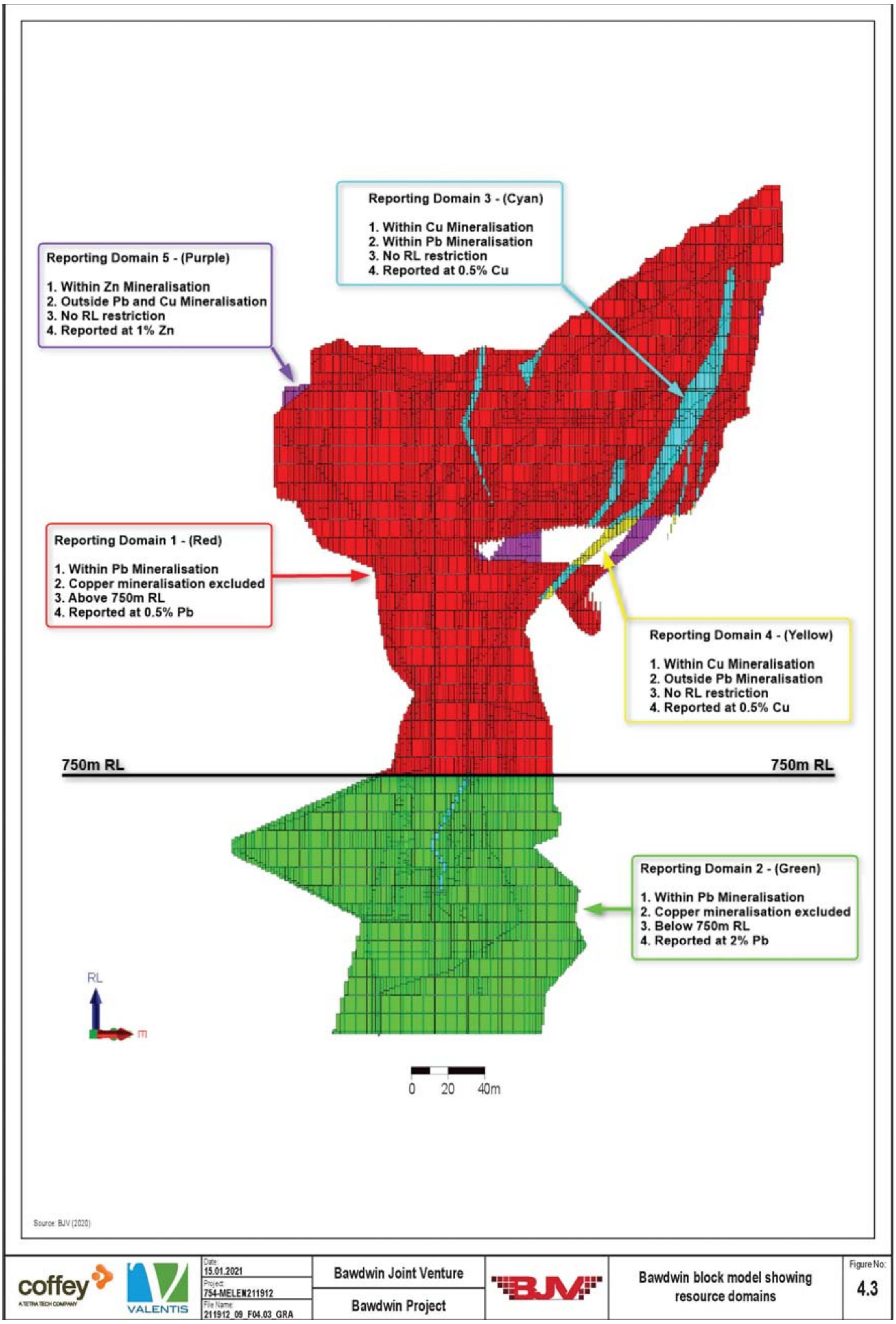


Figure 4.3 Bawdwin block model showing resource domains

Table 4.3 Bawdwin project mineral resource estimate

Oxidation	Class	Tonnage ('000t)	Pb (%)	Zn (%)	Cu (%)	Ag (ppm)
Oxide	Indicated	1,365	1.61	0.05	0.04	68
	Inferred	3,201	1.54	0.07	0.07	79
	Total	4,566	1.56	0.06	0.06	76
Transition	Indicated	3,634	2.90	0.73	0.17	80
	Inferred	2,770	2.76	2.52	0.07	61
	Total	6,405	2.84	1.51	0.13	72
Deep transition	Indicated	1,307	3.77	1.83	0.18	96
	Inferred	96	2.62	0.88	0.12	59
	Total	1,402	3.69	1.77	0.18	93
Fresh	Indicated	36,170	4.16	2.18	0.20	101
	Inferred	52,266	4.23	1.85	0.22	99
	Total	88,436	4.20	1.99	0.21	100
Total	***Indicated***	***42,475***	***3.96***	***1.98***	***0.19***	***98***
	Inferred	***58,334***	***4.01***	***1.79***	***0.20***	***96***
Total		**100,809**	**3.99**	**1.87**	**0.20**	**97**

Source: Bawdwin Project Definitive Feasibility Study (DFS) Report (WMM, 2020)

At the conclusion of the Bawdwin Project Definitive Feasibility Study, an updated ore reserve estimate was produced in accordance with the guidelines in the JORC Code (2012 Edition). All of the ore reserves are reported as ‘probable ore reserves’ and have been derived from the indicated mineral resources and are shown in Table 4.4

Table 4.4 Ore reserves estimate as at 15 June 2020

Classification	Tonnage (Mt)	Pb (%)	Ag (%)	Zn (%)
Proved	-	-	-	-
Probable	32.0	4.6	113	2.5
Total	**32.0**	**4.6**	**113**	**2.5**

The above ore reserve is contained within an open pit containing 163.9 Mt of waste material resulting in a waste to ore (tonnes) strip ratio of 5.2:1. The total mass of rock to be removed from the open pit is 195.9 Mt. Included in the waste material are mineral resources classified within the inferred category, which received no economic value in the financial model run explicitly to verify the economic viability of these reported ore reserves.

Figure 4.4 shows both a plan view and oblique long section of the Bawdwin lead block model for the Shan, China and Meingtha lodes. The block model indicates a significant volume of the intermediate to high grade material that has not yet been mined. Historic mining has focused on high grade ‘lodes’, but significant high grade mineralisation remains in the margins of the stoped zones and in zones that have not been mined, while the majority of the deposit at intermediate grade has not been mined. The block model also shows the “halo” lower grade mineralisation is widespread outside the high grade lodes.

4.4 Exploration

Exploration, in the form of mapping, geophysics, soil, rock chip sampling and drilling will continue to define extensions to known mineralisation and identify new lodes to ensure the long term future of the Bawdwin project. Key areas of further work include Shan North, Mt Teddy, ER Valley, Pangyun Junction and Yegon Ridge. Bawdwin exploration targets are shown in Figure 4.5.

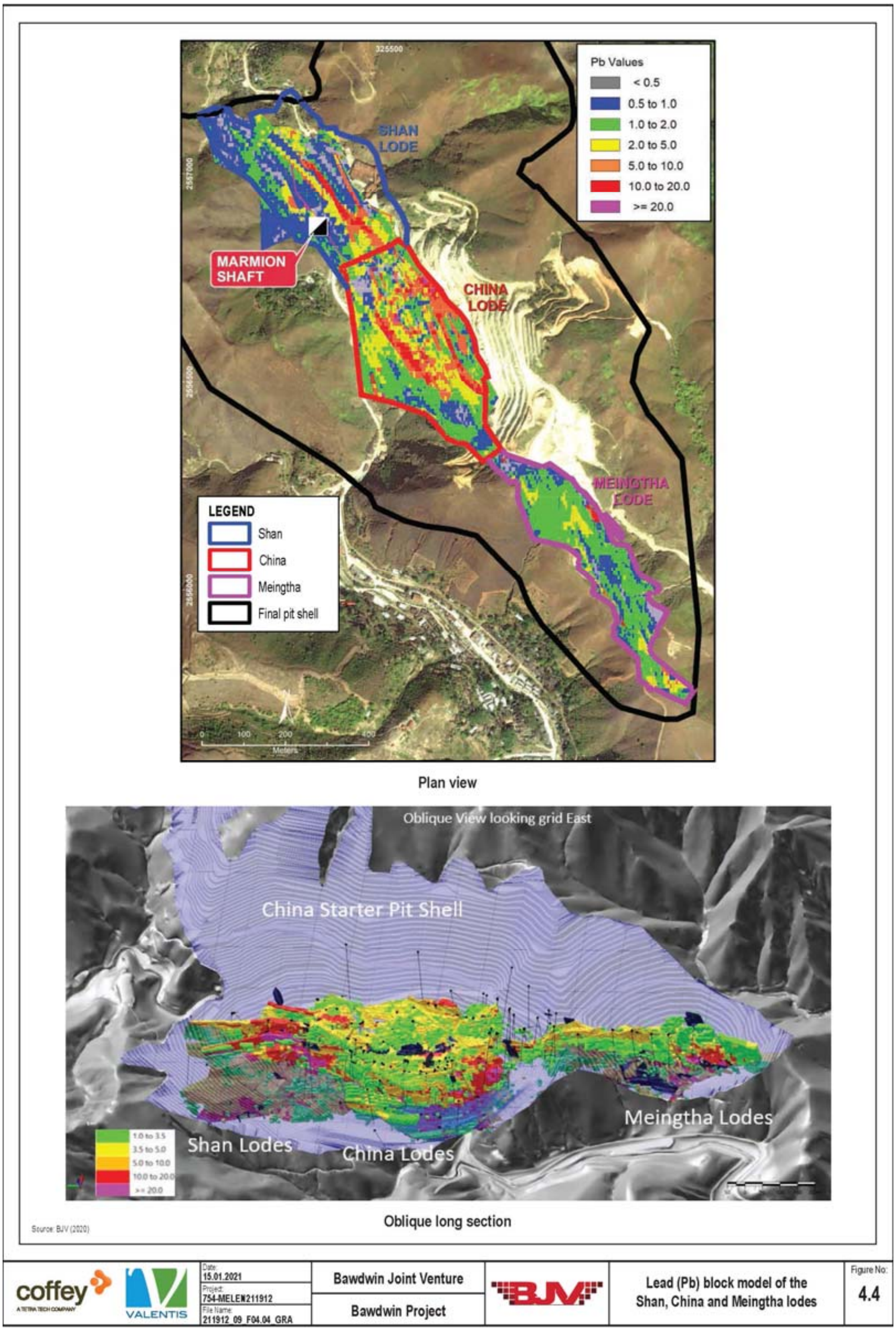


Figure 4.4 Lead (Pb) block model of the Shan, China and Meingtha lodes

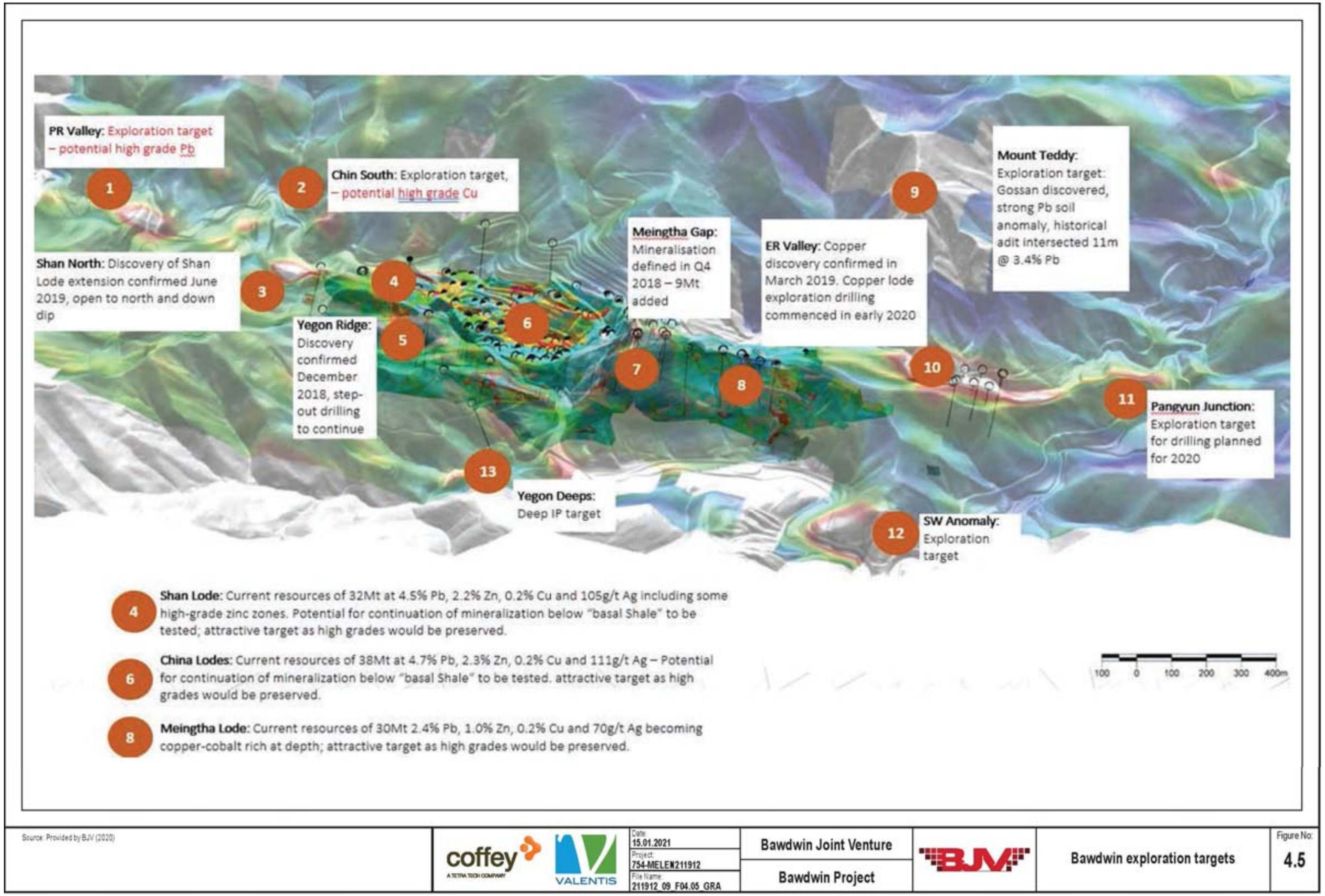


Figure 4.5 Bawdwin exploration target

4.5 Mining

Redevelopment of Bawdwin mine will include expansion of the existing open pit to extract ore from the China, Shan and Meingtha lodes. The existing open pit will be expanded and deepened growing in size from approximately 54 acres to at least 237 acres (21.9 ha to 95.8 ha). The pit will extend down to (1,800 mRL WGS) just above Level 6 (1,795 mRL WGS) of the existing underground workings, approximately 180 metres below the existing pit floor. The rim of the pit will be contained within the catchments of the Nam Pangyun valley and adjacent ER valley. A three-dimensional view of the final open pit in the context of the surrounding landscape is shown in Figure 4.6.

The pit will be mined in four stages as shown in

Figure 4.7. The four stages have been defined for the purposes of mine scheduling and are presented in

Figure 4.8. Corresponding mining inventories for each zone are shown in

Figure 4.9, whereby the different colours represent each pit zone over time.

The mining schedule for each zone along with tonnages of mined material is summarised as follows:

- Central zone – mining will commence in Q4 Year 1 and peak in Year 2, before steadily declining until mining of the zone is complete in Year 8. A total of 43.2 Mt will be mined from this zone.
- East zone – mining will commence in Year 3 reaching a peak in mining in Year 6 before concluding in Year 8. A total of 58.6 Mt will be mined from this zone.
- West zone – mining will commence in Year 3 and peak in Year 5 before concluding in Year 8. A total of 33.0 Mt will be mined from this zone.
- Base zone – mining will commence in Year 8 reaching a peak in Year 9 before declining over the next six years. A total of 60.7 Mt will be mined from this zone.

The open pit is designed to be a stable landform comprising a series of benches and batters, with haul roads connecting the benches. Waste rock will be transported to the waste rock dump to be constructed in the Wallah Valley to the northeast of the pit.

Geotechnical investigations and analysis of the geotechnical core logging were undertaken to characterise the respective rock mass design domains that will be encountered in the proposed open pit slopes. The available laboratory strength data was reviewed and analysed for the purposes of slope design. Geotechnical design domains have been identified based on their lithology, weathering and geotechnical characteristics.

The prevailing stress field, earthquake loading potential and hydrogeological conditions were incorporated to provide the rock mass loading conditions for geotechnical analysis. Probabilistic 2-dimensional finite element modelling was carried out to determine the batter face angle. The acceptance criteria used for the modelling was a factor of safety (FoS) of 1.1 and a probability of failure of 30%. FoS is commonly used to express the safety margin of slopes, or in other words, how much stronger a slope is than it needs to be for an intended load. A factor of safety of 1.0 indicates that a slope is adequately strong to bear a load imposed on it; a FoS value greater than 1.0 means that a slope is stronger than it nominally needs to be for its designed purpose.

Based on this work, the recommended slope design parameters are summarised in Table 4.5.

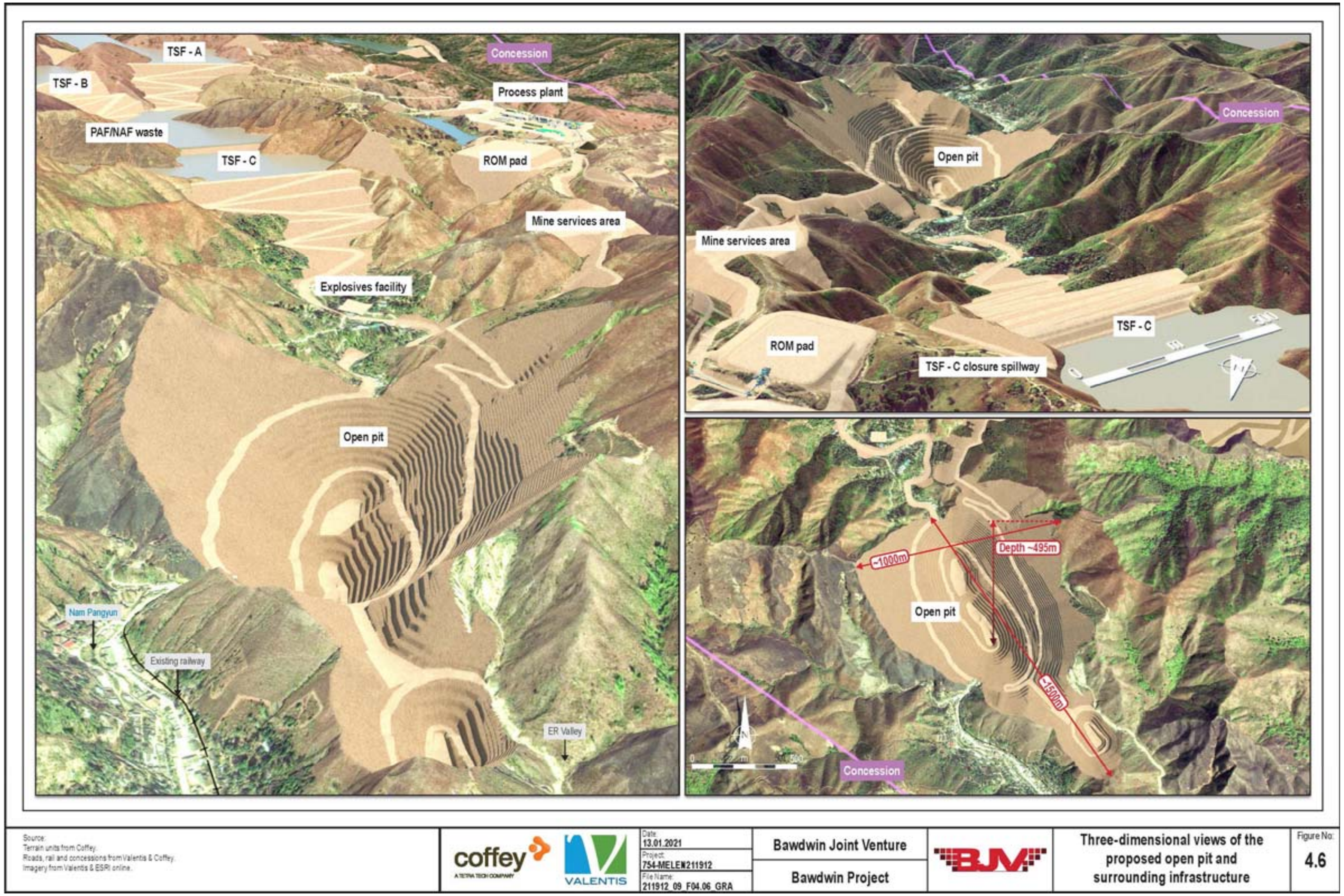


Figure 4.6 Three-dimensional views of the proposed open pit and surrounding infrastructure

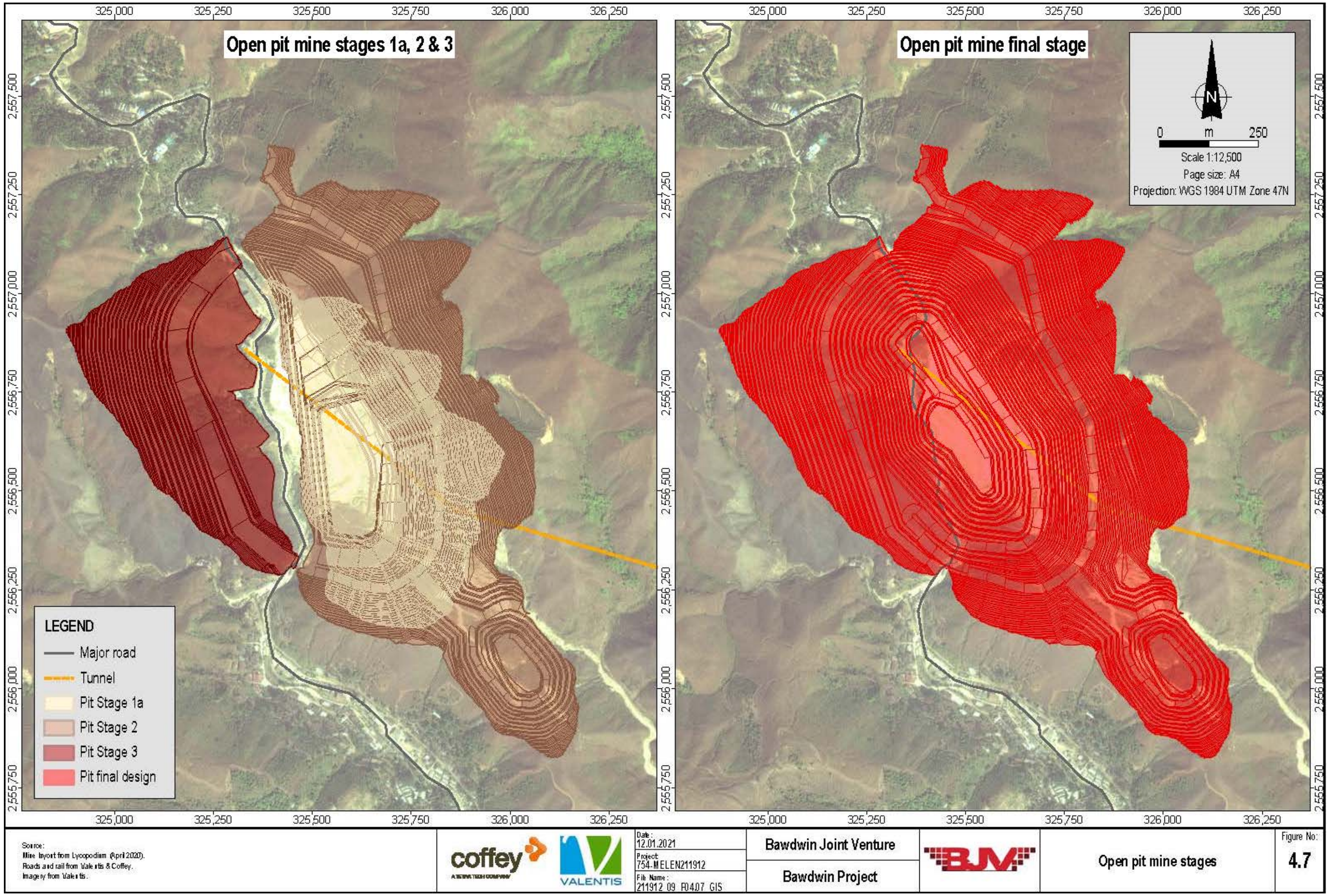


Figure 4.7 Open pit mine stages

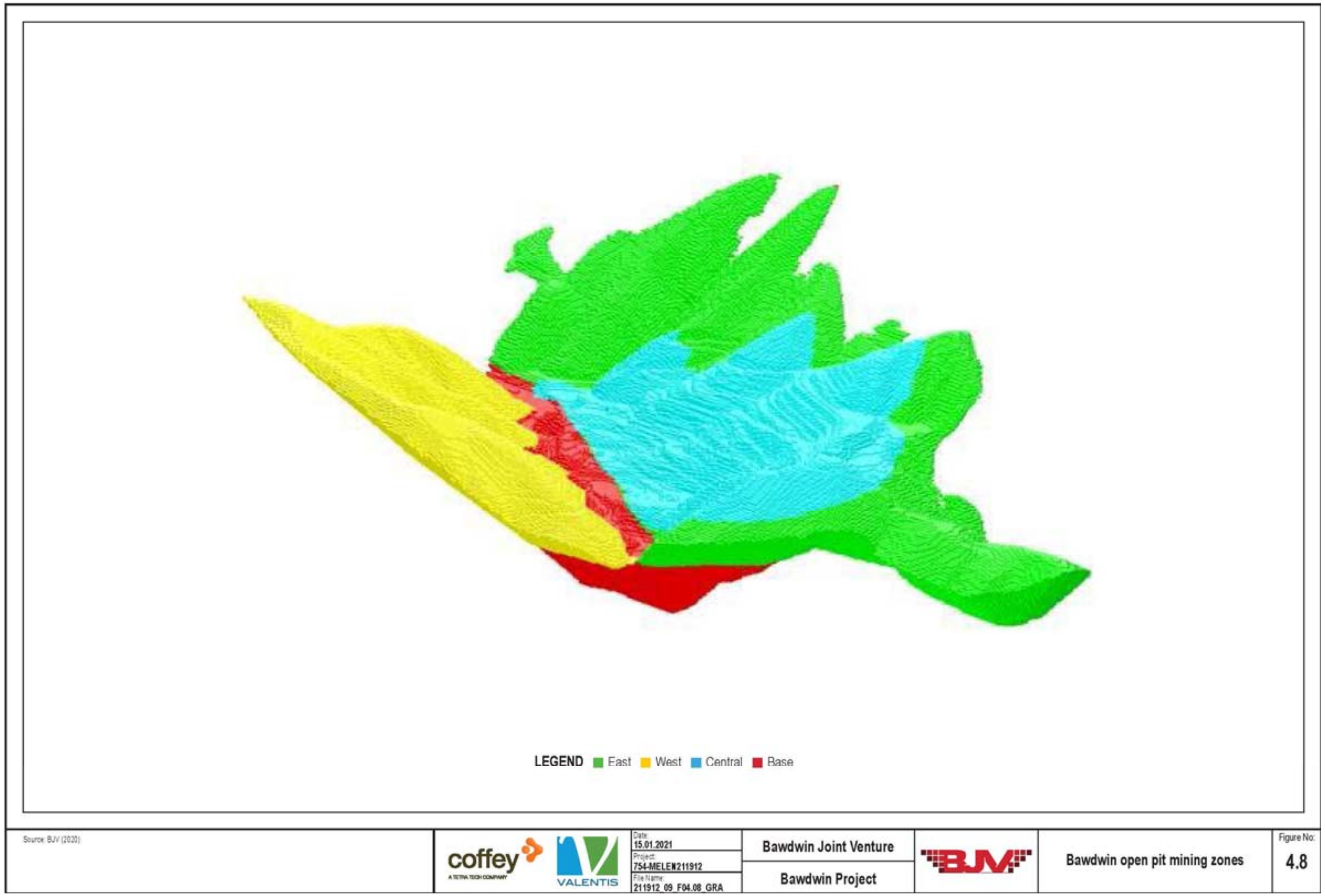


Figure 4.8 Bawdwin open pit mining zones

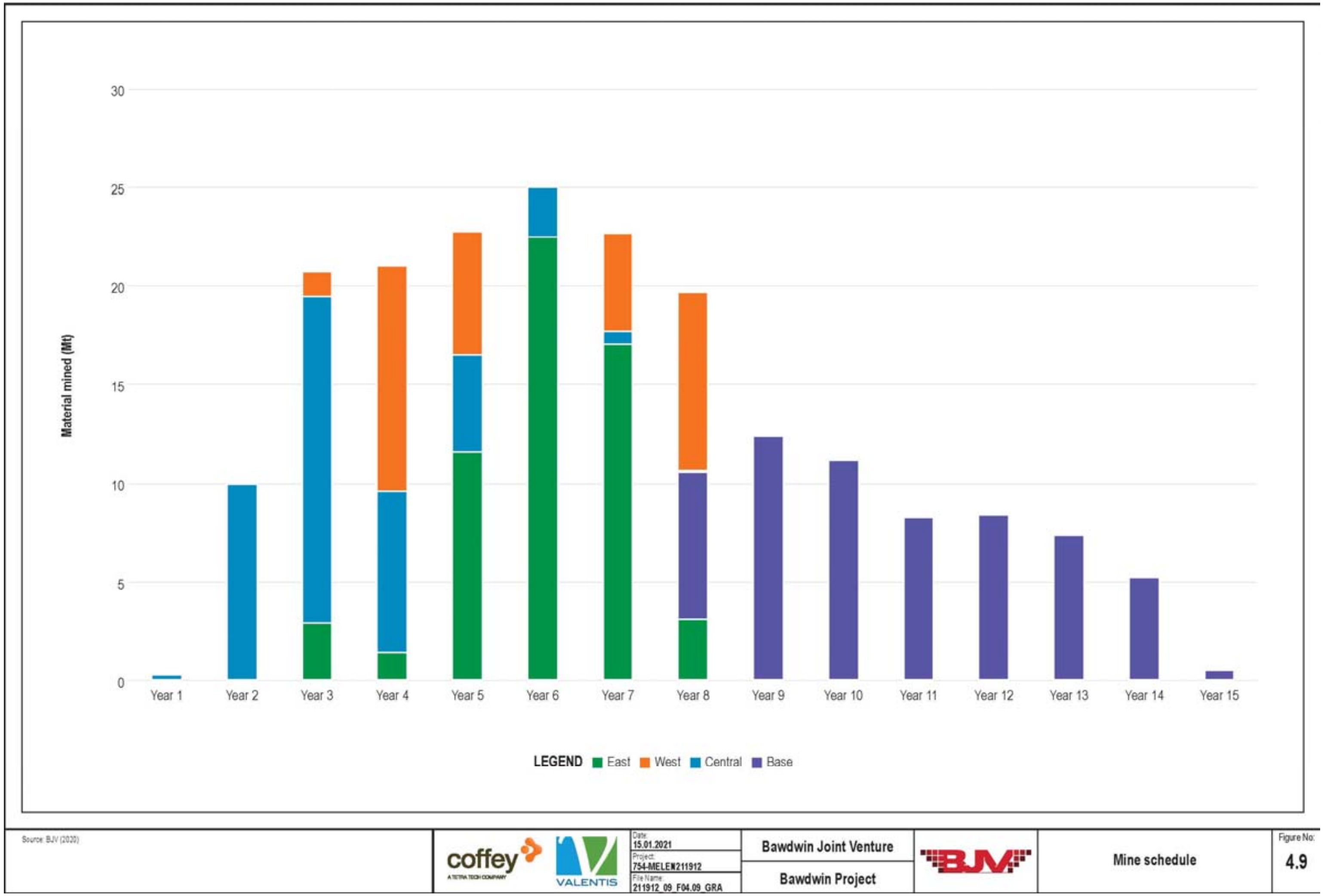


Figure 4.9 Mine schedule

Table 4.5 Recommended geotechnical designs for open pit lithologies

Lithology	Weathered				Fresh			
	Batter Face Angle (°)	Berm Width (m)	Bench Height (m)	Inter Ramp Angle (°)	Batter Face Angle (°)	Berm Width (m)	Bench Height (m)	Inter Ramp Angle (°)
Massive Tuff	55	3.0	5.0	37.6	70	9.0	15.0	46.1
Sandstone	65	4.0	5.0	38.3	75	9.5	15.0	48.0
Porphyry	50	2.5	5.0	36.8	75	9.5	15.0	48.0
Alteration	50	2.5	5.0	36.8	50	2.5	5.0	36.8

Source: Bawdwin Project Definitive Feasibility Study Report (WMM, 2020)

Three-dimensional finite-element modelling was used to analyse overall slope stability, based on DFS pit design. The overall pit stability analysis indicated the pit design exceeds the acceptance criterion of a FoS of 1.3.

4.5.1 Mining method

Mining will use conventional open pit drill and blast methods with ore being transported via haul trucks to the run-of-mine (ROM) pad located at the process plant and tipped onto finger stockpiles by ore type and grade. The ROM pad area will hold at least 300,000 tonnes of ore. A front-end loader will feed a blend of ore into the primary crusher, ore will be blended to allow the process plant to maximize metallurgical recovery while meeting metal production targets.

The mining strategy will be to undertake a series of cutbacks in the walls to the existing open cut to create flat working benches that will allow for geological mapping, infill, grade control and blast hole drilling.

The generation of dust from roads, waste rock dump and working faces of the open pit will be minimised by using water sprayed by watercarts.

Old mine workings present a mining hazard. The old mine workings include square set stopes with timber and backfill, unfilled stopes, drives and crosscuts. Records of underground workings will provide guidance on the location of workings and any voids. If necessary, ground penetrating radar or probe drilling could be used to locate voids, in order to mitigate the risk to plant and personnel associated with voids on the pit floor. Procedures will be developed to manage these risks.

4.5.2 Blast design and procedure

It has been assumed that all material (excluding underground fill) will require blasting since the likelihood of significant quantities of free digging material is low.

Blasting will occur at a maximum rate of one blast per day at a time as agreed by the local community and WMM management. The blast time will either be during the production mining lunch hour or at shift change to minimize blasting disruption to production schedule. Blast boards communicating blasting dates and times will be on display at several locations including:

- All access points to the project area.
- Accessible areas within the surrounding villages.
- Pre-shift meeting areas.

Blasting will only be completed by experienced and competent shotfirers and will be conducted to ensure compliance with the Myanmar guidelines (Myanmar EIA Guidelines) of:

- A maximum level for air blasting of 115 dB Linear. The level of 115 dB Linear may be exceeded on up to 5% of the total number of blasts over a period of 12 months; however, the level should not exceed 120 dB Linear at any time.
- Blasting is only permitted during daylight hours.
- A maximum level for ground vibration of 5 mm/s (peak particle velocity ppv). The ppv level of 5 mm/s may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The level should not exceed 10 mm/s at any time.

Blastholes will be drilled with 115 mm diameters on 5 m bench heights in selective mining zones and 152 mm diameter on 10 m bench heights in bulk waste zones. Bulk explosives pumped directly into the blast holes will be initiated using non-electronic blasting accessories. The blasted material will then be excavated from the pit.

Blast pattern design will be varied to suit the rock material type, proximity to sensitive receptors, and area in order to optimise ore extraction, provide suitable fragmentation for excavation and crusher efficiency, produce good floor conditions and safeguard pit wall stability. Blast holes will be sampled and assayed to quantify ore grades and confirm interpreted ore boundaries.

Prior to blasting, a nominal radius of 500 metres from the blast will used to determine the blast exclusion zone. The operational blast radius will be monitored and adapted as blasting practices, procedures, and monitoring are optimised. All access roads into this area will be blocked by WMM personnel, in concert with assistance from the mining contractor, and have appropriate signage and delineation. A clearance team will conduct an inspection of the blast radius, sounding a pre-blast siren, warning surrounding personnel of the upcoming blast.

Once the shotfirer is satisfied that all access points have been blocked and the clearance run is completed, confirming there are no personnel within the blast radius and that it is safe to do so, the blast will commence. Post blast, the shotfirer will inspect the blast prior to opening access to the blast area. In the event of a misfire, the shotfirer will take appropriate action, which may involve a 30-minute waiting period followed by an attempt to re-fire the blast. Once the shotfirer is satisfied the blast is complete and there is no residual explosive to manage, they will reopen access to the active mining area.

4.5.3 Mining equipment

The primary mining equipment to be used for the project is presented in Table 4.6.

Table 4.6 Primary mining equipment

Equipment item	Equipment Specification	Average Number
Excavator	CAT 395	13
Excavator	CAT 349 D	1
Excavator	CAT 336	12
Excavator	SANY 335	2
Wheel Loader	Liugong 856 H	3
Wheel Loader	Liugong 870 H	1
Vibrating Roller	Liugong 6120 E	1
Dozer	CAT D7 G	1
Dozer	CAT D6 R	1
Dozer	CAT D9 GC	2
Dump Truck	SENTA	19

Dump Truck	Volvo FMX 400	5
Tipper	-	3
Grader	KOMATSU GD 633A	1
Water Bowser	_	3
Dump Truck	China 6 X 4	100
Drilling Machine	Sandvik D 50 KS Ø 251 mm	1
Crawler Drill	FURUKAWA Ø 76 mm	2
Drilling Machine	10 Me	4
Fork Wft	-	2

The proposed excavator fleet is based on the use of 100 t class excavators for the selective mining of ore zones and to undertake pioneering and mining works in the steeper terrain areas, while larger 200 t class excavators will be used in the bulk, primarily waste, mining zones. The 100 t and 200 t class excavators will generally be teamed with 55 t capacity articulated dump trucks and 90 t class rigid dump trucks respectively, though the 100 t class excavator has the flexibility to practically load either truck type. Both truck types are successfully used for efficient haulage in a range of operating and climatic conditions, similar to those at Bawdwin, on a large number of mining projects around the world.

The front-end loader's primary activity is to rehandle ore into the primary crusher from the ROM ore stockpiles built by the mining fleet adjacent to the crusher feed hopper. Under normal operation, one front end loader will deliver the required ore feed rate and a second equivalent loader on site will act as a backup unit. This will ensure that ore feed to the crusher can continue at all times irrespective of servicing and maintenance activities on either of the front-end loaders.

The track dozers, graders, watercarts and roller will support the primary equipment conducting activities such as waste rock dump management, stockpile management, constructing and maintaining haul roads and other running surfaces, dust suppression, preparing blasthole drill areas, clearing vegetation and other pioneering works to establish pit working areas.

The excavator mounted rock breaker will be used to reduce any oversize ore material prior to it being rehandled to the primary crusher. It may be fitted with a quick hitch arrangement to allow the fitting of a small bucket to assist with drainage works and other minor works.

Other auxiliary equipment and infrastructure for mining is shown in Table 4.7.

Table 4.7 Auxiliary mining equipment and infrastructure

Equipment item	Equipment specification	Number
Dewatering pump	HH220	2
Service / fuel truck	8 x 4	2
Telehandler / IT / crane	Various	4
Crane	40 t	1
Tyre handler	Cat IT38	1
Light vehicle / bus	Toyota	25
Mobile lighting plant	Allight	22
Explosives DTH delivery truck		1 - 2
Mining infrastructure		**Quantity**
Office block		1
Workshop		1
Toilet / ablution block		1
Meal room		1

Equipment item	Equipment specification	Number
Warehouse / store		1
Fuel storage and dispensing		1
Equipment washdown		1
Tyre change facility		1
Explosives magazine		1

The estimated, annual diesel consumption rates based on the full period of the open pit mine life are provided in Table 4.8.

Table 4.8 Annual diesel consumption of mining equipment

Activity	Annual diesel consumption (L)
Drill and blast	540,116
Load and haul fleet	8,985,491
Ancillary plant	1,474,183
Front and Loader ROM crusher feed	411,068
Dewatering	119,285
Secondary breakage	26,578
Other	305,956
Total	11,862,677

4.5.4 Pit ramp and haul roads

The pit ramp has been designed as a dual lane ramp. The haul roads have been designed to accommodate the widest dump truck proposed, which will be a 90-tonne rigid truck, but 55 tonne articulated dump trucks will also be used. The haul roads will be dual lane with a width of 25 metres. Wherever possible switch back turns are flattened and have a turning radius of 6 metres. Main haul road gradients are designed at 1:10 but interim ramps within the pit may have steeper gradients as room permits. A typical cross section of a haul road is shown in

Figure 4.10.

All haul roads within the mine operation will be unsealed. The roads will be constructed using the best available waste rock for the road base and the pavement layer.

4.5.5 Mining infrastructure

Mining Services Area

The mining services area will be constructed to the south of the ROM pad on an area roughly 4.2 hectares (10.5 acres) in size. The area will accommodate the following facilities:

- Warehouse laydown area.
- Warehouse.
- Office complex.
- Light vehicle parking.
- Crib room.
- Training room.
- Ablution facility.
- Fuel facility.

Unsealed pavements are proposed for the light vehicle parking, access roads and the warehouse laydown.

Emulsion facility and explosives magazine

The emulsion and explosives magazine facility will be located north of the proposed pit. The location has been selected to ensure that an adequate separation distance is maintained between the magazine and other infrastructure and workplaces, so that they would not be directly affected in the unlikely event of an unplanned explosion at the magazine.

The emulsion and magazine facility is designed to store up to 10,000 kg of explosives. An earthworks pad 54 m x 38 m will be constructed at the emulsion facility and a 32 m x 37 m pad at the magazine. The emulsion facility will have a separation distance of 50 m from the magazine.

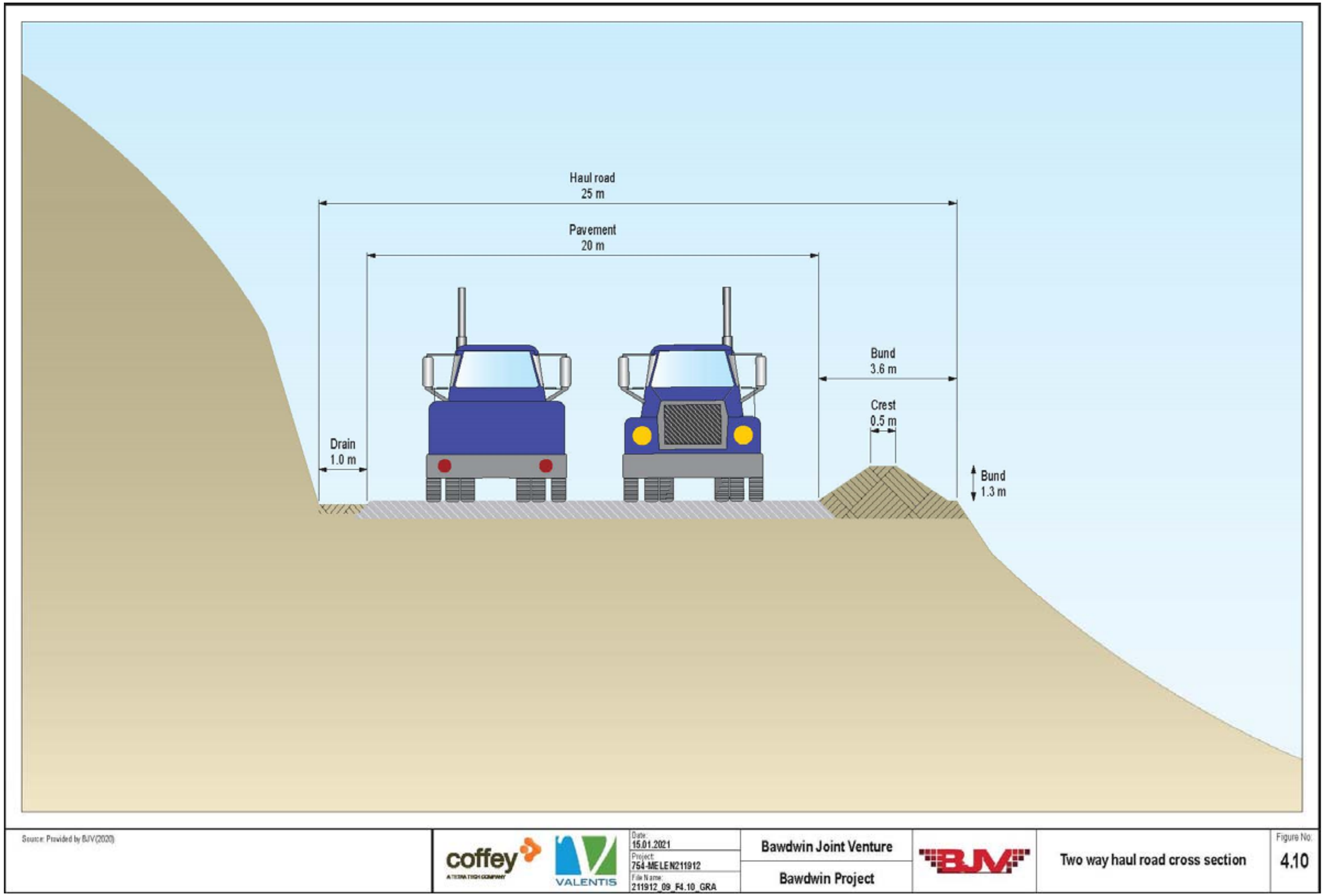


Figure 4.10 Two-way haul road cross-section

ROM pad

The ROM pad will be 200 m x 200 m with suitable elevation to accommodate the process crusher and feed bin. The haul road connects to the ROM pad from the east. The ROM pad may be extended to the south during operations.

Mine dewatering

Mine dewatering equipment will be required during mining of the open pit. Pit dewatering requirements will vary based on the different stages of the operation. Water that accumulates in the pit will be removed using in pit-sumps and mobile pump sets coupled with maintaining appropriate bench drainage measures.

Two primary pump sets will be required comprised of Sykes HH160 and HH220 or similar pumps. These will discharge water into settling ponds for subsequent use of the water for dust suppression purposes or disposal to the Nam Pangyun.

4.6 Ore processing

Ore will be processed to produce mineral concentrates, with the residual material (tailings) disposed onsite in tailings storage facilities (TSFs).

A process plant will be constructed approximately 1,300 m north of the edge of the open pit and approximately 600 m from coarse ore stockpile. The process plant is in an L-shaped configuration to reflect the topography of the area (

Figure 4.11). The general arrangement of the process plant as a three-dimensional view in the surrounding landscape is shown in

Figure 4.12. The primary crusher is located at the northern face of the ROM pad on a hilltop 100 m west of the coarse ore stockpile and connected to the plant by conveyor and crushing plant access road off the main entrance road inside the security fence. The crushing plant is elevated above the main process plant. The ROM pad is immediately south of the process plant.

Processing of ore will involve crushing and grinding and classification followed by separate lead-silver and zinc flotation circuits. Reagents will be required in the grinding circuit (lime, sodium metabisulphite) and also for the lead-silver flotation circuit (lime, sodium cyanide, zinc sulphate and sodium ethyl xanthate) and the zinc flotation circuit (lime, copper sulphate and sodium isobutyl xanthate).

Concentrates will be thickened, filtered and stockpiled for loading into concentrate containers. The concentrate containers will be transported via road to Lashio and then onwards for export to international markets. At the Myanmar border export duty and export license fees will be paid.

The nameplate capacity of the process plant is based on 3 Mtpa of ore feed at 5.44% Pb, 2.62% Zn, 108 g/t Ag and a plant availability of 91.3%. This gives a nominal throughput rate of 375 t/h.

Design concentrate production based on this mass balance is presented in Table 4.9.

Table 4.9 Average concentrate production

Concentrate	Production (dry tpa)	Mass Recovery to Concentrate (%)	Grade		
			Pb %	Zn %	Ag (g/t)
Lead-Silver	~138,000	7.2	53	~4	991
Zinc	~85,000	4.4	~6	42	246

Ore throughput and corresponding concentrate production (in dry tonnes) of both lead-silver concentrate and zinc concentrate, and tailings is shown in

Figure 4.13 and Table 4.10.

Table 4.10 Annual ore throughput, concentrate production and tailings production

Year	Ore Throughput (t)	Lead Concentrate (dry t)	Zinc Concentrate (dry t)	Tailings (t)
2023	252,000	16,500	11,300	224,200
2024	264,000	19,000	17,000	228,000
2025	924,000	56,500	32,000	835,500
2026	1,320,000	100,000	67,000	1,153,000
2027	1,320,000	100,000	67,000	1,153,000
2028	1,320,000	100,000	67,000	1,153,000
2029	1,320,000	100,000	67,000	1,153,000
2030	1,320,000	100,000	67,000	1,153,000
2031	2,244,000	157,500	97,774	1,988,726
2032	2,640,000	185,300	115,000	2,339,700
2033	2,640,000	185,300	115,000	2,339,700
2034	2,640,000	185,300	115,000	2,339,700
2035	2,640,000	185,300	115,000	2,339,700
2036	2,640,000	185,300	115,000	2,339,700
2037	2,640,000	185,300	115,000	2,339,700
2038	2,640,000	185,300	115,000	2,339,700
2039	2,640,000	185,300	115,000	2,339,700
2040	2,640,000	185,300	115,000	2,339,700
2041	2,640,000	185,300	115,000	2,339,700
2042	2,640,000	185,300	115,000	2,339,700
2043	2,640,000	185,300	115,000	2,339,700
2044	2,640,000	185,300	115,000	2,339,700
2045	2,640,000	185,300	115,000	2,339,700
2046	2,640,000	185,300	115,000	2,339,700
2047	2,640,000	185,300	115,000	2,339,700
2048	2,640,000	185,300	115,000	2,339,700
2049	1,000,000	84,500	46,200	869,300
2050	1,000,000	84,500	46,200	869,300
2051	1,000,000	84,500	46,200	869,300
2052	1,000,000	84,500	46,200	869,300
2053	1,000,000	84,500	46,200	869,300
2054	1,000,000	84,500	46,200	869,300
Total	61,164,000	4,406,600	2,725,274	54,032,126

The following section provides a description of the mineral concentration process.

4.6.1 Primary crushing

Ore will be delivered to the ROM bin (200 t capacity) by front end loader. Ore will then be drawn from the bin at a controlled rate by an apron feeder and onto a vibrating grizzly to screen the oversize rocks for discharge into a jaw crusher. The fine rocks bypass the jaw crusher. The crushed product and grizzly undersize material will discharge onto the primary crusher sacrificial conveyor. A self-cleaning belt magnet will be located at the end of this conveyor to remove any tramp metal.

The crushed ore will then discharge onto the stockpile feed conveyor, equipped with a weightometer, for transport to the stockpile.

The primary crushing circuit will be controlled locally, with the front end loader operator ensuring that feed is maintained to the circuit and will communicate with the operator using a two-way radio. The circuit will be independently and sequentially interlocked for shutdown so, in the event of a single component failure, all components will be safely shut down automatically.

A flowsheet of the indicative primary crushing circuit is shown in

Figure 4.14.

4.6.2 Grinding and classification

The primary grinding circuit will consist of a semi-autogenous grinding (SAG) mill and a closed-circuit ball mill, housed in a composite concrete and steel structure with four main levels.

Crushed ore will be fed directly into the SAG mill at a controlled rate via the SAG mill feed conveyor. Process water, sodium metabisulfite and lime slurry will be added to the SAG mill feed chute to achieve the required milling density. Slurry will discharge from the SAG mill through the SAG mill trommel and gravitate to the cyclone feed hopper. The slurry will be further diluted with process water prior to being pumped to the primary cyclone cluster by the cyclone feed pumps.

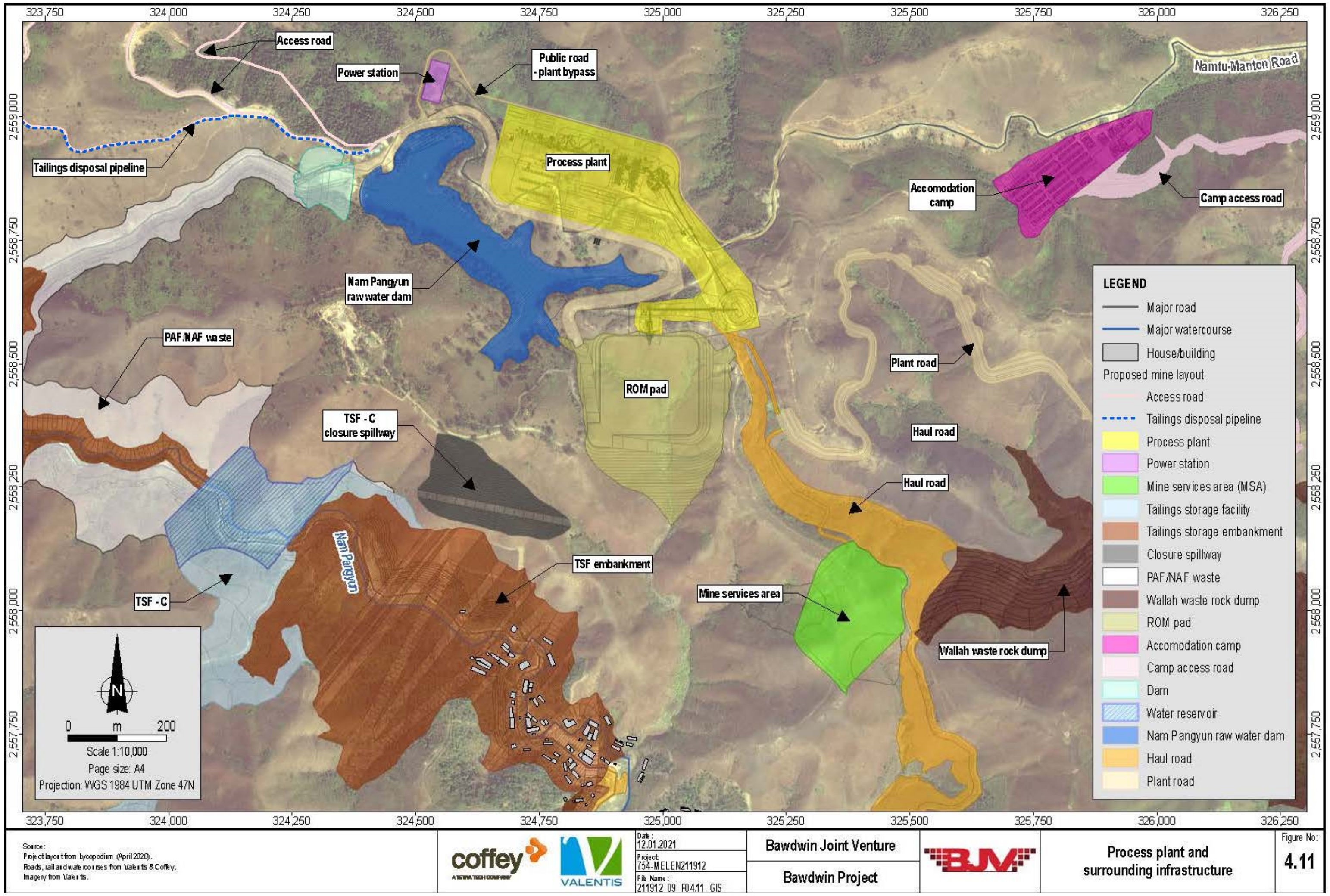


Figure 4.11 Process plant and surrounding infrastructure

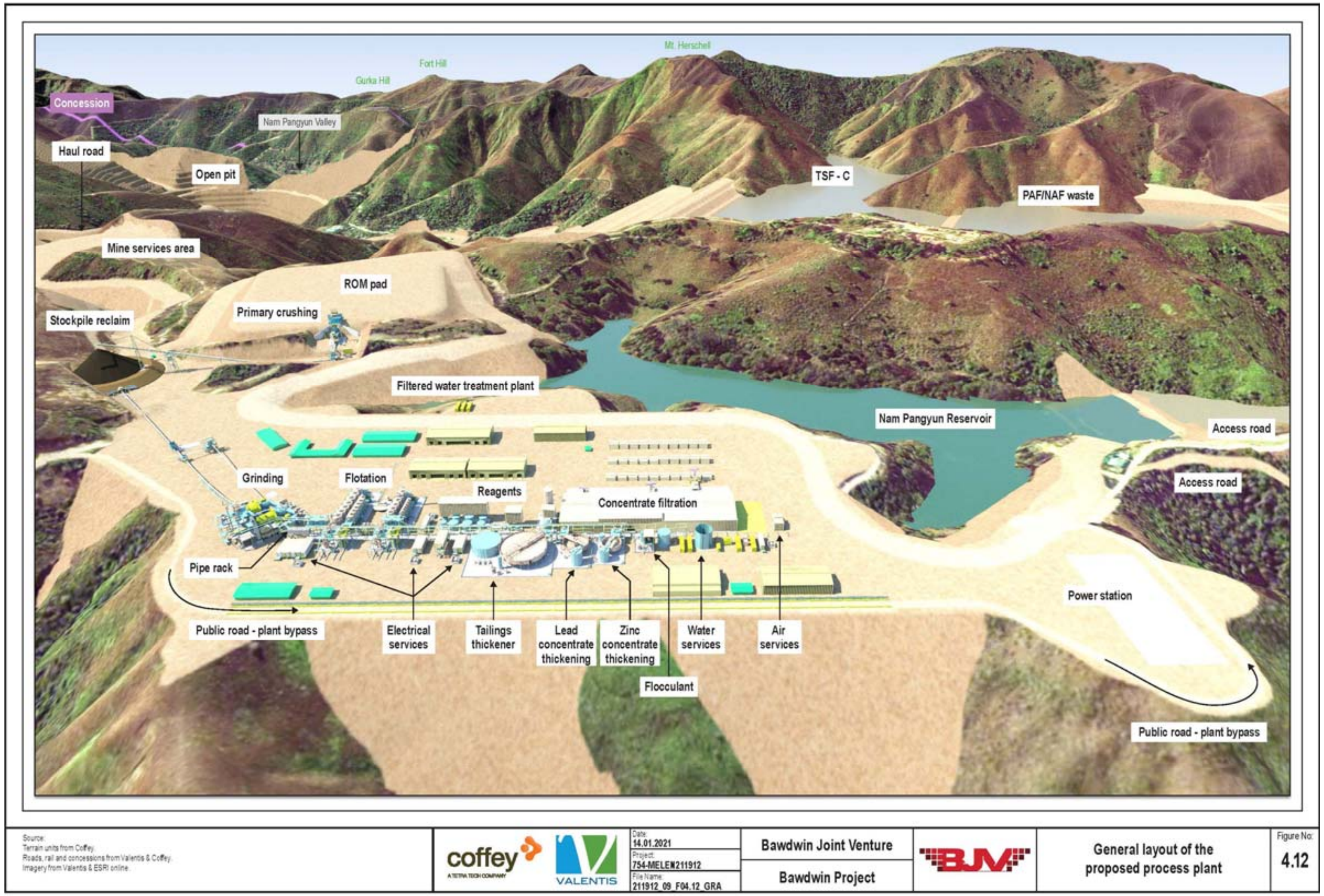


Figure 4.12 General layout of the proposed process plant

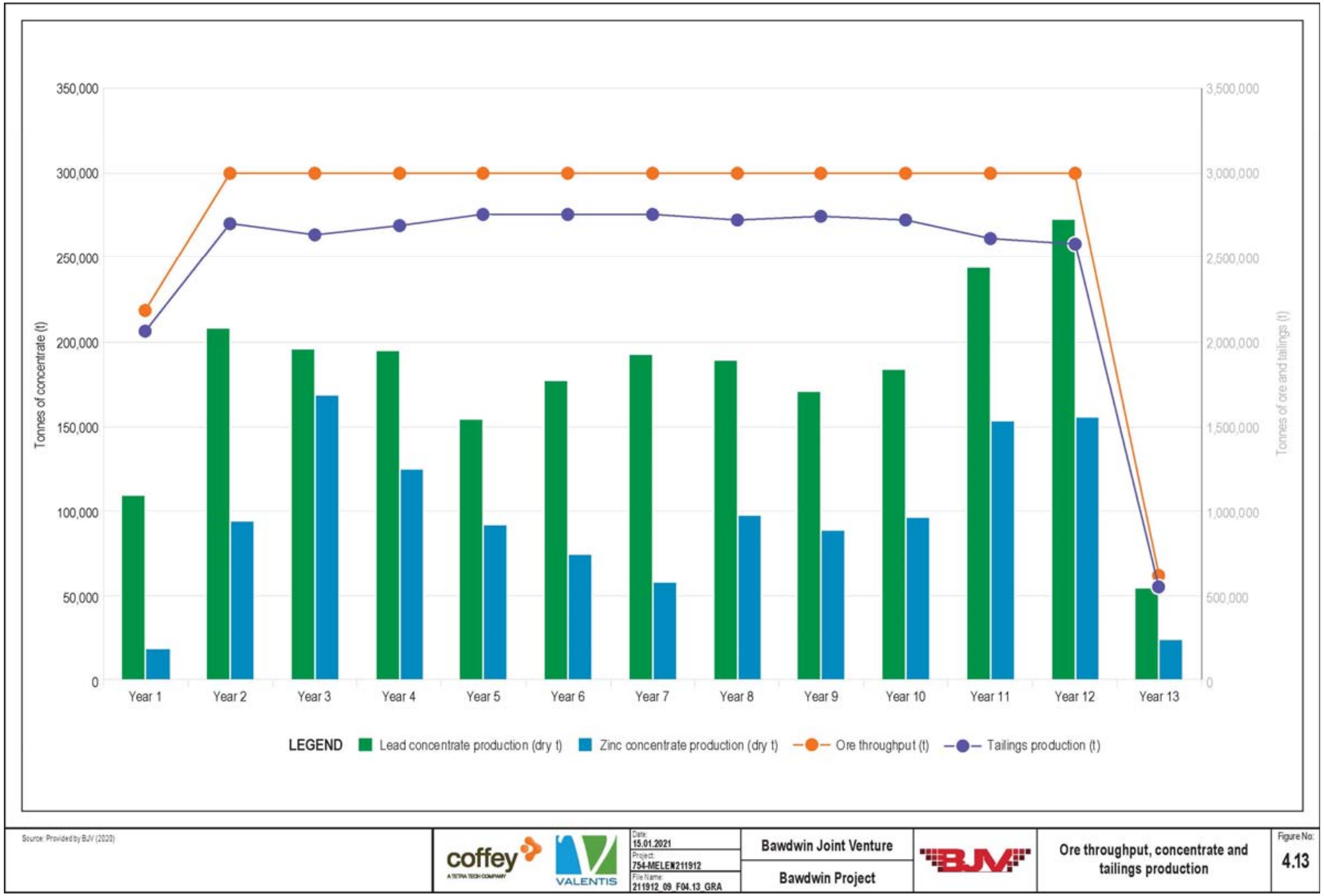


Figure 4.13 Ore throughput, concentrate and tailings production

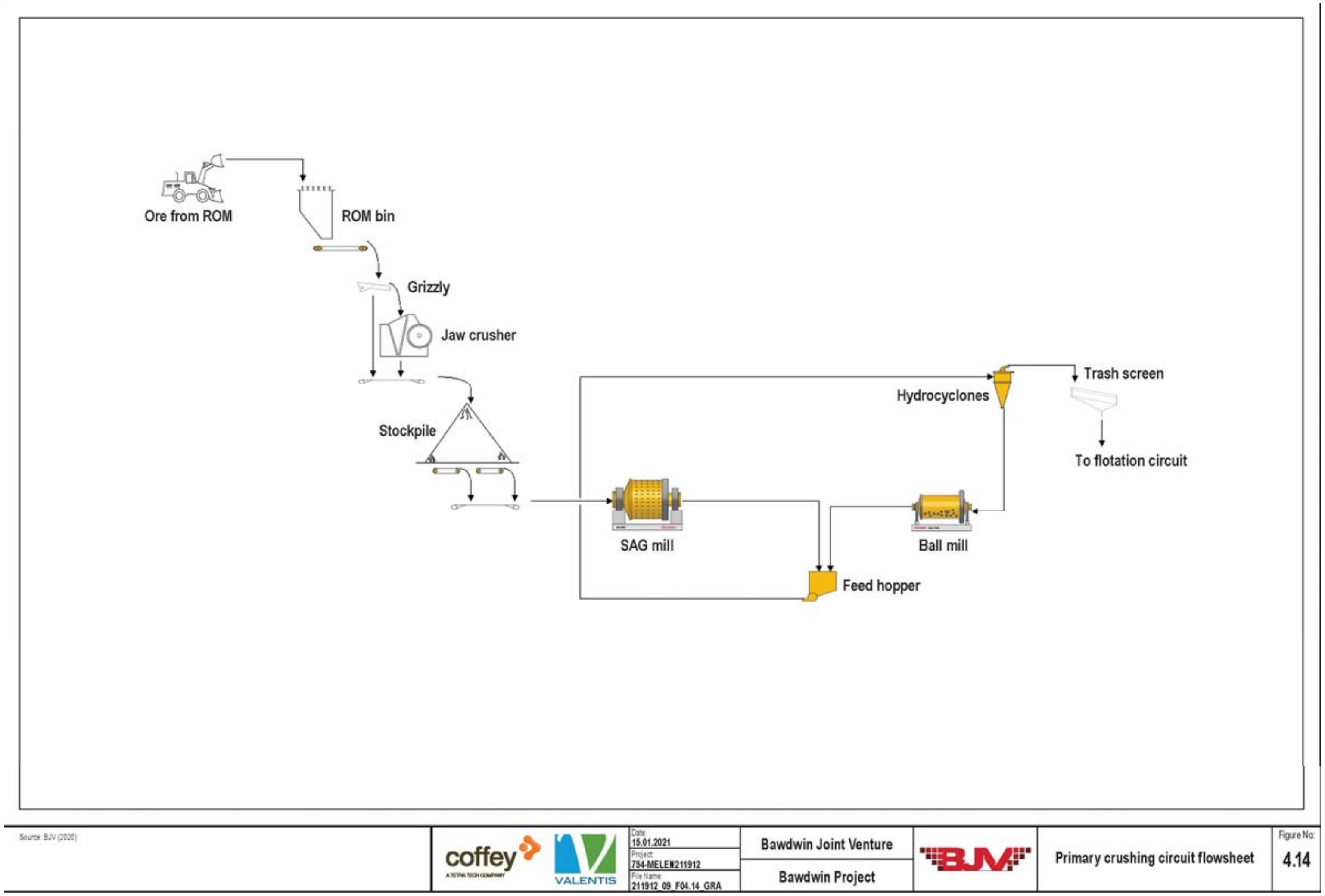


Figure 4.14 Primary crushing circuit flowsheet

The primary cyclones will separate the slurry into fine and coarse fractions. The coarse cyclone underflow stream will be recycled back to the ball mill for further grinding, with provision for a portion to be recycled to the SAG mill as well if required. Process water will be able to be added to the ball mill if needed to achieve the desired milling density. Slurry will discharge from the ball mill into the cyclone feed hopper via the ball mill trommel.

The cyclone overflow product, with a nominal pulp density of 34% solids w/w, will report to the trash screen via gravity. A cyclone overflow sampler and particle size analyser will provide real-time sizing data to assist with control of the milling circuit.

Pebbles, exiting as the SAG mill trommel oversize, will gravitate to the first of two pebble return conveyor in series, one of them fitted with a weightometer. A belt magnet will be provided to remove any tramp metal from the circuit. Pebbles will be discharged directly onto the SAG mill feed conveyor.

4.6.3 Lead-silver flotation and regrind

The lead-silver flotation circuit will consist of two 30 m^3 agitated rougher conditioner tanks followed by seven 70 m^3 tank type flotation cells in series. A flowsheet of the lead-silver flotation circuit and regrind is shown in Figure 4.15.

Cyclone overflow will gravitate to the trash screen, located on top of the conditioning tanks. Slurry will flow into the lead-silver rougher conditioner tanks, while trash will report to the trash bunker.

Reagents such as lime, sodium cyanide, sodium ethyl xanthate collector, aero 404 promoter and zinc sulphate will be added to the rougher conditioner tank, along with process water for dilution to the required slurry density, if required. Frother will be added to the feed box of the rougher flotation cells. Low pressure air will be supplied to each flotation cell.

Lead-silver rougher concentrate from the seven cells report to the lead-silver concentrate hopper and pumps, which transfer the slurry to the lead-silver regrind circuit. Lead-silver rougher concentrate will then report to the lead-silver regrind cyclone feed hopper with process water added to achieve the desired cyclone feed density. Reagents including lime slurry, sodium metabisulfite and zinc sulphate will be added as required. Lead-silver regrind cyclone overflow will gravitate to the lead-silver cleaner conditioner tank. Cyclone feed slurry will be pumped to the lead-silver regrind cyclone cluster by the lead-silver regrind cyclone feed pumps, which will operate in a standby mode. A sump pump will be provided to direct spillage to the lead-silver rougher conditioner tanks.

Lead-silver regrind cyclone underflow, diluted with process water to achieve the required milling density, will gravitate to the lead-silver regrind mill. Slurry will discharge from the lead-silver regrind mill and be returned to the lead-silver regrind cyclone feed hopper. Another sump pump will be installed adjacent to the mill to return spillage to the lead-silver regrind cyclone feed hopper.

Lead-silver regrind cyclone overflow will report to the agitated lead-silver cleaner conditioner tank. Flotation reagents such as lime, zinc sulphate and sodium ethyl xanthate will be added to the conditioner tank. Slurry will gravitate from the conditioner tank to the first of six, 30 m^3 lead-silver cleaner flotation cells.

Lead-silver final concentrate will be pumped to the lead-silver final concentrate on stream analyser and metallurgical sampler and then gravitate into the lead-silver concentrate thickener using the lead-silver final concentrate pumps, which will be installed on a standby arrangement.

Tailings from the lead-silver cleaner will gravitate to the lead-silver flotation tailings hopper, where it will be combined with the lead-silver scavenger tailings. The combined streams will be pumped to the zinc conditioner tanks by the duty / standby lead-silver flotation tailings pumps.

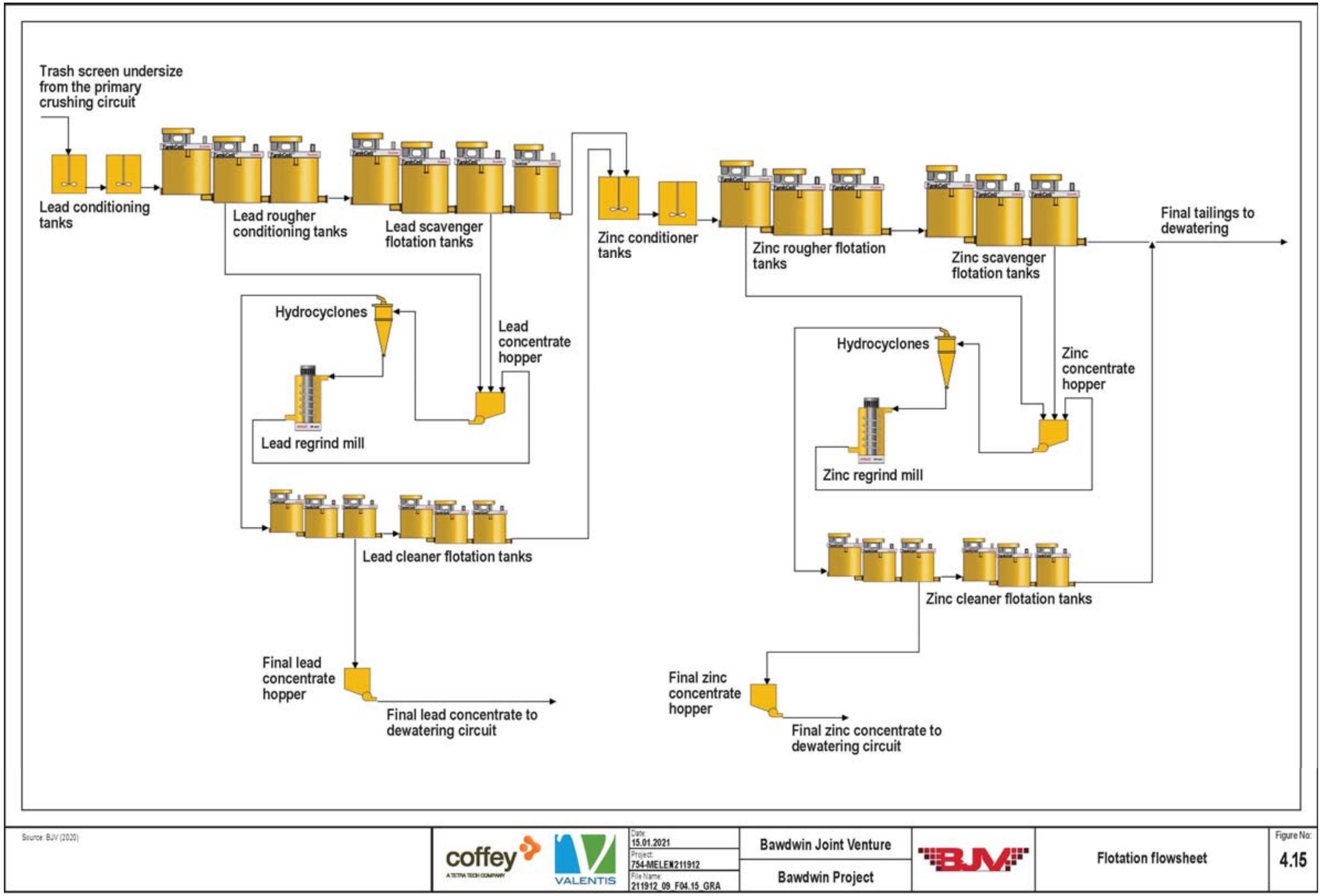


Figure 4.15 Flotation flowsheet

4.6.4 Zinc flotation and regrind

The zinc flotation circuit will consist of two agitated conditioner tanks in series, followed by six, 50 m^3 tank style flotation cells in series. A flowsheet of the zinc flotation circuit and regrind is shown in Figure 4.15.

Lead-silver tailings will be pumped to a zinc rougher conditioner tank (No.1) where copper sulphate activator will be added, with the tank overflowing to a second zinc rougher conditioner tank (No. 2) where sodium isobutyl xanthate and lime will be added if required. Conditioned slurry will flow to the zinc rougher and scavenger five flotation cells in series.

Zinc rougher concentrate will report to the zinc rougher concentrate hopper and pumps that will forward this stream to the zinc regrind circuit. A sump pump will be provided to return slurry to the zinc conditioner tanks.

Zinc rougher concentrate will report to the zinc regrind cyclone feed hopper. Water will be added to the hopper to achieve the desired cyclone feed density. Zinc regrind cyclone overflow will gravitate to the zinc cleaner conditioner tank. One stirred media detritor regrind mill with variable speed drive is included in the circuit. Cyclone feed slurry will be pumped to the zinc regrind cyclone clusters by the zinc regrind cyclone feed pumps on standby mode.

Zinc regrind cyclone underflow, diluted with process water to achieve the required milling density, will gravitate to the zinc regrind mill. Slurry will discharge from the zinc regrind mill and be returned to the zinc regrind cyclone feed hopper. A sump pump will be installed adjacent to the mills to return spillage to the zinc regrind cyclone feed hopper.

Zinc regrind cyclone overflow will report to the agitated zinc cleaner conditioner tank. Flotation reagents such as copper sulphate, sodium isobutyl xanthate and lime will be added to the conditioner tank if required. Low pressure air will be supplied to each flotation cell. Slurry will gravitate from the conditioner tank to the first of six, 10 m^3 zinc cleaner flotation cells.

Zinc final concentrate will gravitate into the zinc concentrate thickener using the zinc final concentrate pumps, which will be installed in a duty / standby arrangement. An on-stream analysis system will be installed to provide real-time assays for process control purposes for both the lead and zinc flotation streams.

Tailings from the zinc cleaner will gravitate to the flotation tailings hopper where it will be combined with the zinc scavenger tailings, and a number of other sump pump waste streams, before being pumped to the tailings thickener by the duty / standby flotation tailings pumps.

4.6.5 Concentrate dewatering

The concentrate thickeners will be located adjacent the tailings thickener, directly opposite the concentrate storage area. The lead-silver concentrate and zinc concentrate areas are separately bunded with their own dedicated sump pumps. The lead-silver and zinc concentrate bund capacities will match the thickener tank volume so that uncontrolled discharge from the thickener will be fully contained to ensure no potential for environmental release.

The proposed concentrate dewatering process is shown on the flowsheet

Figure 4.16 and is described in more detail in this section.

Final lead-silver concentrate will be pumped to the lead-silver concentrate thickener with flocculant added. Thickener overflow water will gravitate to the lead-silver concentrate thickener overflow water tank. From there it will be pumped to the process water tank. Thickener underflow will be pumped to the agitated lead-silver concentrate filter feed tank. Lead-silver concentrate will be pumped to the lead-silver concentrate filter by the lead-silver filter feed pumps. A sump pump will be provided to return spillage to the lead concentrate thickener.

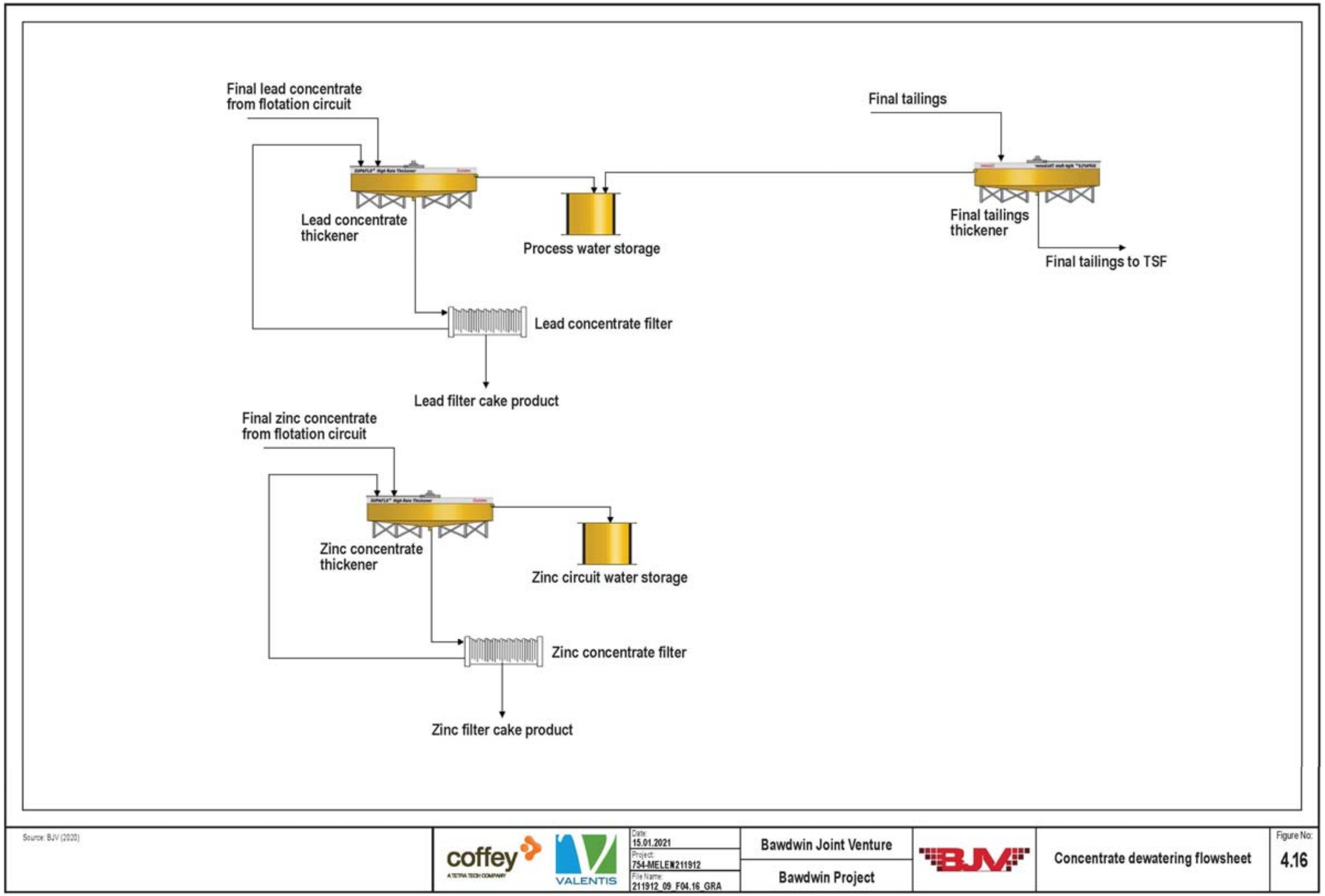


Figure 4.16 Concentrate dewatering flowsheet

Lead-silver concentrate will be pumped in batches to the lead-silver concentrate filter. The filter will remove water from the concentrate to meet the target moisture of 7.5% w/w using a series of pressing and air blowing steps. After the required filtration time, the filter press will open and discharge lead-silver concentrate directly onto the floor of the concentrate shed. Filter cloths will be washed intermittently (every 8 to 10 cycles) using raw water from the lead-silver cloth wash tank. Filtrate from the lead-silver concentrate filter will be returned to the lead-silver concentrate thickener using the lead-silver filtrate pumps.

Zinc final concentrate will report to the zinc concentrate thickener, with flocculant added. Thickener overflow will gravitate to the zinc water tank. Thickener underflow will be pumped to the agitated zinc concentrate filter feed tank. Zinc concentrate will be pumped to the zinc concentrate filter by the zinc filter feed pumps. A sump pump will be provided to return spillage to the zinc concentrate thickener.

Zinc concentrate will be pumped in batches to the zinc concentrate filter. The filter will remove water from the concentrate to meet the target moisture of 8% w/w using a series of pressing and air blowing steps. After the required filtration time, the filter press will open and discharge zinc concentrate directly onto the floor of the concentrate shed. Filter cloths will be washed intermittently using raw water from the zinc cloth wash tank. Filtrate from the zinc concentrate filter will be returned to the zinc concentrate thickener using the zinc filtrate pumps.

The covered concentrate filter building will be serviced by the concentrate filter building maintenance crane.

4.6.6 Concentrate storage and transport

A front-end loader will be used to remove the lead-silver and zinc concentrates from beneath their respective filter presses and transfer them to the adjacent covered concentrate storage area. Approximately 9,000 tonnes of lead-silver concentrate and 4,500 tonnes of zinc concentrate will be able to be stored, which is equivalent to fourteen- and nineteen-days production for lead-silver and zinc respectively at nominal production rate. Concentrates will be loaded into covered 20 ft half height containers by the front-end loaders. The type of container proposed to be used by the project is shown in Plate 4.1.

Dedicated automated samplers, will sample each container, and then the container will be sealed. The containers are of a solid steel or alloy construction and incorporate a sealed top hatch for filling and sealed end door for tipping out. Containers remain sealed until emptying at the smelter. After emptying at the smelter, the containers are washed to meet Myanmar quarantine regulations and sealed for the return journey to Bawdwin.

Dedicated loadcells for mass measurement will weigh containers. The containers will then be removed from the shed by a container forklift, and either stored or placed onto trucks for shipment off site.

A wheel wash will be provided to ensure that all vehicle wheels are cleaned prior to leaving the concentrate handling area.

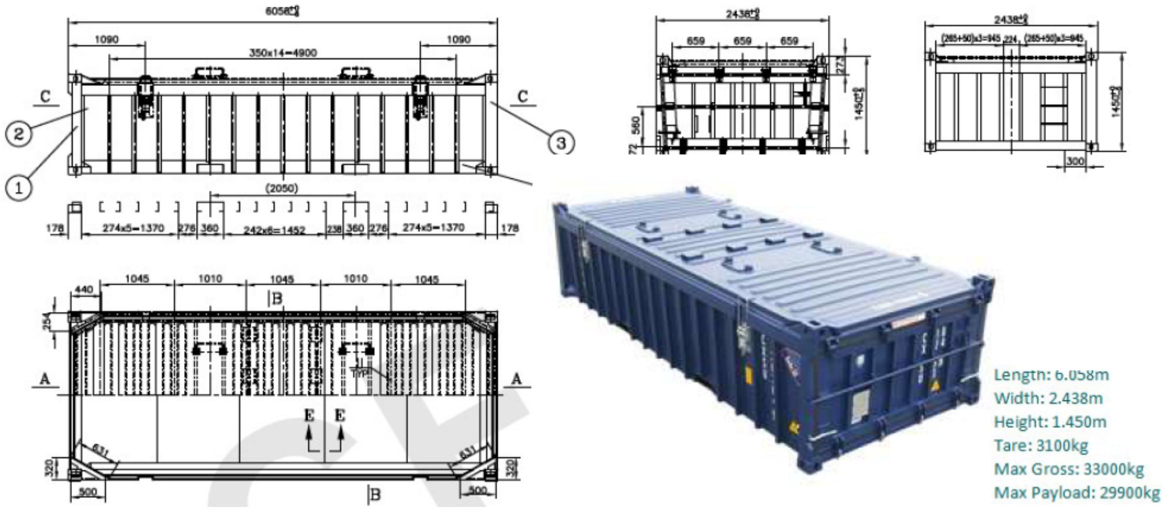


Plate 4.1 Containers proposed to be used for transporting final concentrate products

4.6.7 Processing equipment

A range of specialised mineral processing equipment and machinery is proposed for the project. Table 4.11 describes the major equipment items.

Table 4.11 Major mineral processing equipment

Equipment Name	Description
ROM bin	200 t capacity
Primary crusher	1,300 mm x 1000 mm jaw
Stockpile	6,000 t dry live capacity
SAG mill	Ø 7.90 m x 4.60 m EGL 5,400 kW
Ball mill	Ø 6.40 m x 9.5 m EGL 7,000 kW
Trash screen	2.4 m wide x 4.8 m long
Lead-silver rougher / scavenger cells	7 x 70 m^3 tank cells
Lead-silver cleaner cells	6 x 30 m^3 tank cells
Lead-silver regrind mill	1 x 750 kW stirred media detritor
Zinc rougher / scavenger cells	6 x 50 m^3 tank cells
Zinc cleaner cells	6 x 10 m^3 tank cells
Zinc regrind mills	1 x 355 kW stirred media detritor
Lead-silver concentrate thickener	Ø 14 m high rate
Lead-silver concentrate filter	198 m^2 1,500 mm x 1,500 mm pressure
Zinc concentrate thickener	Ø 11 m high rate
Zinc concentrate filter	144 m^2 1,500 mm x 1,500 mm pressure
Tailings thickener	Ø 23 m high rate

4.6.8 Processing reagents

A range of processing reagents will be used in the mineral concentration process described above. Reagent mixing facilities will be located adjacent the zinc flotation area, and only a short distance from the reagent storage shed for forklift tramming. Proposed processing reagents are described in Table 4.12.

Table 4.12 Proposed processing reagents

Name	Description
Sodium ethyl xanthate	Used to treat the surface of targeted minerals so they become more hydrophobic and can be separated from non-desirable minerals. Sodium ethyl xanthate will be delivered in solid form in bulk bags and stored in the reagent shed.
Promoter (AERO 404)	Promoter will be delivered in intermediate bulk containers (IBC) and stored in the reagent shed until required. A small storage tank will be installed to provide storage capacity local to the flotation area. Multiple diaphragm dosing pumps will deliver the reagent to the required locations within the flotation circuit.
Sodium isobutyl xanthate	Used to treat the surface of targeted minerals so they become more hydrophobic and can be separated from non-desirable minerals. Sodium isobutyl xanthate will be delivered in solid form in bulk bags and stored in the reagent shed. Raw water will be added to the agitated mixing tank.
Frother	Frother is an air bubble enhancer during flotation process. Frother will be delivered in bulk boxes and stored in the reagent shed until required. A small storage tank will be installed to provide storage capacity local to the flotation area. A drum pump will be used to transfer frother from the bulk box into the local storage tank.
Flocculant	Flocculant promotes flocculation and separation by causing colloids and other suspended particles in liquids to aggregate. Powdered flocculant will be delivered to site in 25 kg bags and stored in the reagent shed. A vendor supplied mixing and dosing system will be installed, which will include

Name	Description
	flocculant storage hopper, flocculant blower, flocculant wetting head, flocculant mixing tank, and flocculant transfer pump. Powder flocculant will be loaded into the flocculant storage hopper by hand. Dry flocculant will be pneumatically transferred into the wetting head, where it will be contacted with water.
Hydrated lime	Hydrated lime is used for pH modification and to improve process efficiency. The facility to receive hydrated lime via bulk tanker or in bulk bags will be provided. If bulk tanker deliveries are received, the hydrated lime will be pneumatically conveyed from the tanker to the lime silo. If bulk bags are received, a separate lime transfer hopper, equipped with bag breaker and dust collector, will be used to empty the bags and provide a small storage capacity. The lime transfer blower will be used to transfer hydrated lime to the main storage in the lime silo.
Copper sulphate	Copper sulphate will be delivered in solid form in bulk bags and stored in the reagent shed. Raw water will be added to the agitated copper sulphate mixing tank.
Sodium metabisulphite	Sodium metabisulphite inhibits the flotation of pyrite during processing. It will be delivered in solid form in bulk bags and stored in the reagent shed.
Zinc sulphate	Zinc sulphate will be delivered in solid form in bulk bags and stored in the reagent shed. Raw water will be added to the agitated zinc sulphate mixing tank
Sodium cyanide (NaCN)	Flotation testwork has shown that sodium cyanide is highly effective at depressing zinc and arsenic in the lead flotation stage. The NaCN removes the Cu^{2+} from the surface of the Zn and As bearing minerals, sphalerite and gersdorffite respectively. Sodium cyanide is commonly used in copper-lead-zinc flotation plants and is essential when a portion of the sulphide minerals have oxidized into more soluble varieties, such as with the Bawdwin deposit. Sodium cyanide will be delivered in solid form in bulk bags and stored in the reagent shed.
Grinding media	Grinding media for the SAG and ball mill will be delivered to site in drums or bulk containers. Grinding media will be transferred to the plant using a skid-steer loader and added to the SAG mill feed conveyor via the SAG mill ball hopper. Grinding media will be added to the ball mill using the ball mill kibble and ball mill charging hoist. Ceramic media for the regrind mills will be delivered in bulk bags. Media for the regrind mills will be added to the respective mill using the media charging kibble and hoist.

The volumes of processing reagents and grinding media in the process plant are shown in Table 4.13

Table 4.13 Estimated grinding media and reagent volumes

Item		Unit	Delivery Size	Annual Comsumption
Grinding media				
	SAG mill	t	26	840 t
	Ball mill	t	26	1,720 t
	Lead regrind mill	t	20	73 t
	Zinc regrind mill	t	20	39 t
Reagents				
	Hydrated Lime	t	28	6,726 t
	Sodium metabisulphite	t	24	1,100 t
	Zinc Sulphate	t	27	3,731 t
	Sodium cyanide	t	20	550 t
	Sodium ethyl xanthate	t	17	130 t
	Frother	t	20	328 t
	Promoter (AERO 404)	t	20	14 t
	Flocculant	t	15	19 t
	Copper Sulphate	t	24	971 t
	Sodium isobutyl xanthate	t	17	130 t

4.6.9 Process water services

Raw water for the process plant will be supplied from the Nam La water harvesting facility and the diversion dam (see Figure 1.2). This water will be stored in an enclosed raw water tank at the process plant.

Raw water will be treated in a reverse osmosis (RO) package potable water treatment plant (see

Figure 4.12). The plant potable water tank will be used to store potable water for use in the plant and mining services area for ablutions, safety showers and drinking fountains. Potable water for the camp will be transported from the plant by trucks on regular basis. A sump pump will be provided to transfer brine from the potable water plant to the tailings area via a HDPE pipeline.

Water for use in the lead circuit will be stored in the process water tank. Process water will consist of decant return water, tailings thickener overflow and lead concentrate thickener overflow, with raw water make-up as required. Process water will be distributed to the milling circuit, the lead circuit for process stream dilution, hopper level control and froth breakdown, tailings area and general plant hose down.

Water for the zinc circuit will be stored in the zinc water tank. Recycled water will be sourced from the zinc thickener overflow, with make-up from the process water tank. A water treatment plant will be included to treat zinc water excess and a fraction of the process water flow. The plant will be used to remove metal ions in solution and to remove fine sphalerite from the zinc circuit which could have detrimental impact in the metallurgy (recovery and grade). The permeate (treated water), will be discharged into the process water tank and recirculated back to the process. The brine, containing the treatment plant rejects, will be discarded to tails.

Decant water from the tailings will be pumped from the TSF to the decant return water tank. From here the water will gravitate to the process water tank located at the Bawdwin plant.

A schematic water balance flow diagram for project operations is shown in Figure 4.17.

4.6.10 Process control

The plant will be designed with a level of automation and control that provides the option of local control and remote monitoring or control from a central control room. Instrumentation in the process plant will measure and control key process parameters to minimise operator intervention in standard start-up functions and to provide key monitoring and control to minimise process excursions and maintain steady operation.

The main control room will be located overlooking both milling and flotation area and will house supervisors and data acquisition servers and two operator interface terminals. A third engineering workstation will be provided for control system overview and modifications. The control room is intended to provide a central area from where most of the plant is operated, monitored and adjusted, including the regulatory control loops. All key process and maintenance parameters will be available for trend monitoring and alarming on the process control system.

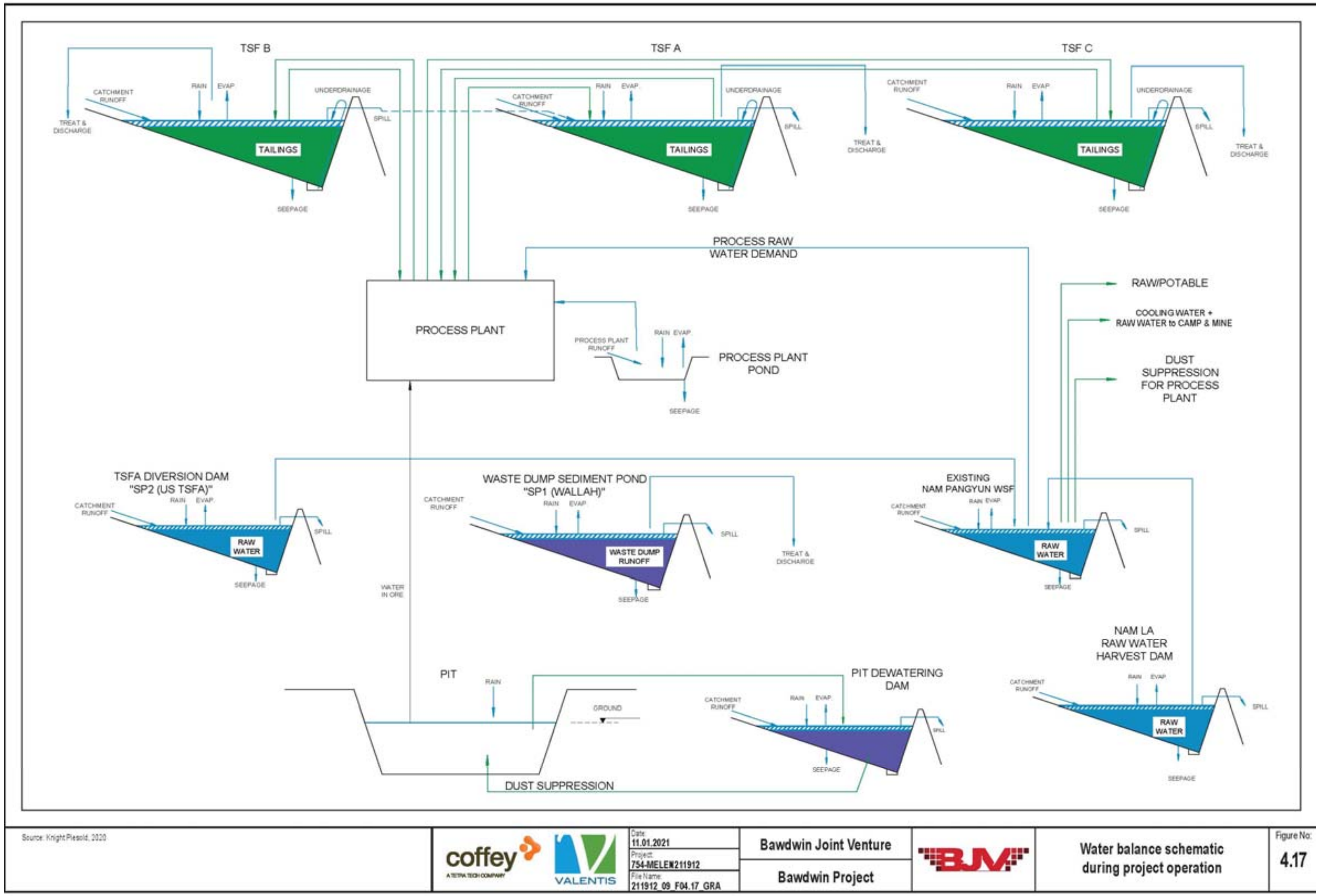


Figure 4.17 Water balance flow schematic

4.7 Waste rock management

Waste rock characterisation and management including design of the waste rock dump was completed by Knight Piesold (2020) to inform the DFS for the project and is included as Appendix A.

Over the life of the project 163.9 Mt of waste rock will be produced. Most waste rock will be stored in a single waste rock dump within the Wallah Gorge comprising benches and embankments. Sediment basins and leachate treatment ponds will be constructed downstream of the waste rock dump to collect and treat discharge and runoff. Waste rock placement will commence at the toe and work back up through the valley thus negating the need for ramps for the majority of the dump. However, ramps will be provided to access the areas of the dump above the surrounding topography. Up to 1.5 Mt of potentially acid forming (PAF) waste rock material is expected. The PAF waste rock will either be placed in TSF C and inundated to prevent acid generation, or an alternative option is for PAF waste rock to be encapsulated in a engineered cell within the waste rock dump.

A breakdown of the waste rock classifications (i.e., underground fill, oxide material, transitional material and fresh material) is shown in Table 4.14.

Table 4.14 Waste rock production schedule

Material	Unit	Pit Stage								Total	Proportion of waste
		1 (Central)		2 (West)		3 (East)		4 (Starter)			
		Start	Finish	Start	Finish	Start	Finish	Start	Finish		
		Year 1	Year 8	Year 3	Year 8	Year 3	Year 8	Year 8	Year 15		
UG Fill	t	414,468		0		76,996		1,260,819		1,752,283	1%
Oxide	t	3,334,597		3,828,014		8,441,032		1,467,731		17,071,374	11%
Transitional	t	17,405,857		28,300,413		24,386,127		7,414,184		77,506,582	49%
Fresh	t	11,354,089		24,718		21,087,035		30,866,737		63,332,579	40%
Total	**t**	**32,509,011**		**32,153,145**		**53,991,191**		**41,009,471**		**159,662,817**	**100%**
File Ref. bawdwin_feb_2020_V14_Schedule_3Mt_sp_smoothed_v26d_forced_with_bcm_movements_Rev6_PS_Apr2023											

Note: minor differences in totals caused by rounding.

4.7.1 Waste rock characteristics

Physical characteristics

The mining schedule indicates that approximately 11% of the waste rock will be oxide, 49% will be transitional and the remaining 40% will be fresh (Table 4.14). Fresh rock refers to rock that has not been weathered. Oxide waste refers rock material in oxide form (i.e., oxygen-bearing minerals). Transitional rock occurs in the transition zone between fresh and oxide rock.

Based on the geotechnical investigation, data reviewed and in consideration of the volcaniclastic and sedimentary geology, it is considered likely that there will be minimal high strength fresh waste rock.

Geochemical characteristics

Method

Knight Piesold (2020; Appendix A) describe the methods to characterise the geochemical properties of waste rock and is summarised below.

A waste rock geochemical study (conducted over two phases) comprised acid base accounting and total multi-element analysis of 205 samples and distilled water extract testing of 90 samples.

In the first phase, samples were selected based on the representative lithologies and comprised 105 samples from twelve boreholes and three lithologies; porphyry (40 samples), Bawdwin tuff (40 samples) and Pangyun sandstone (25 samples). In the second phase, the geological database of over 20,000 samples was reviewed to select a further representative 100 samples based on a range of criteria including geographic spread, lithology, oxidation and concentrations of key 'indicator' elements (sulfur, sulfide, lead, zinc, copper and mercury). The program focussed on a number of analytical methods to characterise the geochemistry including: acid based accounting, net acid generation, acid forming potential, elemental analysis and elemental analysis of distilled water extracts.

Acid base accounting assesses a sample's potential to form acid from the oxidation of sulfides and the ability to neutralise acid by the dissolution of minerals, predominantly carbonates, contained in the sample. In the laboratory, total sulfur and total carbon were estimated using an induction furnace, with infrared detection, with acid insoluble carbon and sulfate sulfur determined by acid digest and infrared / inductively coupled plasma detection respectively. Acid neutralising capacity (ANC) was determined by digestion in a standard solution of hydrochloric acid (HCl), followed by back titration with sodium hydroxide (NaOH) to determine the amount of acid consumed. The results of the acid base accounting testwork are used to calculate the maximum potential acidity (MPA), which is a measure of the maximum amount of sulfuric acid which can be produced from the total oxidation of all sulfides within the sample, assuming all sulfides are present as pyrite.

The net acid producing potential (NAPP) is the balance between the MPA and ANC. A negative NAPP indicates that there is an excess neutralising capacity and a positive NAPP indicates there is excess potential acidity.

Net acid generation (NAG) testwork is a direct measure of a sample's ability to produce acid through sulfide oxidation. The addition of hydrogen peroxide to samples causes rapid oxidation of the contained sulfides to produce sulfuric acid.

The acid formation potential of a sample is calculated based on the acid base accounting, i.e. the balance between a sample's ability to produce acid from the oxidisation of sulfide minerals (MPA) and neutralise acid by the dissolution of alkaline minerals (ANC).

KP prefers to use the results of the acid base accounting in combination with the NAG testing results to classify the acid formation potential of materials, as opposed to solely using the ratio between the ANC and MPA.

Multi-element analysis was conducted to assess elemental enrichments within the waste rock samples. The specified four acid digestion method results in near total digestion of the samples to assess the whole rock geochemistry. Multi-element analysis results were then compared to the average crustal abundance to determine geochemical abundance indices (expressed on a scale of 0 to 6).

Distilled water extract tests are conducted to assess the potential for leaching of environmentally significant elements from waste rock samples, which could have a detrimental effect on the seepage water quality.

Acid forming potential

The results of the sulfur speciation indicate that the total sulfur contents of the samples varied considerably from <0.01% to 6.0% at an average of 0.29% which is moderate. The sulfate contents were typically low ranging from <0.01% to 0.75% at an average of 0.04%, indicating that the vast majority of sulfur is likely present as sulfide. Sulfide contents varied from <0.01% to 3.5% at an average of 0.16%. The highest sulfide contents were typically recorded in the Bawdwin tuff samples.

The maximum potential acidity was calculated from the CRS-determined sulfide contents and varied from negligible to 106 kg H_2SO_4/t at an average of 5 kg H_2SO_4/t, which is considered to be low (Knight Piesold, 2020). Knight Piesold note that this estimate is based on the assumption that all sulfides are present as pyrite. However, in the Bawdwin deposit the majority of sulfides are present as galena and sphalerite, which do not generate acid where oxygen is the oxidant.

The majority of waste rock was found to have a low ANC, with a small proportion of the waste containing significant amounts of ANC. The median ANC value recorded was 3.8 kg H_2SO_4/t, which is low.

The net acid generation test indicates that under extreme oxidising conditions, acid was produced by 44% of samples up to a maximum of 77 kg H_2SO_4/t (i.e., 77 kg of sulfuric acid produced per tonne of fully oxidised rock), with 5% of samples also recording final NAG pH values below 4.5

Lithologically, the PAF material is effectively limited to the Bawdwin tuff, to a lesser extent the narrow, steeply dipping fault shear material and is most prevalent in transitional and fresh waste. It was estimated that 6% of the waste rock samples were potentially acid forming (PAF), the vast majority of which comprised Bawdwin tuff which is host to the majority of the mineralisation. However, the distribution of PAF samples was not uniform throughout the tuff and, therefore, lithology alone is a poor predictor of PAF capacity (Table 4.15). The fault shear samples were found to be highly variable across the limited set of four samples varying from acid consuming (AC) to PAF. The Pangyun sandstone and quartz porphyry did not record any PAF samples.

Table 4.15 Summary of acid forming potential by lithology

Lithology	Acid Consuming (%)	Non Acid Forming (%)	Potentially Acid Forming (%)
Bawdwin tuff (all sub-lithologies)	2	86	12
Bawdwin tuff (un-differentiated)	3	90	7
Bawdwin tuff (Ash)	0	100	0
Bawdwin tuff (Lapilli)	2	82	16
Fault – breccia	0	100	25
Fault – shear	25	50	0
Pangyun sandstone	0	100	0
Quartz porphyry - Loi Mi	0	100	0
Quartz porphyry (with feldspar)	0	100	0
Quartz porphyry (without feldspar)	0	100	0
Quartzite	0	100	0

Source: Knight Piesold, 2020

Seven geometallurgical domains were assigned by CSA Global. These were:

- Carbonate (Carb).
- Potassic-intermediate (K_Int).
- Sericite-intermediate (Ser_Int).
- Potassic-silica (K_Sil).
- Sericite-silica (Ser_Sil).
- Sandstone (SST).
- Argillic domain (Argillic).

Of the eleven waste rock samples classified as PAF-LC or PAF, six were from the potassium feldspar, low silica alteration (K_Int domain), four were from the white mica, silica alteration (Ser_Sil domain), and one fault shear sample was from the potassium feldspar and lesser silica alteration (K_Sil domain).

A review of the spatial distribution of waste rock samples was made with respect to the halo and high-grade lodes defining additional spatial controls to lithology and geometallurgical domains on the distribution of acid forming potential. Knight Piesold concluded:

- NAF material occurred in all domains.
- AC (acid consuming) material was only present outside of the resource grade envelopes and within the Carbonate domain (Carb).
- PAF material was only identified within the >0.5% Pb halo resource envelope.
- PAF-LC material was dominantly found within the >0.5% Pb halo envelope (5 samples) and mostly outside of the >3.5% Pb high grade envelope (1 sample).

Knight Piesold conservatively assumed that 10% of waste rock from these domains within the >0.5% Pb halo resource wireframe is PAF (testing indicated between 0% and 7% of samples from these domains were PAF). This leads to an estimate of the total volume of PAF being 1% of waste rock or approximately 1.5 Mt.

Based on the acid base accounting results, a preliminary classification system is proposed to identify PAF during operations based on total sulfur and NAG testing, as follows:

- Where NAG pH <4.5, handle as PAF.
- Where NAG pH ≥ 4.5 and total sulfur content <1% – handle as NAF
- Where NAG pH ≥ 4.5 and total sulfur content ≥1% – handle as PAF (due to the potential to release high sulfate concentrations during oxidation (even if excess acidity is not produced).

Total sulfur and NAG testing can be readily conducted on grade control samples within a site laboratory to classify material in advance of mining. It is not possible to classify material based on total sulfur and carbon alone due to the presence of non-acid producing sulfides (galena and sphalerite), poor relationship between total sulfur and sulfide (due to presence of sulfates such as barite and anglesite) and non-net neutralising carbonates (siderite).

Multi-element analysis

Comparison of multi-element analysis to the average crustal abundance were used to indicate the level of elemental enrichment in waste rock samples whereby 0 indicates that the element concentration is less than or similar to average crustal abundance, and 6 indicates an element concentration of more than 96 times the average crustal abundance. Values of 0 and 1 being classified as “not enriched”, indices of 2 being classed as “slightly enriched”, indices of 3 and 4 being classed as “significantly enriched” and indices of 5 and 6 being classified as “highly enriched”.

The results of the multi-element analysis on 205 waste rock samples identified a moderate to high number of element enrichments with pervasively high levels of enrichment (i.e., more than 48 times the crustal abundance) in antimony, arsenic, lead and silver (Table 4.16). In addition, no samples met ecological soil screening criteria, whilst the majority of samples also did not meet the human health or soil intervention guidelines.

Table 4.16 Summary of element enrichment results from waste rock samples

Element	Not Enriched	Slightly Enriched	Significantly Enriched	Highly Enriched
Ag	18%	11%	28%	43%
Al	100%	0%	0%	0%
As	1%	7%	26%	66%
B	17%	69%	14%	0%
Ba	95%	2%	2%	2%

Element	Not Enriched	Slightly Enriched	Significantly Enriched	Highly Enriched
Be	100%	0%	0%	0%
Bi	20%	12%	51%	18%
C	59%	14%	24%	3%
Ca	100%	0%	0%	0%
Cd	75%	11%	7%	7%
Cl	100%	0%	0%	0%
Co	88%	5%	6%	1%
Cr	100%	0%	0%	0%
Cu	81%	3%	10%	5%
F	100%	0%	0%	0%
Fe	100%	0%	0%	0%
Hg	45%	17%	28%	10%
K	100%	0%	0%	0%
Mg	100%	0%	0%	0%
Mn	99%	1%	0%	0%
Mo	97%	1%	2%	0%
Na	100%	0%	0%	0%
Ni	95%	3%	2%	0%
P	100%	0%	0%	0%
Pb	23%	6%	17%	54%
S	66%	12%	18%	5%
Sb	1%	3%	32%	64%
Se	46%	2%	52%	0%
Sn	87%	13%	0%	0%
Sr	100%	0%	0%	0%
Th	100%	0%	0%	0%
U	96%	3%	1%	0%
V	100%	0%	0%	0%
Zn	82%	7%	7%	5%

Knight Piesold, 2020; Appendix A

The distilled water extract testing of 90 samples indicated that leachate from the majority of samples would be likely to contain dissolved metal(loids) at concentrations well above reference water quality guidelines. The distilled water extract results were compared to Myanmar National Environmental Quality (Emission) Guidelines. Exceedances compared to the reference guidelines were noted for aluminium, arsenic, cadmium, cobalt, copper, nickel, lead, sulfate, total dissolved solids and zinc (Table 4.17).

Table 4.17 Summary of distilled water extract results

Element	Reference Guidelines (mg/L)		Average Concentration (mg/L)	Percentage of Samples Exceeding Release Guidelines	Percentage of Samples Exceeding Drinking Water Guidelines
	Release (Emission)[1]	Drinking Water[2]			
Ag	N/G	N/G	0.00005	N/G	0%
Al	5	0.2	**0.51**	2%	10%
As	0.1	0.01	**0.86**	17%	61%
B	5	2.4	0.01	0%	0%
Ba	N/G	0.7	0.05	N/G	0%

Element	Reference Guidelines (mg/L)		Average Concentration (mg/L)	Percentage of Samples Exceeding Release Guidelines	Percentage of Samples Exceeding Drinking Water Guidelines
	Release (Emission)[1]	Drinking Water[2]			
Be	N/G	N/G	0.0002	N/G	N/G
Bi	N/G	N/G	0.00001	N/G	N/G
Ca	1,000	N/G	38.8	0%	N/G
Cd	0.05	0.003	**0.127**	17%	34%
Cl	N/G	250	2	N/G	0%
Co	1	N/G	**5.7**	29%	N/G
Cr	1	0.05	0.015	0%	2%
Cu	0.3	2	**1.90**	20%	12%
EC (µS/cm)	N/G	N/G	368	N/G	N/G
F	2	1.5	0.15	0%	0%
Fe	2	0.3	0.1	2%	10%
Hg	0.002	0.006	0.0001	0%	0%
K	N/G	N/G	17.6	N/G	N/G
Mg	2,000	N/G	7.0	0%	N/G
Mn	N/G	0.1	**2.5**	N/G	68%
Mo	0.15	0.07	0.004	0%	0%
Na	N/G	200	3.0	N/G	0%
Ni	0.5	0.07	**6.6**	37%	51%
P	N/G	N/G	0.05	N/G	N/G
Pb	0.2	0.01	**2.0**	46%	66%
pH	6 to 9	6.5 to 8.5	**6.4**	32%	61%
S	N/G	N/G	55.6	N/G	N/G
SO4	1,000	250	166.5	5%	12%
Sb	N/G	0.02	0.01	N/G	17%
Se	0.02	0.04	0.0010	0%	0%
Sn	N/G	N/G	0.0002	N/G	N/G
Sr	N/G	N/G	0.02	N/G	N/G
TDS	2,000	1,000	307	5%	7%
Th	N/G	N/G	0.00001	N/G	N/G
U	0.2	0.03	0.003	0%	5%
V	N/G	N/G	0.010	N/G	N/G
Zn	0.5	3	**7.96**	41%	37%

Source: Knight Piesold, 2020. Bold indicates exceedance to either guideline value.
N/G – No Guideline
[1]Myanmar National Environmental Quality (Emission) Guideline (MOCAF, 2015)
[2]World Health Organisation (2011) Guidelines for Drinking-water Quality

There was a strong correlation between pH and distilled water extract quality, with typically increasing dissolved metal(loid) concentrations recorded in response to lower pH solutions, although arsenic is also indicated to be soluble under weakly alkaline conditions.

Although non-acid forming (NAF) samples were found to produce better quality leachate than PAF samples, the NAF samples still recorded guideline exceedances of environmentally significant metal(loids). Based on these results seepage from waste rock dumps is likely not to meet criteria for discharge to the environment due to high concentrations of aluminium, arsenic, cadmium, cobalt, copper, manganese, nickel, lead and zinc within leachate.

Summary

The assessment of waste rock geochemistry was based on ensuring samples were representative of the overall waste rock within the assay database and geographical spread. Knight Piesold conclude the results are likely to be a reasonable representation of the overall geochemical risk profile, although it is recognised that the assay database excludes material from higher elevations within the proposed pit cut backs, with the majority of drilling conducted at lower elevations in the valley due to access constraints. Inclusion of this material, which is situated away from the centre of the ore zone and likely to be predominantly oxide and/or low in sulfide, will most likely lead to 'dilution' of the overall proportion of PAF.

Overall, the geochemical characterisation of the waste rock indicates that:

- The percentage of PAF waste rock is low overall (1%), however selective management of the PAF waste rock to limit acid forming conditions will help to minimise the amount of metal(loids) that are leached out of the waste rock.
- The drainage or leachate from the waste rock material (even excluding the PAF material) will contain elevated levels of metal(loids) that have environmental significance and will likely not meet criteria for discharge to the environment.

4.7.2 Waste rock dump design

The majority of the waste rock will be stored in a single waste rock dump within Wallah Valley. The final waste rock dump footprint is approximately 106 ha (262 acres) in size and 3 km long running along the valley. The height from the toe of the waste rock dump to the top is approximately 315 m. The conceptual design of the waste rock dump is shown in

Figure 4.18.

The production of waste rock categorised as either oxide, transitional or fresh waste rock is presented in

Figure 4.19.

Waste rock placement in the Wallah Gorge will commence at the toe and work back up through the valley, although a main haul road has been included for ease of access. In addition, ramps have been included to access the higher elevation areas of the waste rock dump, which are above the surrounding topography (Figure 4.20).

The batter slopes are 1V:2.5H with 10 m wide benches and 25 m wide ramps, which results in an overall slope profile of less than 1V:3H. In addition, a 25 m-wide coarse rockfill external surface layer of fresh waste rock (Zone C2) is included on the front face of the waste rock dump to improve the geotechnical stability and reduce the long term erosion potential of the dump.

Waste rock will be classified in advance of mining using a grade control system with an on-site laboratory. This will include the identification of PAF waste. Once identified and segregated the PAF waste rock will be hauled to either a designated PAF storage area in TSF C and inundated to prevent acid generation, or it will be encapsulated within an impervious engineered cell within the waste rock dump. A final decision on the disposal of PAF material will be determined during detailed design when the estimated volume and scheduling of PAF is refined.

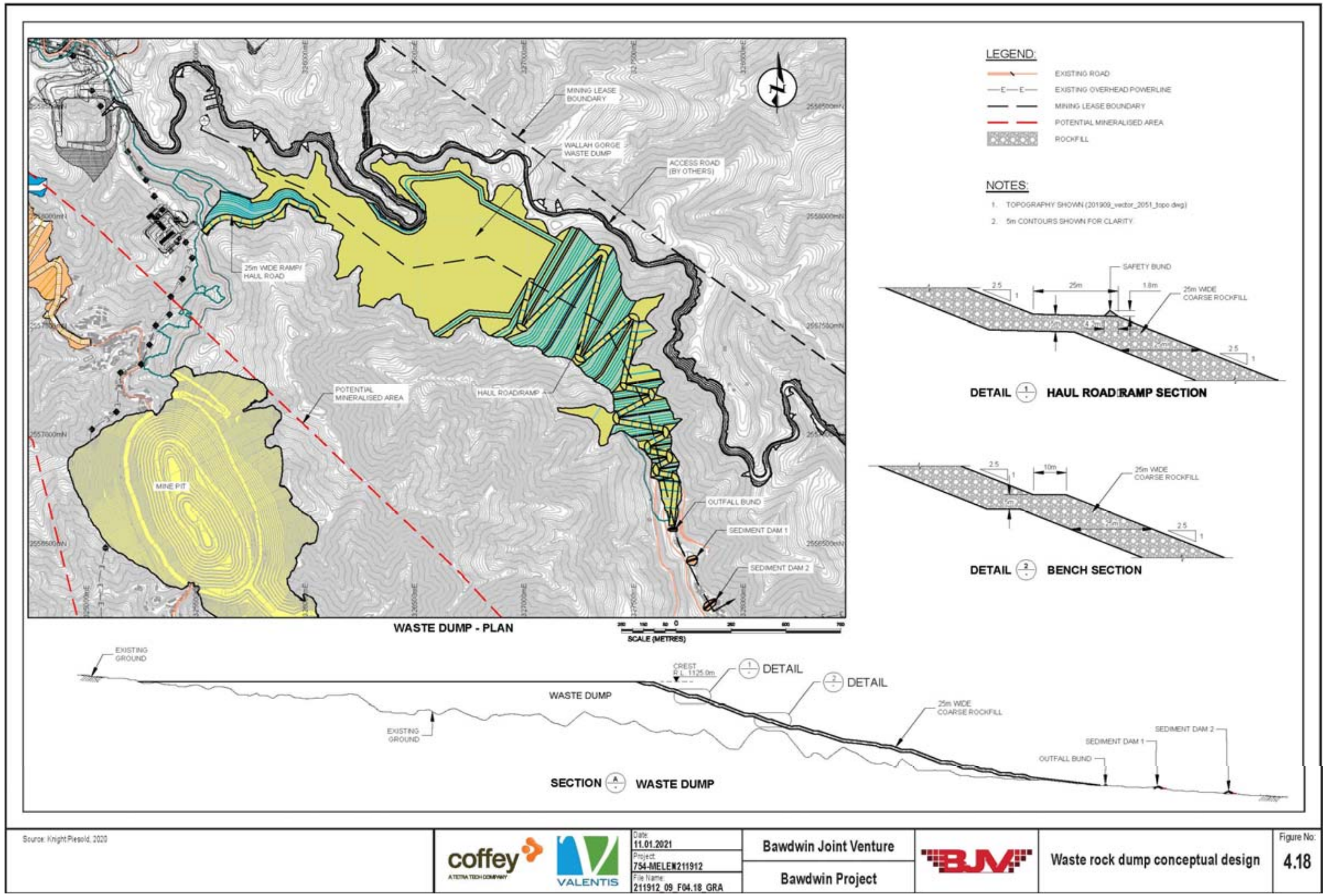


Figure 4.18 Waste rock dump conceptual design

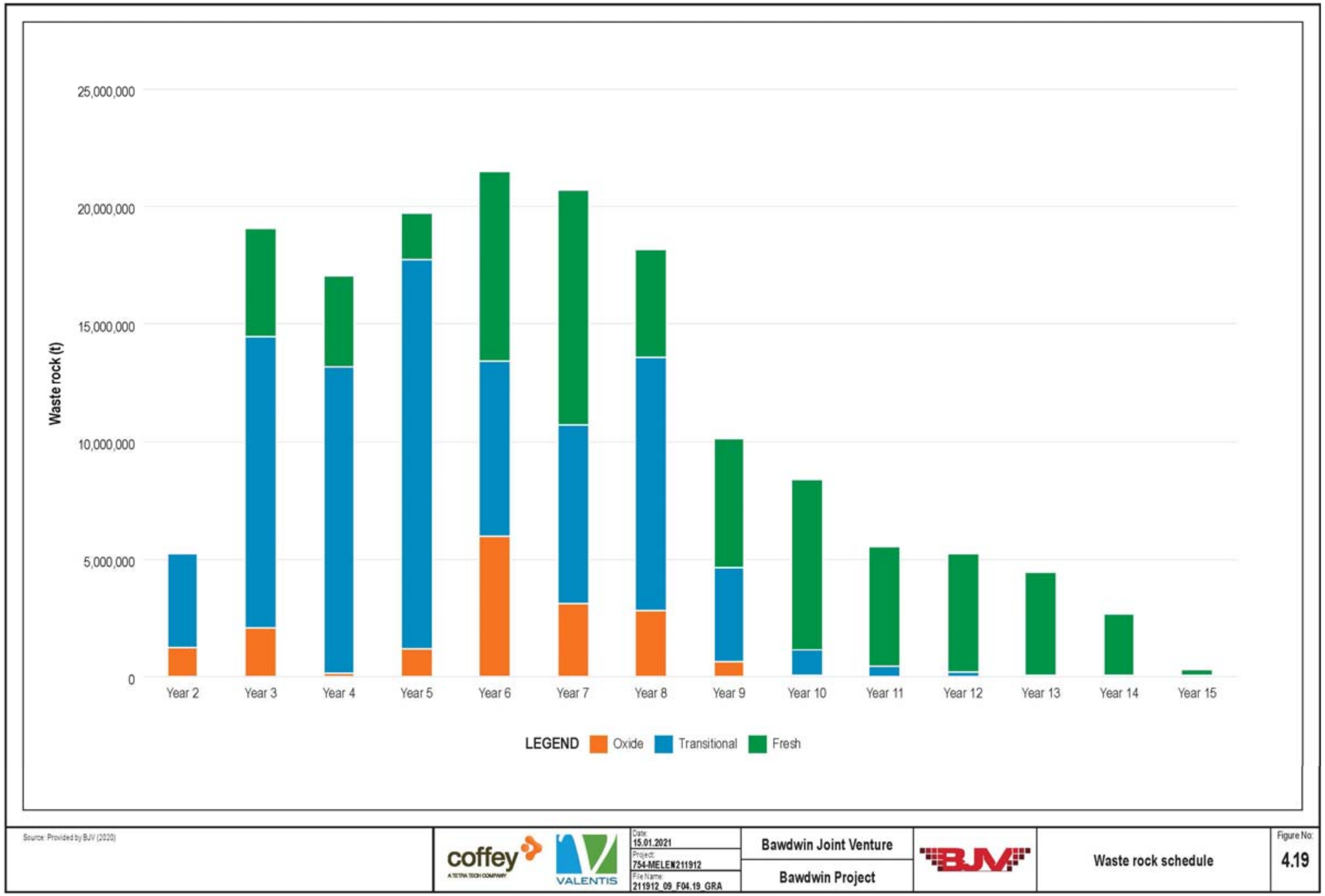


Figure 4.19 Waste rock schedule

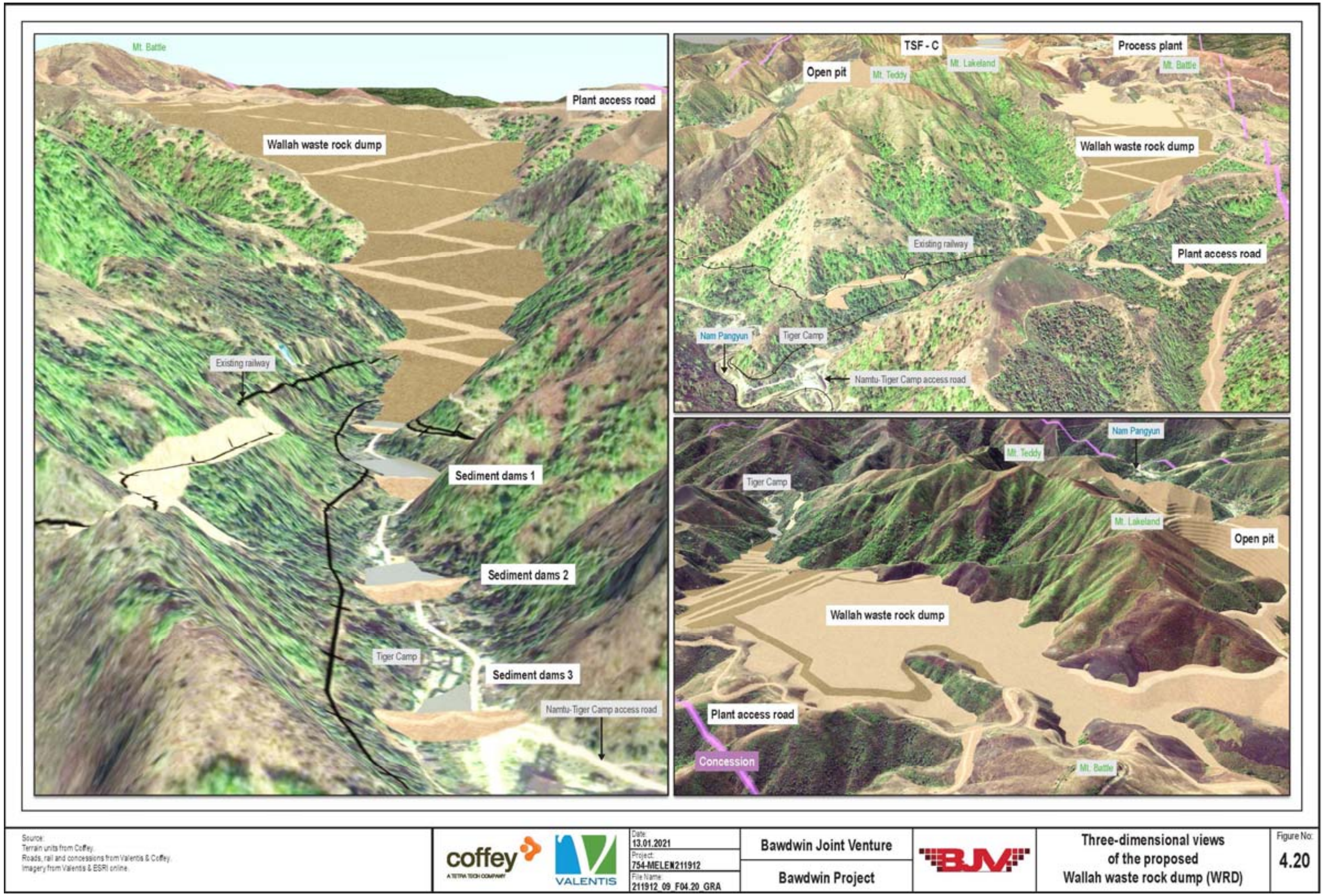


Figure 4.20 Three-dimensional views of the proposed Wallah waste rock dum

Other than selective handling of PAF waste, there will be no other selective handling or layering of waste rock according to the physical or geochemical properties. Waste will be deposited as it is mined and arrives at the waste rock dump, irrespective of lithological type.

The design of the waste rock dump was based on the Guidelines for Mine Waste Dump and Stockpile Design (Hawley and Cunning, 2017). The minimum required FoS provides the basis for the deterministic method of analysing geotechnical stability. Geotechnical stability is influenced by aspects such as the pore pressure, which is influenced by whether the material is drained and undrained or following a seismic event. Therefore, specific factors of safety are typically applied to these three conditions. Waste rock dumps are intentionally built with a FoS greater than 1.0 and are hence stronger than needed for normal usage, to allow for emergency situations, unexpected loads, misuse, or degradation (reliability).

Stability acceptance criteria were assigned for both operations and closure. During operations minor failures can be remediated at an early stage and prior to developing into more significant movements and, for the proposed waste rock dump in Wallah Gorge, there is planned to be no major infrastructure located immediately downstream of the facility. As such, the consequence of failure during operations were assessed to be low. On closure there will be no opportunity to remediate any developing instabilities and there is potential for local residents to utilise the land around the waste rock dump. Therefore, the post closure consequence of failure was assessed to be high (Appendix A).

For both scenarios the waste characteristics data currently available is limited and will remain as such until subsequent design phases or even commencement of mining when the performance of the waste material, blast fragmentation, drainage efficiencies etc. can be established. As such, the confidence level is considered to be low.

The stability criteria for the waste rock dump was defined based on the consequences of failure and the confidence level in the input parameters such as material strength, as summarised in Table 4.18.

Table 4.18 Waste rock dump stability acceptance criteria

Design Condition	Consequence of Failure	Confidence Level	Minimum Factor of Safety		
			Drained	Undrained	Post-Seismic
Operation	Low	Low	1.3	1.1	1.05
Closure	High	Low	1.5	1.5	1.15

Due to the differences in geotechnical properties of the waste rock, the dump was modelled with a layered profile comprising the following materials:

- Mixed oxide and transitional waste (cohesive, normally consolidated, contractive).
- Transitional waste (granular, moderate fines content, dilative, relatively free draining).
- Mixed transitional and fresh waste (granular, low fine content, dilative, free draining).
- Fresh waste (granular, very low fines content, dilative free draining).

The stability model for the waste rock dump has been layered in 5 m lifts, with the number of layers for each material type distributed according to the total volumes in the mining schedule. While it is accepted that placement of material will not occur in such as consistent manner, the intention is to ensure that the modelled failure planes pass through the full range of materials that will be present in the waste rock dump. The stability of the waste rock dump was assessed by Knight Piesold (Appendix A) using SLOPE/W software, developed by Geo-Slope International. Limit equilibrium stability analysis was conducted to assess the stability under short-term (undrained), long-term (drained), and post-seismic loading conditions. The stability results indicate that acceptable factors of safety were achieved. Factors of safety were predicted to be 1.77, 1.46 and 1.36 for long term (drained), short-term (undrained) and post-seismic loading conditions respectively. In addition, the modelled failure surfaces were indicated to be localised bench failures rather than deep-seated movements.

Adequate drainage of oxide and transitional waste material is critical to waste rock dump stability. The requirement for placing coarse rockfill layers at certain elevations within the waste rock dump to allow zones of oxide and transitional waste to remain fully drained will be assessed in more detail once the characteristics of this waste are better understood.

Seepage and drainage

A series of surface drains (i.e., bench, ramp and toe drains) are included in the design to collect the surface runoff and discharge from the waste rock dump in a controlled manner. The surface drains have been designed to be appropriate for both operations and closure with capacity to safely pass the flows generated as a result of a 1 in 1,000-year ARI 24 hour storm event. The drains were designed using storm water modelling software HydroCAD. Bench drains and ramp drains are situated within the interior of the waste rock dump, while a toe drain rings the perimeter of the dump. All drainages report to an outfall bund at the toe of the dump. Bench, ramp and toe drains all report to the outfall bund and then are drained through the series of sediment dams. Water quality of surface run-off has not been predicted and remains an uncertainty to be addressed during detailed design. The surface water management design is shown in

Figure 4.21.

Seepage from the waste rock dump was predicted by Knight Piesold to vary from 175 to 897 m^3 per month (0.2 to 1.2 m^3/hr) varying between the wet and dry seasons. Predicted seepage rates were consistent across the project life at approximately 7,700 m^3per annum. Based on the geochemical characteristics of waste rock the water quality of seepage was predicted to be poor.

Based on the poor leachate quality expected, an underdrainage system for the waste rock dump will collect seepage and discharge it to a series of sediment dams downstream of the dump for treatment, rather than allow seepage to enter the groundwater (Knight Piesold, 2020; Appendix A). The underdrains will promote drainage of the dump and reduce seepage through the base. The drains comprise main seepage drains down the main Wallah Gorge valley spine and secondary drains along sub-valleys. The main seepage drain reports to an outfall bund at the toe of the dump, which is designed to remain flooded during operation to prevent oxygen ingress into the dump via the seepage drains. The seepage and underdrainage design is shown in

Figure 4.22.

Knight Piesold (Appendix A) note that mixing of clean diverted water (from the toe drain), waste rock dump runoff water and waste rock seepage flows within the sediment dam may offer adequate dilution in the wet season to allow subsequent release (without treatment via the microfiltration system), subject to confirmatory testing. In the dry season and at other times where the water within the sediment dam is not of a suitable quality for release, it will have to be treated prior to release.

The seepage water will need to be treated prior to discharging as it contains elevated concentrations of metals. The seepage water will be collected and discharge to a series of sediment dams. The overflow from the final settling dam will be low in suspended solids and suitable to be treated using a microfiltration system. This system will remove fine particles and heavy metal cations, at a constant flowrate of 140 m^3/hr. Its anticipated that the sediment dams would capture a large amount of sediment, although during the peak of higher energy rainfall events the finer silt and clay particles will tend to stay in suspension and flow over the weir crests. Then, as the rainfall intensity subsides, the majority of fines will be retained by the dams.

The treated water will eventually flow into the Nam Pangyun stream through an outfall pipe. It is estimated that during the wet season a maximum monthly discharge of 500,000 m^3 (684.9 m^3/hr) will occur equating to approximately 1.8 M m^3 over each wet season. The microfiltration system will occasionally undergo a backwash cycle, which will discharge sludge into a standby tank. This sludge will be collected by a liquid-waste truck and driven to the process plant for disposal into the tailings pumping system.

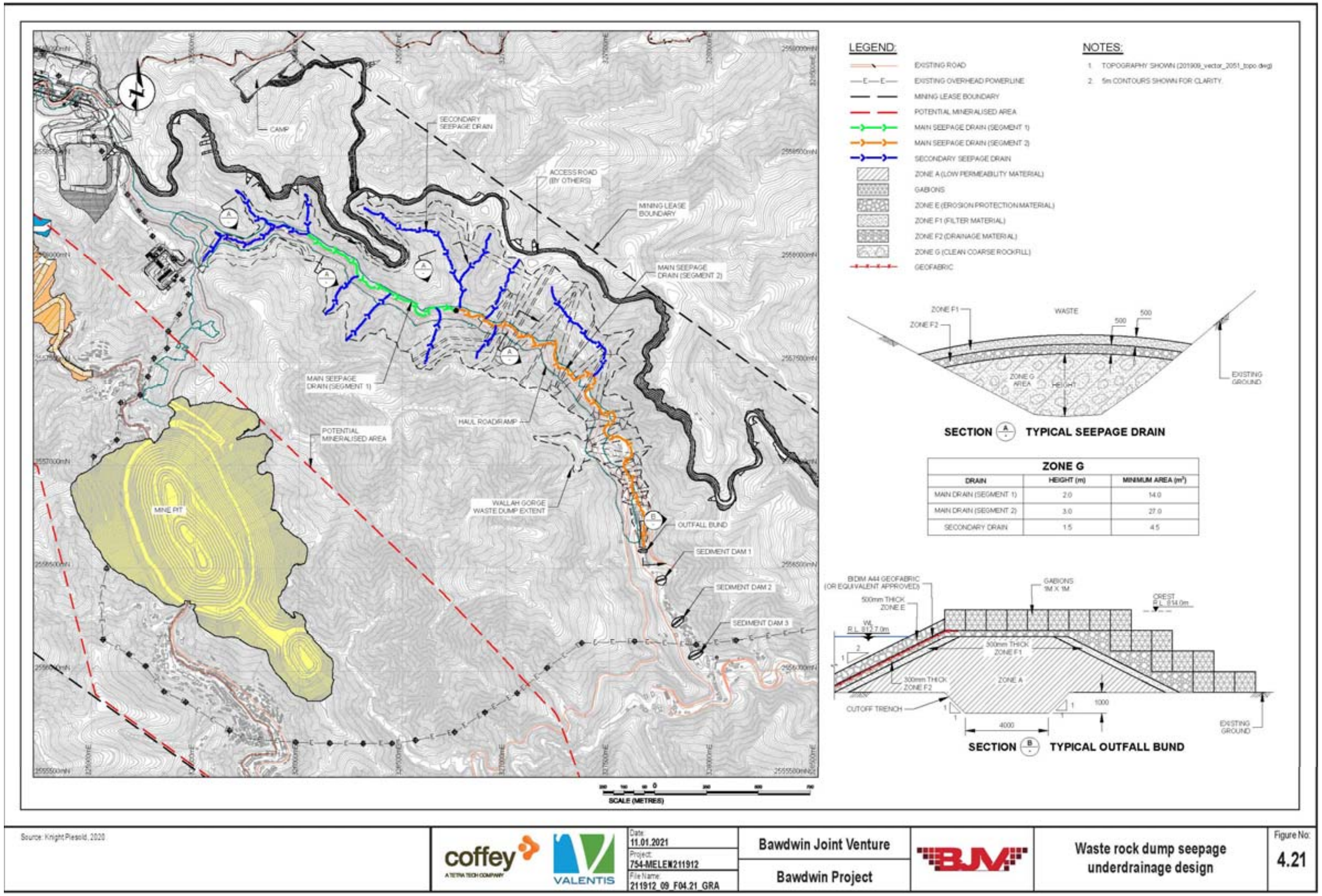


Figure 4.21 Waste rock dump seepage underdrainage design

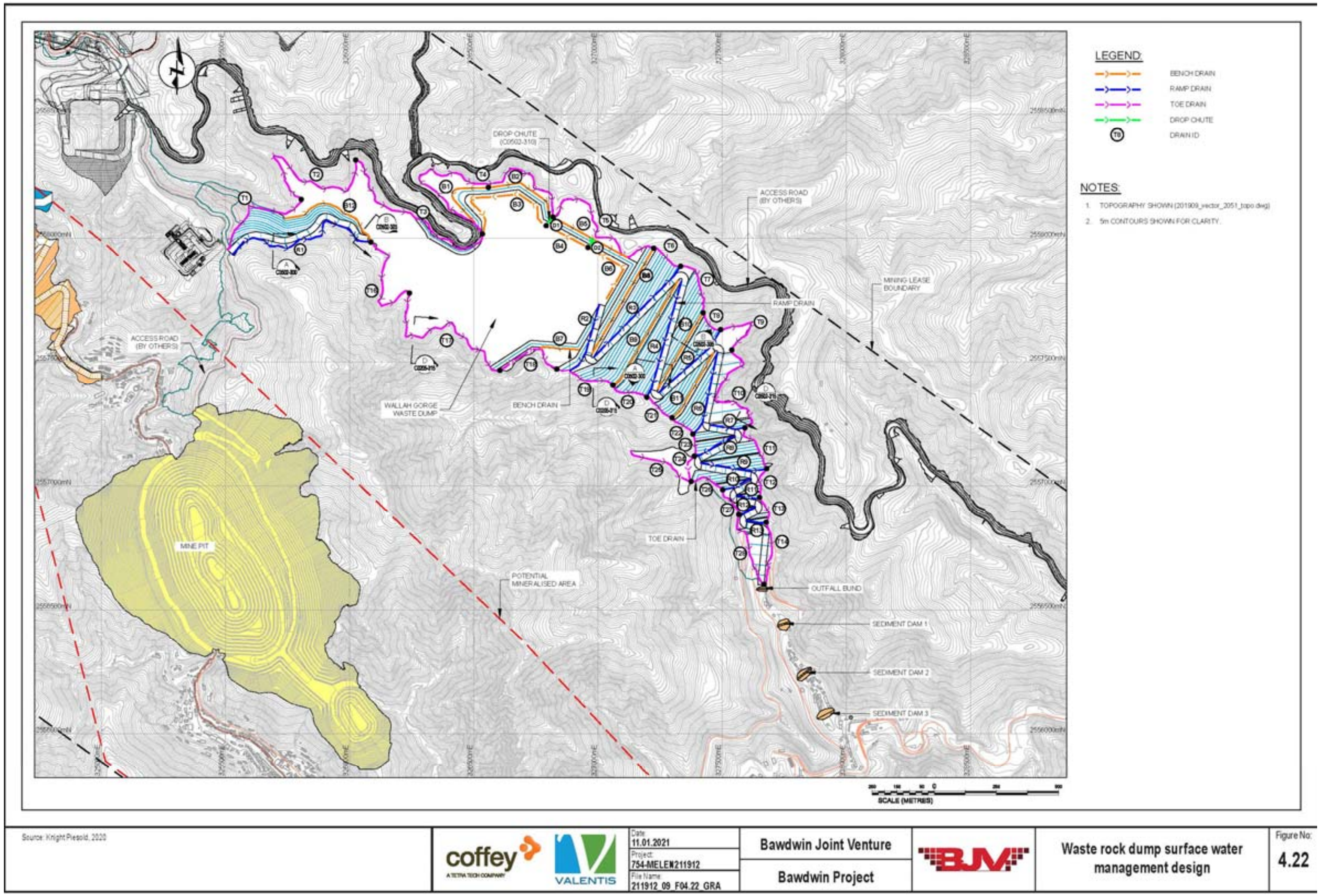


Figure 4.22 Waste rock dump surface water management design

Sediment management

The sediment control system aims to collect and remove sediment contained in the runoff from the waste rock dump. Sediment will be collected in three sediment settling ponds located at the toe of the waste rock dump.

The sediment dams have been designed as three cascade structures:

- An initial, 12 m high, 19,500 m^3 dam, with a crest length of 53 m.
- A second, 8 m high, 15,500 m^3 dam, with a crest length of 73 m; and
- A third, 8 m high, 22,700 m^3 dam with a crest length of 75 m.

The sediment dams also serve to reduce the risk of downstream flash flooding during high rainfall events, as the dams will attenuate discharge from the surface drains. The three tier cascading design provides redundancy in the event of a breach or failure of one structure. The upper sediment pond located directly downstream of the waste rock dump toe will act as the primary sediment control dam, with the downstream structures utilised as complementary sediment control ponds. The sediment retention efficiency of a sediment control dam is predominantly based on the basin top area, depth of permanent pool and the sediment retention depth.

Based on the pond area and depth that can be achieved, the combined sediment retention efficiency of the sediment dam system was assessed and presented in Table 4.19.

Table 4.19 Sediment retention efficiency of waste rock dump sediment dams

Particle Size	ARI (Years)					
	1 in 2	1 in 5	1 in 10	1 in 20	1 in 50	1 in 100
Very coarse sand	100%	100%	100%	100%	100%	100%
Coarse sand	100%	100%	100%	100%	100%	100%
Medium sand	100%	100%	100%	100%	100%	100%
Fine sand	100%	100%	100%	100%	100%	100%
Very fine sand	100%	100%	100%	100%	99%	99%
Coarse silt	94%	90%	87%	84%	81%	79%
Medium silt	63%	54%	50%	46%	42%	40%
Fine silt	26%	20%	18%	16%	15%	14%
Very fine silt	7%	5%	4%	4%	4%	3%
Clay	2%	1%	1%	1%	1%	1%

The results indicate that the sediment control system will retain over 100% of fine sand and 100% of very fine sand sized particles for events up to a 1 in 20-year ARI. The retention efficiency of coarse silt particles is estimated to be lower at around 87% for 1 in 10 ARI flows. The retention efficiency of reduces for medium silt, fine silt, very fine silt and clay with 50%, 18%, 4% and 1% retention for 1 in 10 ARI flows respectively.

Preliminary estimation of the sediment loading rate based on sediment retention estimates indicates that the dams will have sufficient capacity to retain sediment throughout each wet season such that desilting will only be required every six months (i.e., at the start and end of each wet season). The collected sediment will be placed within waste rock dump.

Detailed sediment modelling will be required in subsequent design phases to verify the preliminary estimates of sediment production and retention. Ultimately flocculant and coagulant dosing of discharge may be required to settle the finer particles in the sediment load in order to meet discharge criteria.

Monitoring

It is proposed that a series of inclinometers be installed within the waste rock dump to monitor the internal movements. The inclinometers will be extended to a depth of 25 m below the natural ground surface to allow monitoring of movements within the foundations and embankments fill. Spider magnets and plate magnets will be installed within the inclinometer casing and fill respectively at 25 m vertical intervals to monitor the settlement. The inclinometer casing will need to be extended as the waste rock placement progresses.

Groundwater monitoring bores will be installed to monitor groundwater levels and water quality. There will be two pairs of monitoring bores at the downstream toe of the waste rock dump (comprising a shallow borehole (nominally 5 to 10 metres deep) to target perched groundwater and a deep borehole (nominally greater than 30 metres) to target groundwater within weathered rock. One of these monitoring bore pairs will be located downstream of the waste rock dump sediment dam.

Other monitoring that will be completed includes:

- Water quality monitoring in sediment dams to determine whether treatment is required before release.
- Sediment levels within each sediment dam.
- Inspections of bench, ramp and toe drains for erosion, channel integrity and any blockages.
- Inspections of the waste rock dump for surface erosion.

4.7.3 Waste rock dump closure

The waste rock dump will be progressively rehabilitated during operations. Once a bench of the dump is complete, the outer face will be rehabilitated with a closure cover placed over the surface. The waste rock dump has been designed to achieve the desired slope angles for closure and will not be modified during decommissioning.

Knight Piesold recommend a composite store and release cover system for the waste rock dump, incorporating a capillary break (to prevent upward migration of salts), low permeability layer (to limit infiltration), storage zone (to maintain moisture of the low permeability layer and support vegetation) and growth medium (to encourage revegetation).

Knight Piesold (Appendix A) have provided a preliminary concept for the waste rock dump cover, which consists of:

- A capillary break layer at least 0.25 m deep. The capillary break inhibits dewatering by capillary transport downwards and the potential migration of dissolved harmful substances upwards.
- A low permeability zone at least 0.5 m deep. The purpose of this layer is to reduce percolation into the underlying waste.
- A rock mulch storage layer over the low permeability capping at least 1.5 m deep. The rock mulch in the layer provides resistance to erosion.
- A layer of plant growth medium (at least 0.15 m deep).

The closure design will be refined during the preparation of the detailed design for the waste rock dump.

4.7.4 Forward works

Further works that will contribute to the design and operation of the waste rock dump are proposed and are outlined in Table 4.20.

Table 4.20 Forward works relating to the design and operation of the waste rock dump

Item	Purpose	Detail
Geotechnical investigation of waste rock dump area	• Confirm geotechnical properties and shear strength parameters of the waste rock. • Allow stability analysis of the Wallah waste rock dump.	Site specific geotechnical drilling of the proposed waste rock dump location to recover samples for testing.
Construction materials balance	• Confirm there is suitable filter and drainage material for construction of the TSF and WRD and other waste storages.	Field investigations to determined available volume of suitable filter and drainage material.
Geochemical properties of waste rock samples	• Refine understanding of waste rock geochemistry and subsequent prediction of potential seepage quality.	Ongoing laboratory testing of representative waste rock samples including kinetic leach tests.
Hydrogeological investigation of the waste rock dump	• Refine site-specific understanding of groundwater system at the proposed location waste rock dump area	Geohydrological drilling and field testing of geohydrological parameters.
Contaminant fate and transport modelling	• Provide quantitative predictions of discharge and seepage quantity and quality and subsequent dispersion. • Provide input to design of water treatment infrastructure and systems	Develop a numerical groundwater model incorporating both quantity and quality.
Closure plan update	• Provide detailed assessment and plans to satisfy regulatory progress. • Guide WMM closure/rehabilitation activities. • Allow refinement of closure costs.	An update is required within 3 years of the project operations. This will include identification of potential cover materials and sources, and post-closure water management.
Detailed design of waste rock dump, plus associated sediment dams and water quality treatment plant.	• Develop detailed design and construction drawings • Develop surface water and seepage managements system • Refine sediment load calculations and refinement of sediment dam sizes.	Detailed design will be completed using international good practice standards.

4.8 Tailings management

Tailings are the waste by-products from mineral processing. Tailings will be stored in valley fill TSFs located in the northwest of the Bawdwin concession. The process plant will produce thickened tailings with a moisture (H_2O) content of 40% which is suitable for piping the tailing to the TSFs.

Tailings characterisation and management including TSF design was completed by Knight Piesold (2020) to inform the DFS for the project and is included as Appendix A.

4.8.1 Tailings characteristics

Tailings were characterised based on two composite samples of tailings slurry that were generated by ALS Metallurgy. The samples termed Stage 1/2 and Stage 4 were composited to represent early and late stage tailings.

Physical characteristics

The tailing samples have a design P80 of 80 μm (meaning that 80% of the material is smaller than 80 μm) and on average were found to consist of 22% sand, 65% silt and 13% clay. The testing indicates that samples are a low to medium plasticity sandy silt/clay, which would be classified as CL-ML (fine-grained soils) in accordance with Australian Standard for geotechnical investigations (AS1726:2017). The samples are also classified as potentially liquefiable soils.

The sedimentation tests indicate that both samples will settle quickly (i.e., the tailing solids will settle from tailing water) with complete settlement taking about a day. The samples released approximately 44% of water in slurry to supernatant in the undrained test, reducing to about 34% in the drained test. The samples achieved a moderate dry density from settlement before air drying or consolidation with a void ratio of 1.1 to 1.4. In the air drying tests, the samples achieved an average maximum dry density of 1.58 t/m^3, taking about 2 to 3 days at an average evaporation rate of 12 mm/day (approximately 30 mm of total evaporation). The results of consolidation testing indicated that samples are moderately compressible and will consolidate quickly with loading.

In the range of expected settled densities, the vertical permeability was found to be approximately 3 x 10^{-7}m/s for both samples. As the tailings consolidate it is anticipated that the permeability may reduce only slightly (by half an order of magnitude) due to the coarse silt nature of the material.

Geochemical characteristics

Knight Piesold (2020; Appendix A) describe the methods to characterise the geochemical properties of tailings, which is similar to those used for the waste rock geochemistry assessment described above. The program focussed on a number of analytical methods including: acid based accounting, net acid generation, acid forming potential, and elemental analysis.

Both tailings samples recorded high total sulfur contents of 1.9% to 2.5%, which was indicated to be present predominantly as sulfide. As such, the samples have high maximum potential acidity (MPA) values of 43 and 62 kg H_2SO_4/t for the early (Stage 1/2) and the late (Stage 4) tailings samples respectively. However, the acid-neutralizing capacity (ANC) values were found to be high to very high, and present almost entirely as carbonates. Based on the MPA and ANC values, the early (Stage 1/2) tailings sample has a negative net acid production potential (NAPP) and the late (Stage 4) tailings sample a positive NAPP.

The net acid generation (NAG) pH results were approximately neutral and similar to the paste pH results. On the basis of these results, the early (Stage 1/2) tailings sample was classified by Knight Piesold as non-acid forming (NAF) and the late (Stage 4) tailings sample as having an uncertain (UC) acid forming potential due to conflicting NAPP and NAG results. However, this sample was reclassified by Knight Piesold as NAF as the testing indicates the sulfides present are likely to be predominantly galena and/or sphalerite as and do not generate acid as opposed to pyrite, which does. Although samples are not expected to generate excess acidity, elevated concentrations of sulfate would be expected in drainage flows in response to oxidation of the sulfide minerals in the tailings.

Whole rock multi-element analysis of the tailings was also conducted to identify element enrichments. The analysis results were compared to average crustal abundances to calculate the geochemical abundance indices. Samples were found to have a high number of element enrichments when compared to crustal abundances, with the level of enrichment also tending to be high (Table 4.21). Highly enriched elements comprised silver, arsenic, bismuth, cadmium, copper, mercury, molybdenum, lead, sulfur, antimony and zinc. Concentrations of arsenic, copper, lead, sulfur and zinc in particular showed very high enrichment (Table 4.21).

Comparison of the multi-element assay results of the tailing samples to soil quality screening guidelines indicates that the tailings samples do not meet these guidelines due to elevated metal(loid)s.

Table 4.21 Multi-element assay results, average crustal abundances and indices of enrichment

Element	Unit	Early stage tailings (Stage 1/2)	Late stage tailings (Stage 4)	Average crustal abundances	Early stage tailings enrichment	Late stage tailings enrichment
Ag	ppm	31	66	0.07	6	6
Al	ppm	43,346	44,699	82,000	0	0
As	ppm	4,756	3,402	1.5	6	6
B	ppm	50	62	10	1	2
Ba	ppm	386	229	500	0	0
Be	ppm	1.5	1.3	2.6	0	0
Bi	ppm	22	8	0.048	6	6
Ca	ppm	12174	6253	41,000	0	0
Cd	ppm	141	44	0.11	6	6
Cl	ppm	350	300	130	0	0
Co	ppm	926	674	20	4	4
Cr	ppm	702	528	100	2	1
Cu	ppm	2694	3283	50	5	5
F	ppm	474	397	950	0	0
Fe	ppm	28700	30600	41,000	0	0
Hg	ppm	5.7	4.9	0.05	6	6
K	ppm	36,348	28,729	21,000	0	0
Mg	ppm	6,116	4,360	23,000	0	0
Mn	ppm	1,203	630	950	0	0
Mo	ppm	73	75	1.5	5	5
Na	ppm	464	352	23,000	0	0
Ni	ppm	2,768	1,609	80	4	3
P	ppm	508	322	1,000	0	0
Pb	ppm	21,457	32,684	14	6	6
S	ppm	19,450	25,300	260	5	6
Sb	ppm	133	185	0.2	6	6
Se	ppm	0.05	0.07	0.05	0	0
Sn	ppm	13	16	2.2	2	2
Sr	ppm	16	9	370	0	0
Th	ppm	10	9	12	0	0
U	ppm	8	9	2.4	1	1
V	ppm	29	29	160	0	0
Zn	ppm	19,823	7,761	75	6	6

Source: Knight Piesold, 2020

Legend:

Not Enriched = 0 – 1	0 -1
Slightly Enriched = 2	2
Significantly Enriched = 3 -4	3 – 4
Highly Enriched 5 - 6	5 - 6

The two samples were submitted for supernatant testing to provide a preliminary indication of the water quality which may be encountered in the facility during operations. However, the testing does not account for long term water quality which may occur following oxidation of the tailings. This would require kinetic testing, which will need to be conducted as part of the subsequent design phases.

The predicted supernatant water (i.e., the water that occurs on the surface of the TSF) was shown to be of a very poor quality and did not meet the release guidelines (i.e., Myanmar discharge criteria), with exceedances of total dissolved solids (TDS), cadmium, cobalt, lead, nickel, sulfate and zinc recorded in both samples. Additional exceedances were recorded for arsenic (0.36 mg/L vs 0.1 mg/L Myanmar discharge criteria) in the early (Stage 1/2) sample and free cyanide (0.14 mg/L vs 0.1 mg/L Myanmar discharge criteria) in the late (Stage 4) sample. Of particular note was zinc at almost 200 times the guideline limit (both samples), cadmium at 150 times the threshold (Stage 1/2 sample) and nickel at 100 times the release guideline (Stage 1/2 sample).

In regard to free cyanide concentrations, it is expected that natural attenuation in the environment, dilution with run-off water and the intermittent use of NaCN will mean that discharge limits can be met without dedicated cyanide destruction circuit.

4.8.2 TSF site selection and design

After investigation of numerous potential TSF sites and designs (see Chapter 3) an option comprising three separate TSFs located in the northwest of the Bawdwin concession was adopted.

The three chosen TSF sites are located in the headwaters of the Nam Pangyun River, upstream of the open pit and approximately 1.2 km west of the process plant. The three interconnecting facilities comprise cross valley storages. Each TSF has been designed as a starter embankment with two downstream raises. The total footprint of the three TSFs is approximately 125 hectares (308.9 acres). A three-dimensional view of the TSFs is shown in

Figure 4.23.

The storage capacities for each facility and stage are provided in Table 4.22.

Table 4.22 Staged embankment construction

Facility	Stage	Cumulative Tailings Storage (Mt)	Cumulative Tailings Storage (Months)	TSF Embankment Elevation (m RL)	Total Height (Crest to DS Toe) (m)	Embankment Volume (Cumulative) (Mm^3)
TSF A	1	1	11	1,272.4	99.0	2.2
	2	6.3	35	1,292.3	123.1	4.2
	3	8.2	44	1,297.8	132.8	6.0
TSF B	1	3.3	15	1,278.9	109.7	3.2
	2	6.0	27	1,289.4	126.2	4.5
	3	9.1	40	1,302.0	147.0	7.2
TSF C	1	2.7	12	1,185.4	117.7	4.9
	2	8.2	36	1,197.7	133.1	6.9
	3	15.0	73	1,215.1	161.4	11.3
Total		**32.3**	**120**			**24.5**

Tailings storage facility A

TSF A has an upstream catchment area of 135 ha. The valley sides at the embankment location have an approximate slope of 1V:1.75 H, with the valley floor sloping at approximately 1V:11H to the southeast. The base of the valley at the embankment centreline is at approximately 1,195 m RL. The deposition modelling indicates that a final embankment level of 1,298 m RL would have a storage capacity for 8.2 Mt of tailings.

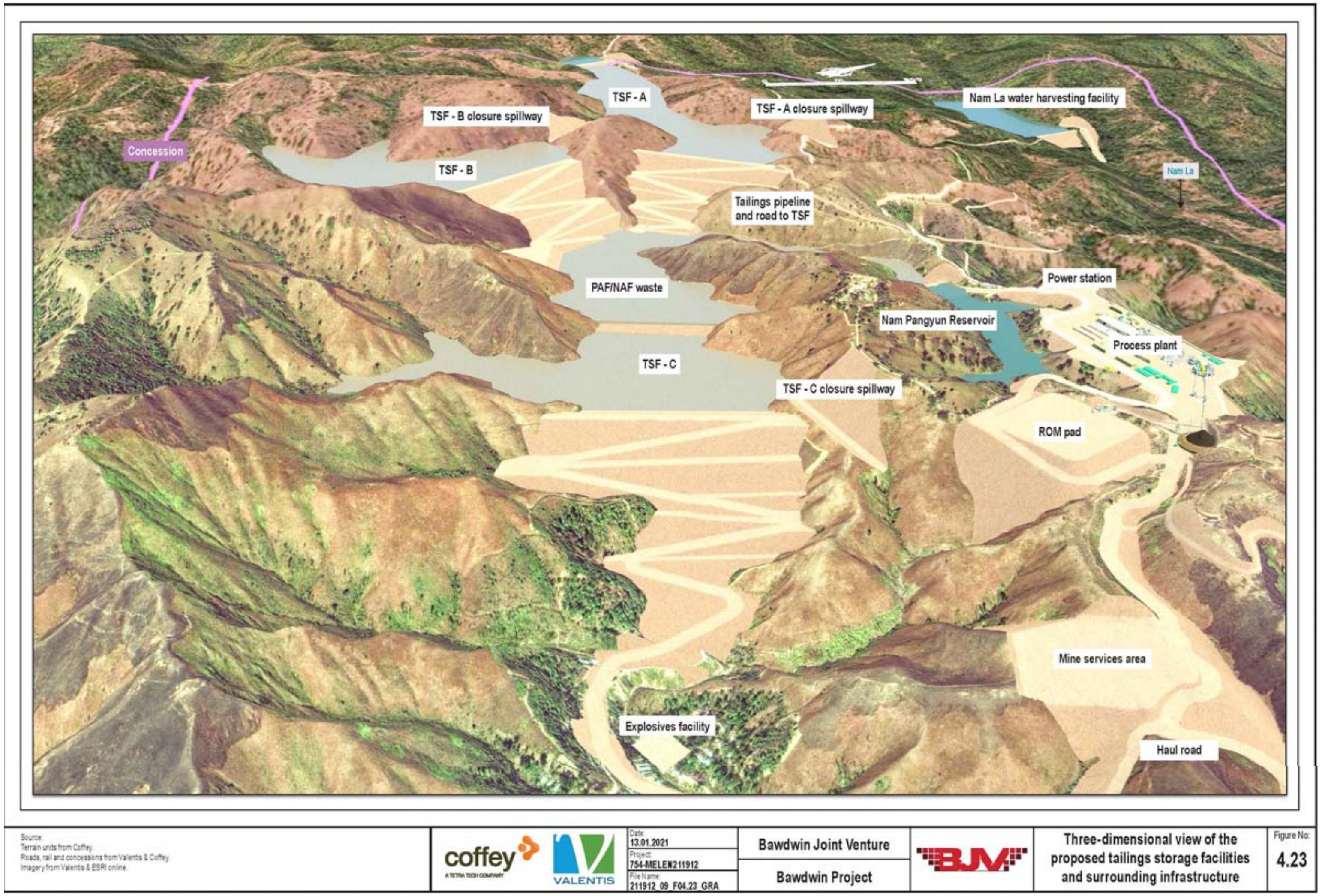


Figure 4.23 Three-dimensional view of the proposed tailings storage facilities and surrounding infrastructure

The shape of the valley is moderately efficient for tailings storage with deposition points required along the main embankment and additional point deposition locations; two located in the upstream end of basin, one in a sub-valley in the west of the facility, one located on the saddle dam in the main valley and a final point in a sub-valley in the southern part of basin. The decant pond will be concentrated against the natural valley slope in the northwest of the facility.

The embankment A volume was calculated based on the topography. The embankment volumes at final stage (crest elevation of 1,298 m RL) is approximately 5.95 Mm^3.

The water from a sub-catchment upstream of the TSF would be intercepted and temporarily stored in the TSF A diversion dam prior to being pumped to the process plant for raw water supply. In the final stage of the TSF construction a saddle dam will be constructed to prevent tailings from entering the Nam La catchment to the north.

On closure, the spillway will discharge excess water into the Nam La catchment.

Tailings storage facility B

TSF B is located to the south of TSF A and has a catchment area of 77 ha. The valley sides at the embankment location have an approximate slope of 1V:2H with the valley floor sloping at approximately 1V:10H to the east. The base of the valley at the embankment centreline is at approximately 1,205 m RL. The deposition modelling indicates that a final embankment level of 1,302 m RL would have a storage capacity for 9.1 Mt of tailings.

The shape of the valley has a low efficiency for tailings storage with deposition points required along the southern boundary of basin. The decant pond will be concentrated against the natural valley slope in the north of the facility. On closure, the spillway will discharge excess water into TSF A (and subsequently the Nam La catchment to the north).

The embankment volume was calculated based on the topography. The embankment volume at the final stage (crest elevation of 1,302 m RL) is approximately 7.15 Mm^3.

Tailings storage facility C

TSF C is located approximately 1.5 km to the northwest of the pit. The facility has a catchment area of 224 ha upstream of the embankment location. The valley sides at the embankment locations have an approximate slope of 1V:1.3H with the valley floor sloping at approximately 1V:16H to the southeast.

The base of the valley at the embankment centreline is at approximately 1,090 m RL. The deposition modelling indicates that a final embankment level of 1,215 m RL will have sufficient storage capacity for 7.1 Mt of tailings and also 7.3 Mt of waste rock materials in the northern part of the basin. Immediately upstream of the embankment, the PAF rock will be capped with tailings. Additional non -acid generating waste can be placed in this facility on top of the PAF waste to buttress the embankments of TSF A and TSF B if required or preferred from a waste economics perspective.

The layout of the TSF along with a cross section highlight where PAF will be placed are shown in

Figure 4.24.

The shape of the valley is moderately efficient for tailings storage with deposition points required along the main embankment and two additional points located in the valleys to the west of the facility. The decant pond will be concentrated against the boundary of NAF materials in the northern part of the basin.

The embankment C volume was calculated based on the latest topography files that have been provided. The embankment volume at the final stage (crest elevation of 1215.1 m RL) is about 11.3 Mm^3.

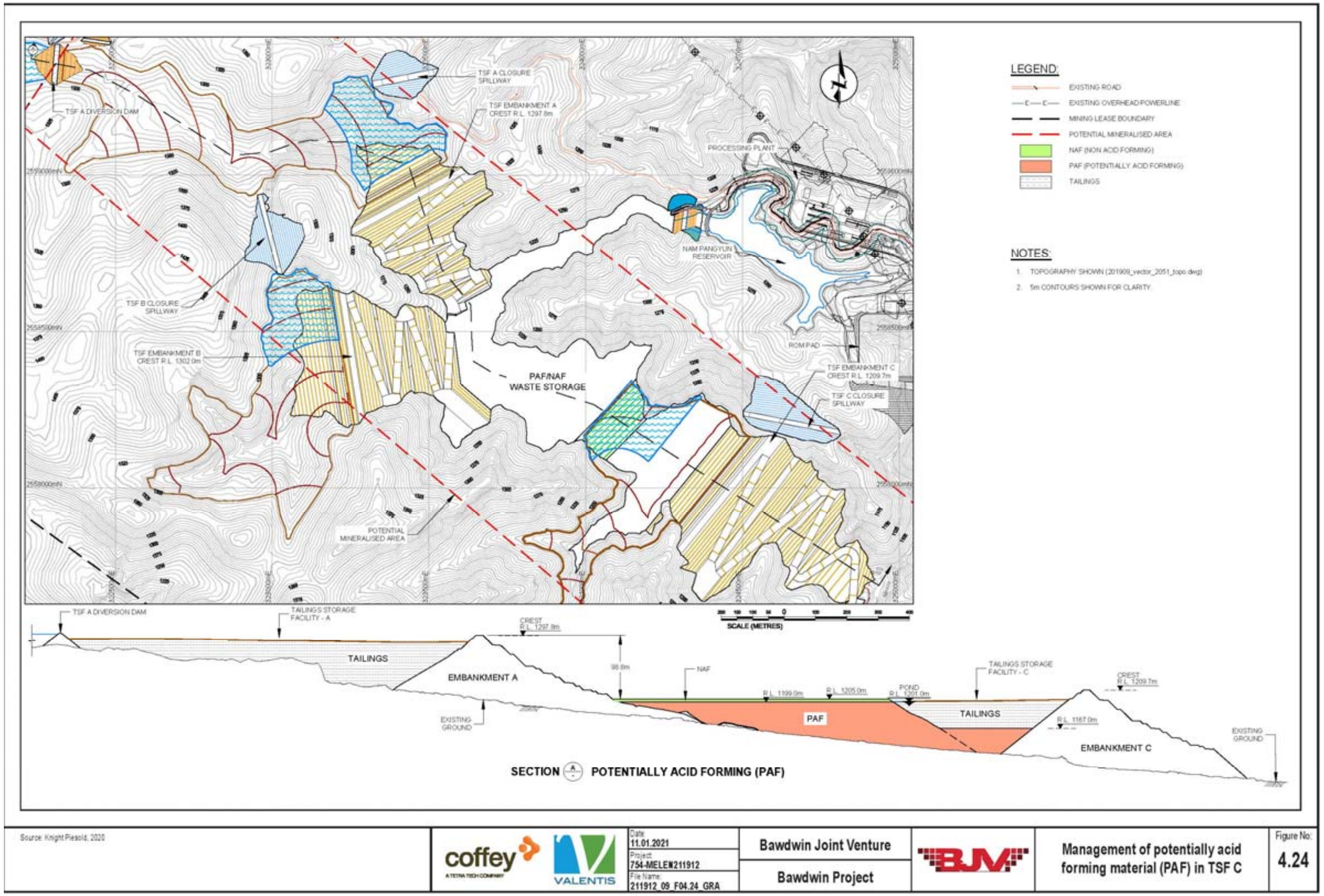


Figure 4.24 Management of potentially acid forming material (PAF) in TSF C

TSF embankment designs

The TSF designs consider the geotechnical data obtained as part of the geotechnical investigation by Knight Piesold (Appendix A). This involved an evaluation of the sub-surface conditions of each of the proposed TSF locations. This included completing 21 bore holes (8, 10 and 3 at TSF A, TSF B and TSF C respectively) and 34 test pits (8, 10, and 14 at TSF A, TSF B and TSF C respectively).

A single embankment design is proposed for each TSF. The upstream embankment batter slopes of each facility are 1V:2.5H with benches included for each raise. The downstream inter-bench slopes are 1V:2H with benches and access ramps provided that reduce the overall slope profile to less than 1V:3H.

The proposed tailing depositional arrangement (Appendix A) will result in water ponding against the embankment at the early stages of operation. Therefore, the embankments have been designed with a 1.5 mm high-density polyethylene (HDPE) liner on the upstream batter, upstream and downstream structural zones (Zone C1 and C2), a low permeability core (Zone A) and fully intercepting filters (Zones F1 and F2) downstream of the core which report to a basal filter/drainage blanket. In addition, the filters and drainage blanket report to an outfall drain to safely pass seepage flows to the downstream toe of the embankment.

The structural zone has been designed to allow for placement of cohesive oxide and transitional waste (Zone C1) and fresh granular waste rock (Zone C2) to match with the anticipated waste production schedule from the pit.

The embankment design for TSF A is shown in

Figure 4.25. Embankment designs for TSF B and TSF C are similar and are presented in

Figure 4.26.

Based on the feasibility designs excessive drying of tailings is not anticipated during active deposition due to the high rate of rise of the tailings facilities and relatively small beach areas. Tailings will be deposited to the TSFs sequentially, with the first TSF reaching capacity before deposition into the next TSF commences. However, post closure of each TSF, a robust closure cover system will need to be installed that is resistant to erosion and dust generation.

The criteria adopted for the TSF design are summarised in Table 4.23. The TSF risk assessment, geotechnical design criteria, and hydraulic design criteria dams have been designed in accordance with guidelines prepared by The Australian National Committee on Large Dams Incorporated (ANCOLD Inc) (Appendix A). These are considered to be international best practice guidelines.

Stability analyses were conducted using SLOPE/W software, developed by GeoSlope International (Appendix A). Limit equilibrium stability analyses were conducted under short-term (undrained), long-term (drained), and post-seismic loading conditions in accordance with ANCOLD guidelines (ANCOLD, 2012) that recommend factors of safety for tailings facilities 1.5 for long term drained and short-term undrained (potential loss of containment), 1.3 for short-term undrained (no potential loss of containment), and 1.0 – 1.2 post seismic conditions.

The results of the stability analyses are summarised in

Table 4.24. The stability assessment indicates that the embankment designs satisfy the minimum FoS recommended by ANCOLD (ANCOLD, 2012).

Table 4.23 TSF design criteria

Criteria	Unit	Value
Tailings Production and Properties		
LOM tailings throughput	Mt	32.2
Average annual tailings production	Mt	2.59
Tailings percent solids (thickened tailings)	%	60
Tailings deposition dry density	t/m^3	1.14 to 1.42
Tailings beach slope	-	1V:100H
Tailings deposition method	-	Sub-aerial
Tailings geochemistry	-	NAF, high metals
TSF Risk Assessment		
Severity of damage and loss	-	Catastrophic
Population at risk (assuming resettlement occurs)	-	10 to 100
Dam failure consequence category	-	High A
Severity level - environmental spill	-	Minor
Environmental spill consequence category	-	High C
TSF Embankment Design Criteria		
Embankment crest width (final stage)	M	21
Upstream embankment slope (excluding benches)	-	1V:2.5H
Downstream embankment inter-bench slope	-	1V:2H
Overall downstream embankment slope	-	<1V:3H
Raise construction method	-	Downstream
Geotechnical Design Criteria		
Static long-term drained factor of safety (FoS)	-	1.5
Static short-term undrained FoS (potential loss of containment)	-	1.5
Static short-term undrained FoS (no potential loss of containment)	-	1.3
Post Seismic FoS	-	1.0 – 1.2
Hydraulic Design Criteria (Freeboards)		
Wet season storage allowance	AEP	1:100 wet season
Extreme storage allowance	AEP	1:100 72 hr flood
Contingency freeboard (wave run-up)	AEP	1 in 10 AEP wind
Spillway capacity (design flood)	-	Probable maximum flood (PMF)
Wave freeboard above spillway maximum water level	M	None
Dam Design Earthquake Loading		
Operation phase - OBE	AEP	1:1,000
Operation phase - SEE	AEP	1:10,000
Post closure	AEP	Maximum considered earthquake (MCE)

Table 4.24 Stability modelling results

Loading Condition	TSF A (Factor of Safety)	TSF B (Factor of Safety)	TSF C (Factor of Safety)
Drained	1.56	1.71	1.72
Undrained	1.55	1.63	1.59
Post-seismic	1.29	1.36	1.29

Cut-off trench

In order to reduce the potential for shallow seepage under the embankments, the low permeability core (Zone A) extends below the finished ground level and a cut-off trench is also included under centre of the core. The cut-off trench will be excavated to a depth of nominally 5 m (depending on ground conditions), backfilled with Zone A and form a continuous structure under the core in each embankment. The side slopes of the cut off trench have been designed at 1V:1H to allow compaction of material against the excavation batter.

Under drainage system

The supernatant water was found to be of a very poor quality, with numerous metals exceeding the guidelines by several orders of magnitude. As such, and in consideration of the fractured rock typically encountered across the wider site area, the TSFs require robust measures to reduce seepage and mitigate risks to downstream groundwater and surface waters. The TSF design will incorporate an underdrainage system to reduce seepage and promote consolidation.

A basin underdrainage system has been designed to reduce basin seepage and encourage dewatering and consolidation of the tailings. The underdrainage system also includes embankment toe and bench drains to promote drainage of the upstream embankment batter and reduce the hydraulic head acting on the upstream HDPE liner.

The basin underdrainage system is located within the natural drainage lines at each TSF site. The drains comprise a trapezoidal cut channel with side slopes of 1V:2H, base width of 2,000 mm and a depth of 900mm. The outer 300 mm of the drain will be filled with fine filter sand (Zone F1) which will have an inner 300 mm gravel drainage media (Zone F2). Two 100 mm diameter Class 400, slotted HDPE drain coil pipes with filter sock will be installed in the collector drains.

Embankment toe drains will be constructed at the upstream toe of each embankment comprising trapezoidal drains with a depth of 900 mm. The outer 300 mm of the drain will be filled with fine filter sand (Zone F1), with an inner zone of gravel drainage media (Zone F2) surrounding the drain pipes (2 No. 100 mm diameter Class 400, slotted HDPE drain coil pipe with filter sock). Embankment bench drains will also be constructed along the upstream bench of each embankment with the same dimensions and design components as the toe drains.

The basin underdrains and embankment toe and bench drains report to the underdrainage sump with the flows pumped to the supernatant pond via a riser pipe. The riser pipe will be placed in a trench cut up the natural abutment.

An underdrainage plan is provided in

Figure 4.27.

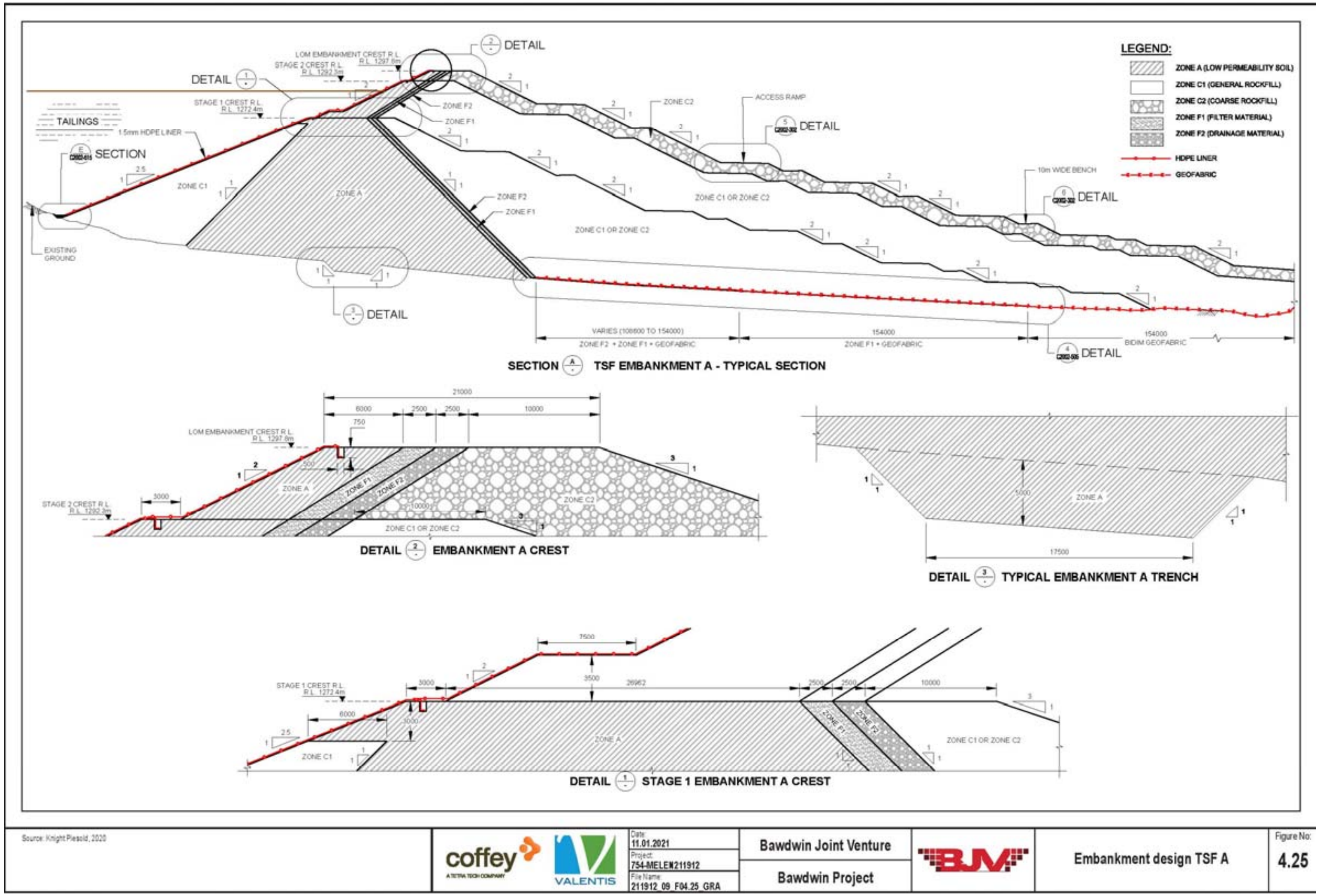


Figure 4.25 Embankment design TSF A

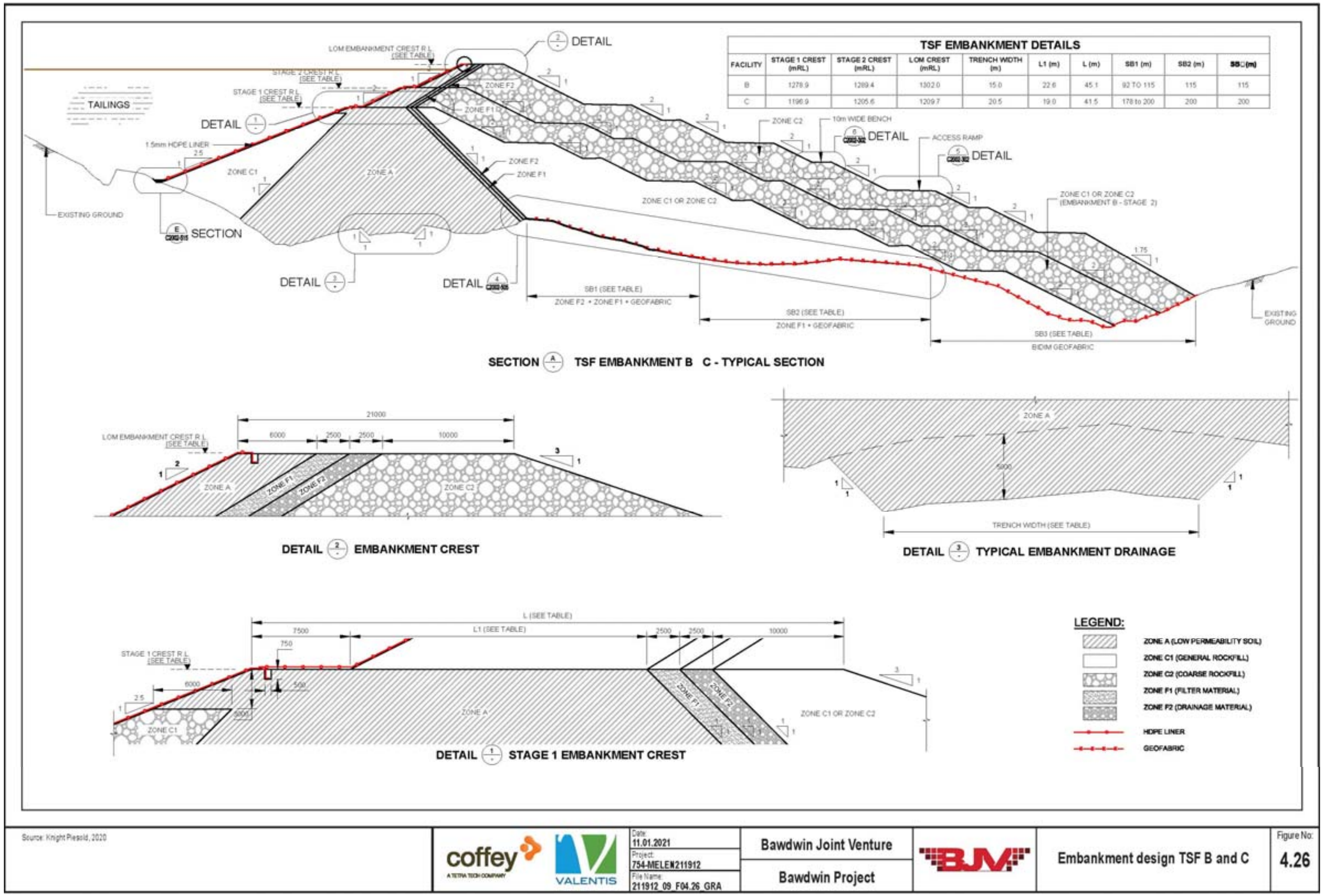


Figure 4.26 Embankment design TSF B and C

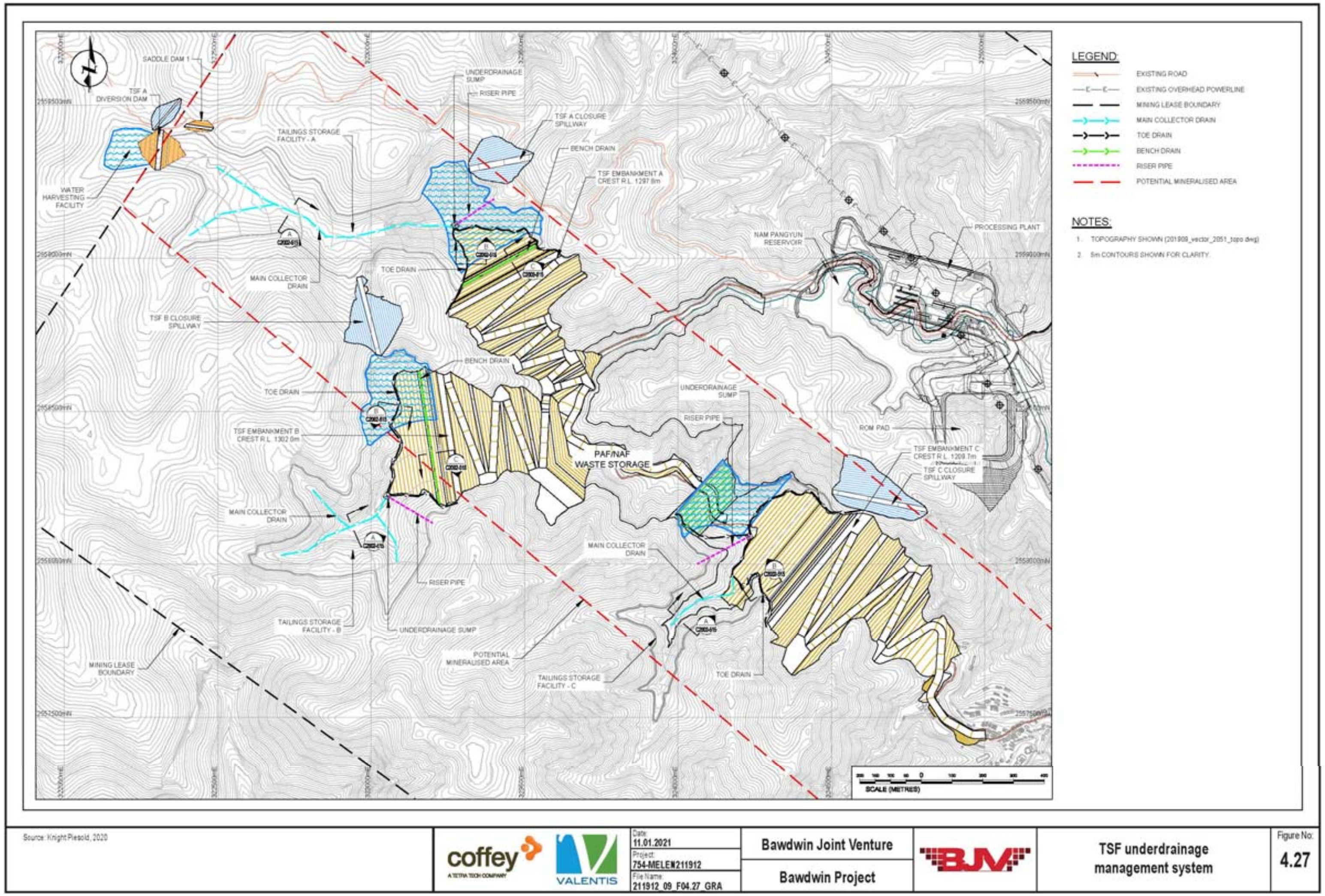


Figure 4.27 TSF underdrainage management system

Embankment internal drainage

The TSF embankments have been designed with an internal drainage system to reduce pore pressures in the downstream structural embankment zones and seepage uplift pressures in the foundation.

The internal filter and drainage zones downstream of the low permeability embankment core drain to a basal sand blanket layer consisting initially of Zone F1, F2 and geotextile, reducing to Zone F1 and geotextile after a variable distance (related to embankment height) before reducing again to just a geotextile to the downstream toe. Where the sand blanket changes composition secondary seepage drains are positioned to drain flows to a central seepage outfall drain located along the valley spine to safely drain the flows beyond the downstream toe of the embankment. The secondary seepage drains comprise trapezoidal drains constructed on the foundation and consist of a 1 m thick Zone G material (clean, coarse rockfill) overlain by a 300 mm layer of Zone F2 drainage media. The main seepage outfall drain comprises a 2 m thick layer of Zone G in the valley spine overlain by 300 mm layers of both Zone F2 and F1.

Tailings and decant return pipelines

Tailings and decant return pipelines will run between the process plant and each facility. A service road will be constructed to nominally follow the pipeline route. Where the road and the pipeline route coincide, the road cross section will be a 1 m shoulder, 3 m wide lane, 1.5 m for a drain and a 2 m wide service corridor including 300 mm high berms. At approximately 500 m intervals a passing bay will be required.

Tailings slurry will be pumped to the facilities via a high density polyethylene (HDPE) pipe. This pipe will be located in a bunded corridor designed to contain the spills should the pipeline fail.

Water will be decanted from the TSFs and pumped back to the process plant via a HDPE pipeline which will be installed within a bunded corridor. The decants will be mounted on barges to allow for the rapid filling rates and significant movement of the supernatant ponds during the early phases of operation which prevents the use of fixed location decant systems such as towers.

WMM will monitor the tailings pipeline for leaks, ruptures or failures and, in the event of such failures, implement shutdown procedures. Pump pressure and flow monitoring will assist with detecting leaks or blockages within the tailings pipeline. Visual inspections of the pipeline will also be undertaken regularly during operations.

Crest settlement

Knight Piesold predicted crest settlement (Appendix A) of around 1 m in the TSF embankments. Accordingly, the embankments have been designed with appropriate freeboards and internal filter zones of sufficient width to accommodate the expected deformations. Knight Piesold recommend further detailed deformation analyses for the detailed design of the embankments to verify these estimates.

Spillways

Each tailings facility has a spillway for the final stage of operation to prevent water accumulating in the storages. The spillways have been designed to safely pass the rainfall runoff generated as a result of critical duration probable maximum precipitation PMP storm event while meeting appropriate hydraulic and revetment stability criteria. A PMP storm event is the theoretical maximum precipitation for a given duration under modern meteorological conditions.

In TSF A, the spillway is located in the north of the facility and discharges into the Nam La catchment. In TSF B the spillway flows to TSF A (and subsequently the Nam La valley). The operational spillway in TSF C cuts through a ridge to the east of the embankment crest into an adjacent valley, which then drains back into the Nam Pangyun stream between the downstream toe of the embankment and the pit.

4.8.3 Design and construction controls

WMM will comply with the Global Industry Standard on Tailings Management (Global Tailings Review, 2020) and the International Commission on Large Dams (ICOLD) standards and guidelines. WMM will implement a range of construction controls to manage risk associated with the tailings facility lifecycle. These will include but are not limited to:

- The Engineer of Record (role described below) shall prepare a Design Basis Report (DBR) that details the design assumptions and criteria, including operating constraints, and that provides the basis for the design of all phases of the tailings facility lifecycle. The DBR shall be reviewed by the Independent Tailings Review Board (described below) or senior independent technical reviewer.
- Develop a design for each stage of construction of the tailings facility, including but not limited to start-up, partial raises and interim configurations, final raise, and all closure stages.
- Design the closure phase with sufficient detail to demonstrate the feasibility of the closure scenario and to allow implementation of elements of the design during construction and operation as appropriate.
- Construct each TSF according to the design intent, using qualified personnel and appropriate methodology, equipment and procedures, and data acquisition methods.
- Implementing quality control and quality assurance procedures in accordance with international best practice.
- Implement a construction vs design intent verification (CDIV) process to ensure that the design intent is implemented and is still being met if the site conditions vary from the design assumptions.
- Prepare a detailed Construction Records Report ('as-built' report) on completion of construction and whenever there is a material change to the tailings facility, its infrastructure or its monitoring system. This report will be reviewed and approved by the Engineer of Record and the Responsible Tailings Facility Engineer (these roles are discussed below).
- Develop, implement, review annually and update as required an operations, maintenance and surveillance (OMS) manual that supports effective risk management as part of the tailings management system. The OMS manual will follow best practices, clearly provide the context and critical controls for safe operations, and be reviewed for effectiveness.
- Implement a formal change management system that triggers the evaluation, review, approval and documentation of changes to design, construction, operation or monitoring during the tailings facility lifecycle. The change management system shall also include the requirement for the Engineer of Record to prepare a periodic deviance accountability report, that provides an assessment of the cumulative impact of the changes on the risk level of the as-constructed facility.

4.8.4 Tailings deposition

The deposition of tailings into the three facilities will occur sequentially. All tailings will first be deposited in TSF A, before being placed in TSF B once TSF A is full, and then TSF C once TSF B is full.

Tailings deposition into the facilities will commence from the embankments to push the decant pond away to the northern part of each facility from where supernatant water and rainfall runoff will be recovered via a decant pump installed on a floating barge. The final stage in each TSF allows for the pond to be directed towards the closure spillway location.

Tailings will be discharged into the facilities by sub-aerial methods of deposition utilising banks of spigots along with additional single point discharge as required to manipulate the ponds towards the decant locations.

Sub-aerial deposition allows for the maximum amount of water removal from the facility by the formation of a beach for drying and draining, compared to sub-aqueous deposition. However, the relatively high rate of rise will limit drying and water recovery to some extent. Together with keeping the pond size to a minimum, sub-aerial deposition will increase the settled density of the tailings, and hence maximise the storage potential and efficiency of each facility.

Tailings deposition within the three facilities was modelled to predict tailings storage capacity, tailings beach contours and supernatant pond configurations under a range of conditions throughout the life of mine. The deposition modelling results are presented in Table 4.25.

Table 4.25 Deposition modelling results

Tailings Storage Facility	Tailings Capacity (Mt)
TSF A	8.2
TSF B	9.1
TSF C	7.1
Total	24.4

4.8.5 TSF water management

Based on the water balance modelling by Knight Piésold (Appendix A) the following conclusions were reached in regard to water management of the TSFs.

Collecting and redirecting TSF seepage via an underdrain system is a critical design feature. The TSF underdrain water will flow under gravity into a sump, whereupon it is continuously pumped, via a riser pipe, back into the TSF supernatant pond. The underdrain will facilitate a reduction in pressure at the engineered wall.

Seepage estimates are expected to steadily increase during the first five years of operations with monthly estimates peaking in Year 10 and Year 11 with approximately 40,000 m^3 (54.8 m m^3/h) predicted. Seepage estimates over the life of mine are presented in

Figure 4.28.

The supernatant pond levels under 1 in 100 average recurrence interval (ARI) wet conditions generally sit at higher elevations than the maximum tailings beach elevations at the embankments throughout the life of mine. As such, the embankment crest elevations were defined based on the elevation of the pond based on the following criteria:

- Embankment Stages 1 and 2 are designed with a wet pond storage area to accommodate a 1 in 100 Year ARI plus probable maximum precipitation (PMP) inflow plus a 1 m contingency.
- Embankment Stage 3 is designed with a wet pond storage area to accommodate a 1 in 100 Year ARI and a 1 in 100 ARI 72 Hour Inflow (Extreme Storm Storage Allowance), plus a 1 m contingency freeboard plus a PMP spillway depth and 1 m dry freeboard.

To avoid storing a large amount of water within the TSFs that has negative impact on embankment stability, tailings density and requires increased embankments crest elevations, excess supernatant water will be treated and discharged to the environment. The predicted volume of this water that will be treated and discharged during the life of mine (before closure of the tailings facilities) under average meteorological conditions is estimated to be approximately 13 M m^3 per year consisting:

- 2,853,730 m^3/year for TSF A.
- 3,173,970 m^3/year for TSF B.
- 6,663,028 m^3/year for TSF C.

This volume would rise marginally during 1 in 100 ARI annual wet conditions.

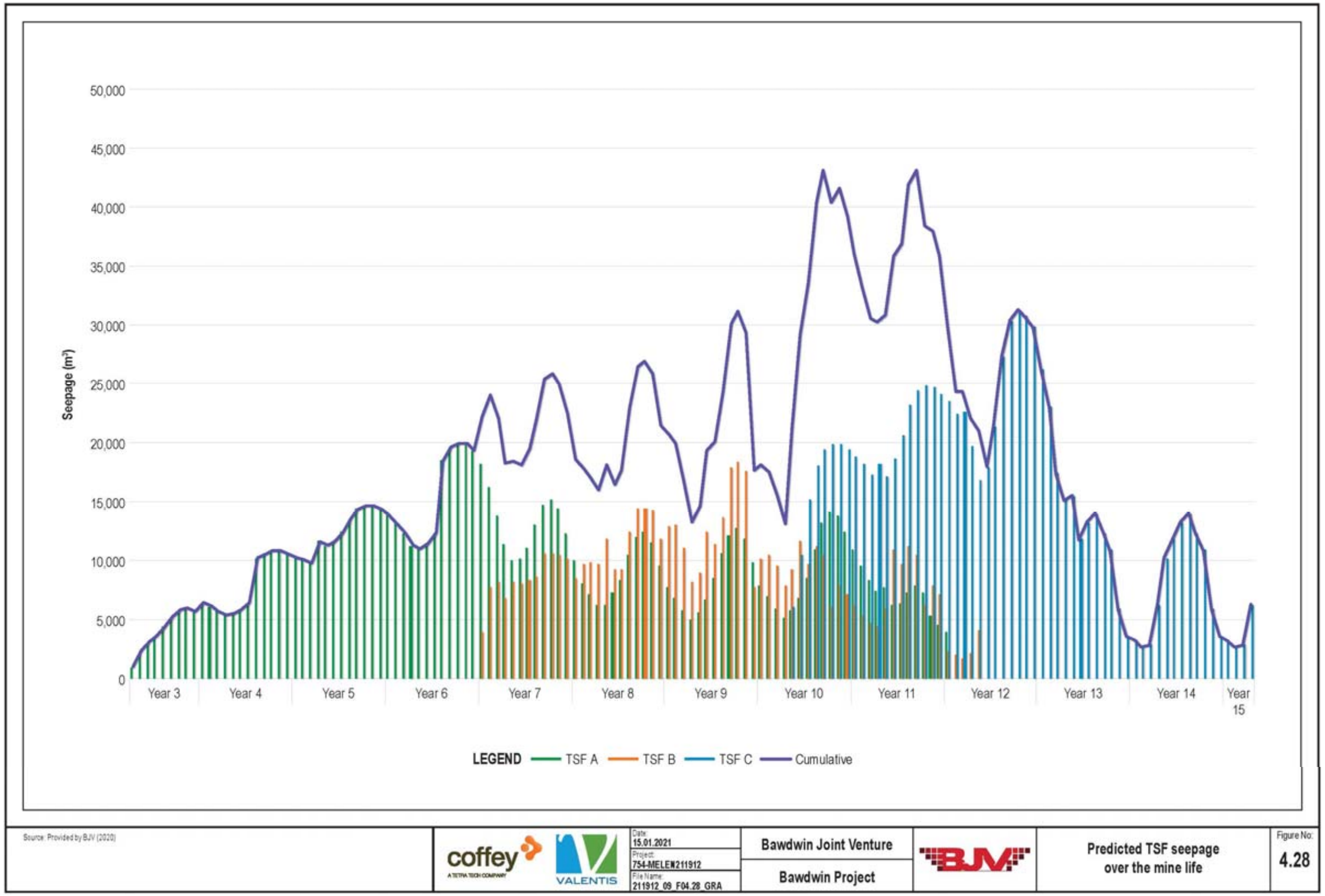


Figure 4.28 Predicted TSF seepage over the mine life

The discharge volumes have been adjusted to avoid any process shortfall in the subsequent dry season. As such, discharge is required once the supernatant pond volume within any TSF exceeds 100,000 m^3. The required discharge volume varies from 0.04 m^3/sec for TSF B & C and 0.01 m^3/sec for TSF A.

Under average conditions, the water return (as a percentage of water in slurry) from the TSFs varies from 40% to 65%.

Water release to the environment (i.e., spillway discharge) is not anticipated under average conditions from the TSF A Diversion Dam until the end of Year 9. Once the tailings beaches on TSFs A and B are rehabilitated in end of Year 9, approximately 2,000 m^3/month to 382,000 m^3/month (2.7 m^3/hr to 523.3 m^3/hr) of offsite release into the Nam La will occur from the TSF A spillway under average conditions. The TSF C spillway inlet elevation results in a permanent pond (minimum 2 m deep) over the PAF storage area. At the end of Year 12, approximately 5,000 m^3/month to 417,000 m^3/month (6.9 m^3/hr to 571.2 m^3/hr) of offsite release into the Nam Pangyun will occur from the TSF C spillway under average conditions.

Excess supernatant water from the TSFs will be treated using a water treatment microfiltration plant located at the process plant to remove fine particles, residual reagents and heavy metal cations at a constant flowrate of 140 m^3/hr. The treated water will be discharged to the Nam Pangyun, while the backwashed sludge will periodically report to the tailings tank. A water piping system will be designed to pump water from the TSFs to the water treatment plant and then from the water treatment plant to a discharge point on the on the Nam Pangyun.

4.8.6 TSF operational management and monitoring

The design of the embankments includes installation of series of multi-level vibrating wire piezometers. At each piezometer location, multi-level sensors will be installed within the foundation and embankments at 25 m vertical intervals.

It is proposed that a series of inclinometers be installed within the embankments to monitor the internal movements. The inclinometers will be extended to a depth of 25 m below the natural ground surface to allow monitoring of movements within the foundations and embankments fill. Spider magnets and plate magnets will be installed within the inclinometer casing and fill respectively at 25 m vertical intervals to monitor the settlement. The inclinometer casing will need to be extended as the embankments are constructed.

Groundwater monitoring bores will be installed to monitor groundwater levels and water quality. There will be two pairs of monitoring bores at the downstream toe of each embankment (comprising a shallow borehole (nominally 5 to 10 metres deep) to target perched groundwater and a deep borehole (nominally greater than 30 metres) to target groundwater within weathered rock.

Other operational monitoring will include:

- Water quality monitoring (including concentrations of cyanide) of supernatant water and discharges.
- Operational performance including (but not limited to) regular bathymetric surveys of tailings surface, deposition performance, seepage flow rates, supernatant pond depth and available freeboard, and flow rates of tailings and decant return pipelines.

The WMM will implement an audit program based on international best practice that will include:

- An annual construction and performance review by the engineer of record or senior independent technical.
- A five-yearly independent dam safety review. The review shall include technical, operational and governance aspects of the tailings facility and shall be completed according to best practices.

4.8.7 TSF governance

WMM recognises the importance of a robust governance framework for the construction, operation and closure of its' TSFs. Measures that will be implemented and further developed during the detailed design stage include:

- Establish a tailings governance framework and ensure that the environmental management system and other critical systems encompass relevant aspects of the tailings facility management.
- Appoint one or more Accountable Executives who is/are directly answerable to the CEO and shall be accountable for the safety of tailings facilities and for avoiding or minimising the social and environmental consequences of a tailings facility failure.
- Appoint a site-specific Responsible Tailings Facility Engineer who is accountable for the integrity of the tailings facility, who liaises with the EOR and internal teams such as operations, planning, regulatory affairs, social performance and environment, and who has regular two-way communication with the Accountable Executive.
- Engaging an engineering firm with expertise and experience in the design and construction of tailings facilities of comparable complexity to provide engineer of record services for operating the tailings facility.
- Appoint an Independent Tailings Review Board that reports to the Accountable Executive and certify in writing that the WMM follow best practices.

4.8.8 TSF closure

Closure of TSFs will occur progressively once each facility reaches capacity. The timing of closure will also take into account drying time for tailings, to facilitate access for subsequent placement of capping materials.

The top surface of each facility will require a cover system on closure which is resistant to erosion to isolate the tailings from the environment. In addition, the cover system requires a low permeability layer to prevent ongoing recharge of the tailings mass to reduce long term seepage.

Based on the climatic conditions, the Bawdwin site is well suited to a composite store and release / low permeability cover system. The store and release cover system will comprise a basal capillary break layer (e.g. inert ROM waste rock) to prevent upward migration of salts from the tailings, overlain with a low permeability soil layer which reduces infiltration into the tailings. This is in turn overlain by a storage zone (typically silty sand and gravel) which retains rainfall and maintains saturation of the basal clay layer. The storage zone is then overlain with topsoil to support plant growth. The vegetation, which will reduce the erosion potential, is supported through the dry season by rainfall stored within the cover system.

On closure the operational spillways will be excavated further to drain the facilities, minimise the pond volume stored on the tailings and to allow flood events to be safely discharged. The closure spillways will be designed to safely pass the rainfall runoff generated as a result of critical duration PMP storm event while meeting appropriate hydraulic and revetment stability criteria.

4.8.9 Forward works

Further works that will contribute to the design and operation of the TSFs are proposed and are outlined in Table 4.26.

Table 4.26 Forward works relating to the design and operation of the TSFs

Item	Purpose	Detail
Geotechnical investigation of TSF area	Confirm stability of the TSF embankments and the diversion and saddle dams.	Site specific geotechnical drilling of proposed TSF location and subsequent assessment including deformation analyses.
Hydrogeological investigation of the TSF locations	• Refine the understanding of groundwater conditions. • Refine seepage predictions.	Geohydrological drilling and field testing of geohydrological parameters.
Construction materials balance	• Confirm there is suitable filter and drainage material for construction of the TSF and WRD and other waste storages.	Field investigations to determined available volume of suitable filter and drainage material.
Geochemical properties of tailings samples	• Refine predictions of supernatant water quality in the TSFs. • Refine prediction of seepage quality.	Further laboratory testing of representative tailings samples including kinetic leach tests.
Contaminant fate and transport modelling of TSF seepage	• Refine predictions of seepage quantity and quality. • Evaluate the proportion of seepage not captured by the TSF under-drainage system. • Assess potential impacts to groundwater.	Develop a numerical groundwater model incorporating both quantity and quality based on the results of geochemical testing and hydrogeological investigations.
Post closure water quality	Predict post-closure quality of run-off water from the TSFs, including water quality reporting to the Nam La catchment.	Use chemical mass balance and loading calculations (or other method), based upon updated site flow and water quality data.
Closure plan update	• Provide detailed assessment and plans to satisfy regulatory progress. • Guide WMM closure/rehabilitation activities. • Allow refinement of closure costs.	An update is required within 3 years of the project operations this will include but not be limited to detailed of closure spillways, cover designs, post closure water management and identification of potential cover materials and sources.
Detailed design of each TSF, plus associated water quality treatment plant.	• Develop detailed design and construction drawings. • Develop surface water and seepage managements system.	Detailed designs will comply with the Global Industry Standard on Tailings Management (Global Tailings Review, 2020).

4.9 Water supply and management

4.9.1 Raw water supply

The project will require raw water for the process plant, mining services area and accommodation camp and a potable water supply. The raw water requirements for stead state operations are shown in Table 4.27.

Table 4.27 Project water demand

Raw Water Requirements	Unit	Design
Process plant	m^3/hr	134.1
Accommodation camp	m^3/hr	3.0
Mine services area	m^3/hr	1.0
Potable water	m^3/hr	12.8
Site total	**m^3/hr**	**150.9**

The project is in a high rainfall environment and receives roughly 1.4 m of rainfall each year. To investigate water supply, Knight Piésold completed water balance modelling and run-off investigations. A range of water supply options were investigated during the PFS and DFS. The chosen water supply option comprises several sources including:

- Nam La Stream – primary clean water source.
- Nam Pangyun – secondary clean water sources (from the TSF A diversion and the Nam Pangyun reservoir).
- TSF decant return – primary raw water source.
- Marmion Shaft – limited use potentially for dust suppression.

Nam La Stream

Water abstraction from the Nam La is the preferred primary water supply source for the project. This decision was based on its suitable location 1.7 km from the process plant, an access point located on the Bawdwin concession, the quality of the water, and the availability of water particularly during the wet season. The Nam La is, however, an important water source for downstream users; the Nam La Flume supplies the Tha-Ta-La (Win Myint Mo) Quarter consisting of four villages on the outskirts of Namtu township, as well as the Pan Hai market area of Namtu township, which relies on the Nam La for year-round water supply.

To enable the use of Nam La as the primary water source for the project, Knight Piésold designed a water harvesting facility in the upper reaches of the Nam La valley. The design has an upstream catchment area of 3.62 km^2 (360 ha), which equates to 10.2% of the total catchment area. The dam will contain 1,125,840 m^3 to provide a guaranteed year-round source of good-quality raw water. The dam design includes a large spillway to allow excess water to decant from the dam during operation and after closure.

To ensure that water supply to Namtu township is not affected, WMM will ensure that flow of the creek is maintained. During construction, the headwaters of the Nam La will be diverted around the embankment construction area by diverting the stream using pipework. During operations, WMM will actively maintain compensation flow downstream of the water harvesting facility via the spillway when the dam is full, or via an engineering or operational means such as a pumping. Most of the water required for the project will be captured during the wet season and then drawn down over the dry season. WMM will also maximise the use of water from other sources (i.e., Nam Pangyun and through recycling water through the TSF).

Further work is currently being completed to estimate the baseline flows of the Nam La and further modelling work will be completed to estimate required compensatory flows and to assess impacts to existing water supply to Namtu and potential ecological effects of reduced stream flow.

The proposed water harvesting facility embankment has been designed as a conventional earth fill water retaining embankment with upstream and downstream structural zones (Zone C1 and C2), a low permeability core (Zone A) and cut-off trench and fully intercepting filters (Zones F1 and F2) downstream of the core which report to a basal filter/drainage blanket. In addition, the filters and drainage blanket report to an outfall drain to safely pass seepage flows to the downstream toe of the embankment. A HDPE liner has also been included on the upstream batter as erosion protection and improved stability during rapid drawdown conditions.

The embankment has a crest elevation of 1,155 m RL resulting in an overall height of 25.2 m from the toe of the embankment. The upstream embankment batter slope is 1V:2.5H, the downstream batter slope is 1V:3H and the crest width is 12 m. A spillway has also been provided to safely pass a PMF event. The spillway channel will be excavated through in-situ weathered rock adjacent to the left abutment.

The design of the Nam La water harvesting facility is shown in Figure 4.29.

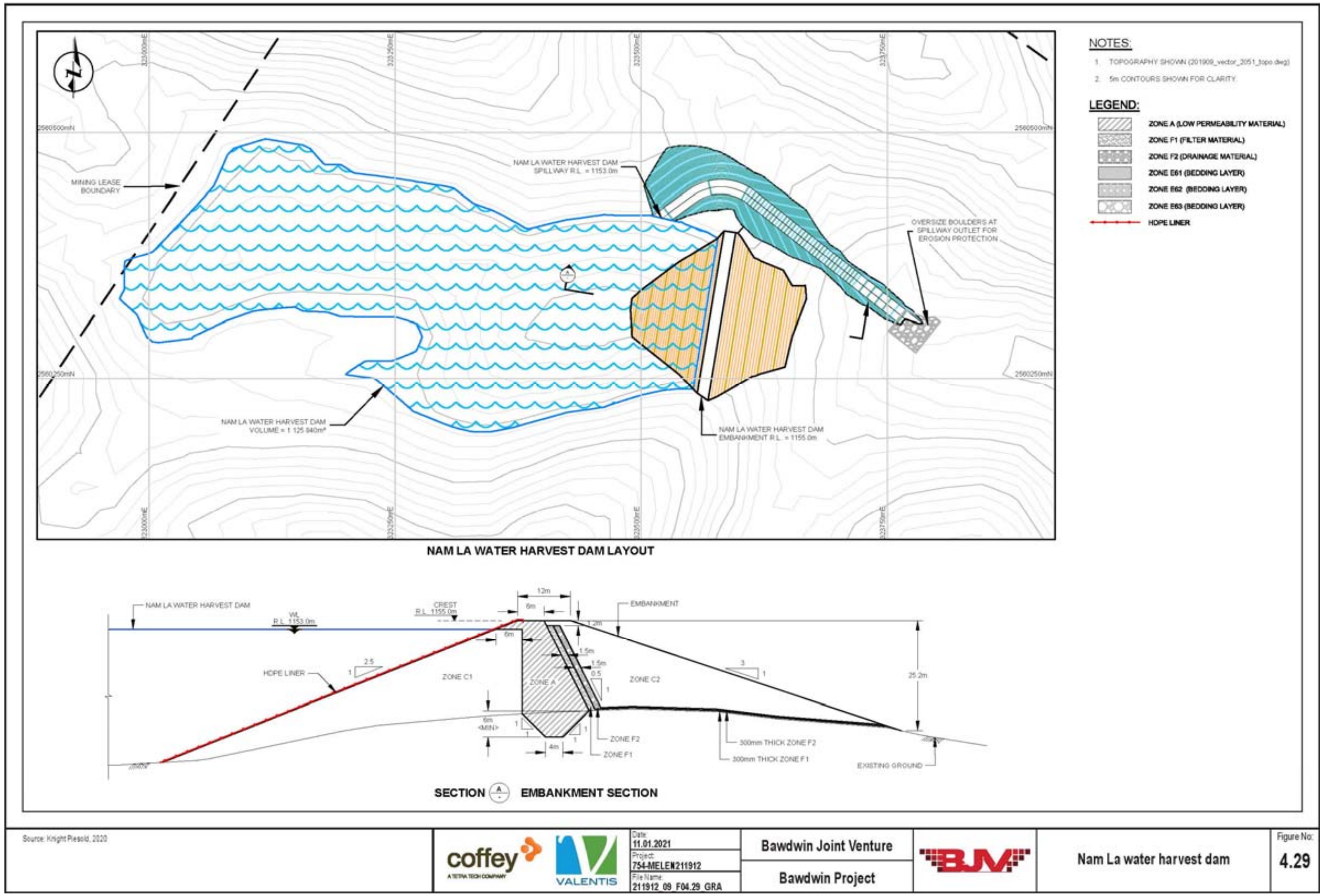


Figure 4.29 Nam La water harvesting facility

Nam Pangyun Stream

The northwestern section of the Nam Pangyun stream is a relatively clean source of raw water. The western side of TSF A will intersect the Nam Pangyun stream. It is proposed that a diversion dam will be constructed on the northwestern arm of TSF A, to intercept water flowing from upstream in the catchment and divert it around the TSF, thereby reducing run-on to the dam. The dam also provides an opportunity to pump the accumulated water to the process plant and satisfy a portion of the raw water requirement of the plant.

Knight Piésold have designed an embankment for the TSF A diversion dam (Appendix A). The upstream embankment batter slope is 1V:3H, the downstream batter slope is 1V:3H and the crest width is 16.8 m. The embankment of the TSF A diversion dam has been designed with a low permeability core (Zone A) and cut-off trench and fully intercepting filters (Zones F1 and F2) downstream of the core which report to a basal filter/drainage blanket. Coarse rockfill forms the retaining embankment with upstream and downstream structural zones (Zone C1 and C2).

Nam Pangyun Reservoir

An existing freshwater dam named the Nam Pangyun Reservoir, or 'Big Dam', is located adjacent to the proposed process plant location. It has a small catchment, at only three times its surface area, and is not fed by a water course. WMM propose to use this dam to store the raw water abstracted from the Nam La and Nam Pangyun streams. The raw water supplying the process plant will be pumped from the Nam Pangyun Reservoir to the raw water tank at the process plant. It is proposed the embankment will be upgraded to increase the dam capacity.

Knight Piésold have designed an embankment for the upgrade of the Nam Pangyun Reservoir (Appendix A). The new embankment will increase the storage capacity of the facility from approximately 446,860 m^3 to 483,390 m^3. The upstream embankment batter slope is 1V:2H, the downstream batter slope is 1V:2.5H and the crest width is 19.3 m. Stability analyses indicated that the facility has acceptable factors of safety under static drained / undrained and post seismic conditions. A spillway was designed to safely pass a PMF event.

A piping and pump system will connect the Nam Pangyun Reservoir to the raw water tank located at the process plant.

4.9.2 Dust suppression

The mining department will require 400,000+ m^3/annum (33,000 m^3/month) of water for dust suppression in the open pit and on the haul roads. It has been decided that water from the Marmion Shaft will be used for dust suppression.

4.9.3 Potable water supply

Potable water for the project will be supplied by reverse osmosis plant constructed at the process plant. An assumption of 90% water recovery to potable water has been incorporated into the site water balance. The reverse osmosis plant will treat approximately 8,202 m^3/day (<100 mg/L TDS) (341.8 m^3/hr). Approximately 34 m^3/day of brine will be produced by the reverse osmosis plant, which will be pumped to the tailings tank for discharge in the TSF.

4.9.4 Surface water management

The objectives for site surface water management for the project are to:

- Maximise the diversion of runoff from undisturbed areas and to minimise inflow to the project site and thereby minimising the volume of water that needs to be managed.
- Capture and manage surface water and groundwater flows from impacted catchments to ensure that there are no uncontrolled releases from the project and to ensure compliance with environmental discharge criteria.
- Maximise the reuse of water.
- Avoid the impact of flooding on project infrastructure and operations.
- Avoid the disturbance of existing surface water drainage channels and features, where possible.

Key aspects of site-wide water management include:

- Peak flow and volume management. Hard-stand areas and mine infrastructure increase the surface water runoff from these areas with consequent increases in peak flow rates and the runoff volumes. An internal drainage capture system will be designed to manage this water.
- Erosion control. Given that the mine site is located in an area with high rainfall and hilly topography, there is significant erosion potential on the site, particularly from disturbed areas. The management of surface water runoff will include controls for erosion and management of mobilised sediments (see below).
- Sedimentation control. Sedimentation is managed by slowing turbid flows using settling. A number of sediment control structures or ponds will be constructed to capture mobilised sediments.
- Stormwater system design criteria. Stormwater management infrastructure will be designed to account for large rainfall events.
- Water discharges. Investigations to determine the quality of water to be discharged are underway which will guide the management of water that is discharged into the environment.

The project area and surrounding topography is steep with the majority of the terrain sloping in excess of 20%, and approximately half of the terrain sloping in excess of 30%. The topography necessitates steep diversion channels in certain areas which will mean high flow velocities and high erosion potential in these channels.

Surface water management to prevent erosion and to control sediment requires an integrated approach, defining the discrete catchment/drainage areas, and allowing appropriate engineering solutions. To design the surface water management system, CSA Global (Appendix B) delineated catchments impacted by the project and estimated peak design flows based on a 100 year return period event to convey rainfall runoff from within the project area.

Key surface water management features include:

- Installation of sedimentation basins in each disturbed catchment/drainage area to limit sediment (and other contaminants) from entering natural drainage systems.
- Diversion of upstream surface water flows around structures where feasible with discharge into adjacent or downstream defined surface water drainage lines.
- Construction on or near natural drainage lines will be planned for the dry season, where practical.
- Use of temporary stabilisation measures (such as using soil binders, applying synthetic matting, straw or rip rap) will be used in high erosion risk zones. Areas of major erosion hazard will be identified and avoided, where practical, or specific management measures will be implemented in order to reduce erosion risk.

Conceptual surface water management designs have been developed to manage rainfall runoff and surface water in the vicinity of the open pit. Wherever possible, runoff from undisturbed surface water catchments draining towards the pit will be conveyed directly downstream of the pit, to a downstream water course, via a diversion channel (4.30). To mitigate in-channel flow velocities, channel slopes of a maximum of 1 in 200 have been adopted for the external diversion channel sections. Mitigating the in-channel flow velocities will reduce the requirements for riprap, concrete and reinforced concrete lined channels. All trapezoidal channels have a 1:1 side slope. Drop structures will be constructed with gabion basket fronting to mitigate undercutting, erosion and deterioration of the channel at the structures and will be placed at locations suitable to the topography to minimise channel earthworks. Where this is not possible, the runoff from undisturbed surface water catchments will drain to the pit and will require management and sediment settlement treatment consistent with disturbed runoff originating from the disturbed pit catchment.

CSA, 2020 (Appendix B) present detailed plans and sizing of the surface water management system around the pit and operational areas.

On overview of the surface water management system is presented in

Figure 4.30.

Particle size distribution analysis was undertaken on a soil sample obtained from the existing pit catchment area in order to characterise the sediment load of runoff from the current disturbed pit catchment and a sample from the Nam Pangyun immediately adjacent to the existing open pit. The particle size distribution indicates that the sediment load of existing runoff consists primarily of very fine particles, with approximately 95% of the sediment particles smaller than 100 µm in both samples, however there is a higher percentage of finer particles in the pit sample than that taken from the Nam Pangyun. Smaller particles have a slower settling velocity, and hence require larger sedimentation basin areas to provide the retention time to allow the particles to settle. There are limitations on suitable locations available for sedimentation basins, due to the steep topography at the site, and ultimately flocculant and coagulant dosing of discharge may be required to settle the finer particles in the sediment load.

The design flowrate of sedimentation basins downstream of the open pit, ROM pad, process plant and haul roads has been estimated based on the 1 in 2-year return period 30-minute duration event rainfall intensity of 55 mm/hr. The design targets the removal of approximately 80% of the 62 µm particle size, with a much higher removal of larger particle sizes. The basins are designed to operate with a permanent pond, which overflows during rainfall events.

4.9.5 In-pit river diversion

The Nam Pangyun is the primary water course that will be impacted by the open pit. The river currently flows in an open channel adjacent to the existing open pit. As the open pit expands, the pit will intersect the current alignment of Nam Pangyun, and require diversion for this portion of the river reach. An in-pit river diversion channel is proposed to convey flow from the natural river channel upstream, through the pit footprint and convey it to a discharge point back into the natural water course channel downstream of the pit.

A berm with a slope of approximately 1 in 25 has been incorporated into the western pit wall as part of the pit design, to facilitate the new road alignment and this berm will also accommodate the river diversion in tandem. The in-pit river diversion channel will be cut into the berm at a shallower slope than the berm slope, with drop structures in channel to compensate for the elevation difference. The river diversion channel will be shotcrete lined to prevent excessive erosion of the channel during high flows, and to mitigate seepage from the channel to the adjacent pit development.

4.9.6 Mine dewatering

Inflows into the open pit will comprise: groundwater inflows through permeable materials, structures and the bulk rock-mass, which will commence as the mine excavation progresses below the water table; and surface water inflows from rainfall runoff within the pit footprint itself and the immediately adjacent surface catchments which drain towards the pit, particularly during the rainy season.

A 3D numerical groundwater flow model was developed by CSA Global (Appendix B) for the Bawdwin project area and was used to predict groundwater inflows into the pit. Surface water pit inflows were derived from rainfall runoff from the surrounding catchments that cannot be diverted.

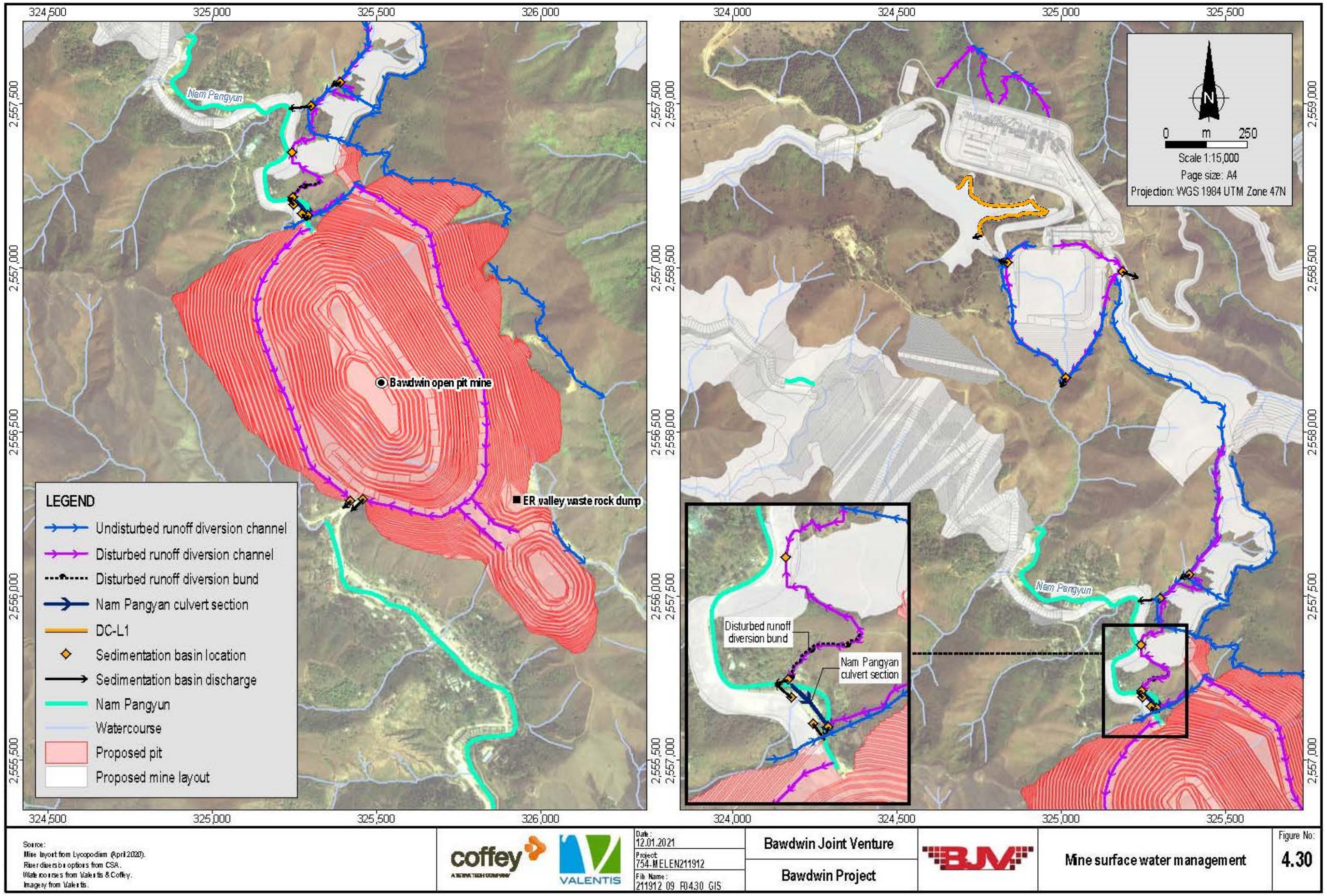


Figure 4.30 Mine surface water management

Pit dewatering will be primarily driven by surface water runoff particularly large storm events and sustained rainfall over a prolonged wet period. Groundwater pit inflows were predicted to be relatively minor compared to the pit inflows resulting from large rainfall events, but are more apparent during extended dry periods and for areas of enhanced permeability.

Pit dewatering is planned to be achieved primarily through an in-pit sump dewatering system capturing groundwater and surface water pit inflows that will gravity drain to in-pit sumps at local low points at the base of both the main pit and the south pit. Water collected within the in-pit sumps will be pumped out of the pit to a sedimentation basin on the southwest corner of the open pit.

The in-pit sump dewatering systems are designed to manage all surface water and groundwater inflows during the 24-hour 100-year return period rainfall event and during a sustained wet period. An in-pit dewatering system has been developed based on the pit inflow estimations, pumping rate requirements and the pumping head requirements. It is proposed that Allight Sykes HH220i high head pumps (or similar performing pumps) are used for the main pit in-pit sump dewatering system and Allight Sykes HH80 pump (or similar performing pump) are used for the south pit in-pit sump. The pumping requirements have been selected based on operating 80% of the time, to allow for re-fuelling, scheduled maintenance and other factors.

From years 5 to 8, water will be collected in a sump (10,000 m^3) in the main pit and discharged directly into the adjacent Nam Pangyun. Depending on the quality of this water, water treatment may be required before discharge. For Year 8 through to the final pit development, a second sump is proposed in the south pit. This would discharge to an in-pit diversion channel, which is part of the surface water management system and discharges via a sedimentation basin to the Nam Pangyun.

4.9.7 Forward works

Further works that will contribute to the design and operation of surface water management and water supply system are proposed and are outlined in Table 4.28.

Table 4.28 Forward works relating to the design and operation of surface water management and water supply system

Item	Purpose	Detail
Baseline stream flows	• Obtain seasonal baseline flow data • Refine understanding of flow regimes	Conduct hydrological monitoring to measure baseline flows of the Nam La at suitable locations and continuation of monitoring of the Nam Pangyun.
Hydrological modelling of the Nam La	• Estimate required compensatory flows to the Nam La downstream of the proposed water harvesting facility • Confirm maximum feasible abstraction rate for the project and limits for each season	Develop a numerical surface water model incorporating based on baseline stream flows.
Geohydrological model update	• Improved understanding of groundwater flow regimes • Update of water balance model	Based on hydrogeological studies for the TSFs and waste rock dump (see Tables 4.20 and 4.26) update existing geohydrogeological model
Downstream water quality	• Input to selection of water quality compliance criteria • Identify suitable mixing zones	Use chemical mass balance and loading calculations (or other method), based upon updated site flow and water quality data.
Post closure water management	• Provide detailed assessment and plans to satisfy regulatory progress • Guide WMM closure/rehabilitation activities • Allow refinement of closure costs	An update is required within 3 years of the project operations commencing.
Detailed design of surface water management structures	• Refine site-wide water balance for operations and closure phases	Detailed design will be completed using international best practice standards.

Item	Purpose	Detail
	• Refine surface water and management system • Develop detailed design and construction drawings	

4.10 Power supply and energy use

The existing mine is supplied by a 33 kV overhead transmission line from Mansam Falls and Kong Nyaung hydroelectric power stations. The existing transmission line and power stations do not have the capacity required to supply the new process plant, and an onsite power station with the required 20 MW of capacity is required.

The onsite power station will comprise modular diesel generator configuration. It will be located adjacent to the process plant and connect to an 11 kV switchboard to supply both the process plant and an overhead transmission line to provide power to other key infrastructure. The power station will be sized based on an N+2 reliability criteria to ensure adequate generation availability to supply the process plant loads during routine maintenance in the power station. In other words, the system will be designed with two alternate paths (N+2 design), one path could be down for maintenance, a failure could occur in a second path, and ideally, the third path would supply power to the load without interruption. The power station control system will automatically manage the number of generators to ensure sufficient generators during mill starts.

Modular generator sets will be enclosed in standard 20 ft shipping containers and will meet Myanmar emission discharge standards for air and noise. In total there will be 26 diesel generators in series in containers, plus five containerised fuel tanks and supporting infrastructure (Plate 4.2). The power plant will cover a fenced area of approximately 35 m by 110 m.

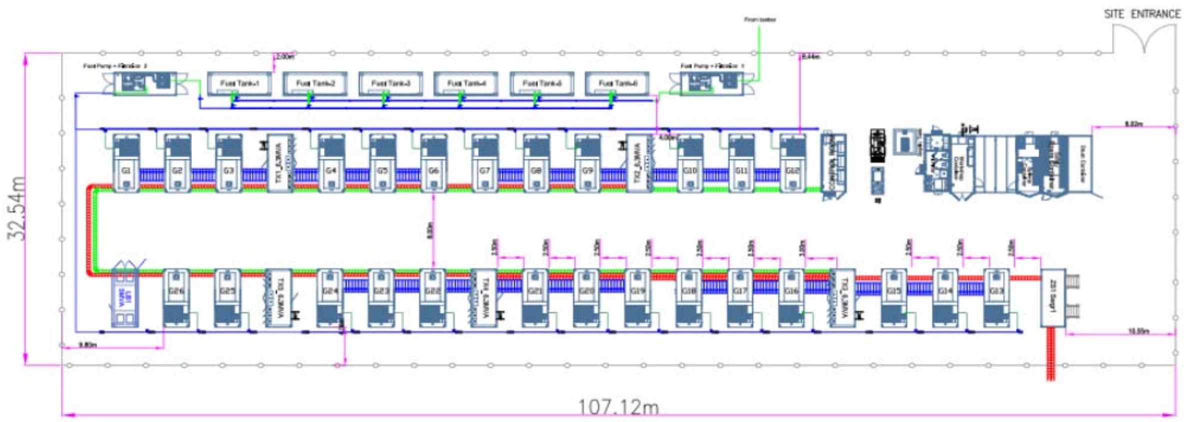


Plate 4.2 Conceptual layout of the onsite power station

Estimated emissions for each engine stack are provided in Table 4.29 based on the site conditions and typical fuel specifications, as provided by WMM. In multi-stack configurations stacks are closely spaced together. A stack cluster can practically be considered as a one stack construction albeit with higher volumetric air flows.

Table 4.29 Maximum emission mass flow rates for each engine stack

Parameter	Unit	Engine Load		
		100%	75%	50%
Nitrogen oxides (Calculated as NO_2)	g/s	12.78	9.64	9.48
Carbon monoxide (CO)	g/s	0.67	0.50	0.35
Sulphur oxides (Calculated as SO_2)	g/s	2.62	1.98	1.37
Particulate matter (as dry dust)	g/s	0.26	0.20	0.18
Non-methane non-ethane hydrocarbons calc. as CH_4)	g/s	0.66	0.59	0.46

Further work will be completed during detailed design to refine the design of the power plant.

4.10.1 Electrical distribution

The electrical system for the project is based on an 11 kV distribution and 415 V working voltage. System frequency is designed at 50 Hz. The largest power requirements within the process plant are the ball and SAG mill motors (7,000 kW and 5,400 kW respectively).

From the power station 11 kV main switchboard, the 11 kV supply is reticulated from a tariff metered plant feeder to the process plant 11 kV switchboard.

The main process plant will consist of six containerised switchrooms located in the following areas:

- Crushing.
- Milling.
- Flotation.
- Regrind.
- Thickening.
- Services.

An 11 kV overhead transmission line will provide electricity from the power station to:

- The accommodation village.
- Mine service area.
- TSFs.
- Raw water supplies.

Emergency generation capacity will also be provided at the accommodation village via standalone generators.

An allowance has been made to decommission 35 existing transmission towers that currently run through the pit and new plant areas. These towers are part of the existing 33 kV distribution system and supply some small loads north of the new plant site. An allowance has been made to supply these loads permanently from the power station. During construction, an allowance has been made to power to these loads from a diesel generator.

4.11 Site access and security

4.11.1 Site access roads

Three new access roads will be constructed to provide safe and reliable site access for the project. These are:

- The Namtu-Tiger Camp access road, which will provide access from Namtu to Tiger Camp.
- The plant access road, which will provide access from Tiger Camp to the process plant.
- The camp access road, which will provide access to the accommodation camp from the plant access road turnoff to the accommodation camp.

Other access roads will include connections to the TSF service road and the Namtu-Manton public road bypass around the process plant.

Namtu-Tiger Camp access road

A new private road is proposed to be constructed between Namtu and Tiger Camp, using the existing Bawdwin to Namtu railway corridor. This road will be 9 m-wide and 10 km in length. WMM will allow Tiger Camp village and Bawdwin lower village to use the road, prior to their resettlement, under closely managed conditions to minimise safety risks. The existing railway has gentle vertical grades and adequate horizontal curves that are suitable for road traffic. By placing the road directly on the rail bed, the road construction earthworks will be minimised. Several sections will require widening to suit two-lane road operations where the railway cross section is too narrow. Widening of the corridor will be achieved using fill with scour protection installed (either gabion baskets or bulk rock armour) in areas adjacent to the Nam Pangyun. The route traverses multiple waterway crossings, ranging in size from small box culverts to bridge structures. Construction of the road will involve replacement of these structures with new box culverts. On the east side of Tiger Camp is a circular grade change for the railway traversing four bridges. One of the bridges, an arch bridge, will be retained.

Plant access road

The plant access road will be 8 m wide and 8.9 km long. The road starts from Namtu-Tiger Camp access road and ends at the process plant security gate. The road will provide transportation access to the process plant and the camp facility. The plant access road will have 0.5 m shoulders and will be 1 m narrower that the Namtu-Tiger Camp access road. The plant access road will have a speed limit of 20 kph.

Camp access road

The camp access road will be 8 m wide and 1.2 km in length. The access road will start from the plant access road about 3 km from the process plant security gate. The camp access road will have the same shoulder size and speed limit as the plant access road.

Other access roads

The same road design will be used for access roads from the Namtu road turnoff to the process plant and camp on the plant access road. Each road will be sealed with two coats of bitumen.

Road design

The road design will be in accordance with AUSTROADS '*Guide to Road Design Part 3'* and as presented in Table 4.30. Road signage will consist of speed, advisory curve ahead, guide signs and guide posts with reflectors. There will be no pavement markings. Typical cross sections for the proposed new access roads are shown in

Figure 4.31.

Table 4.30 Design standards – Namtu-Tiger Camp access road

Parameter	Proposed Standard Basis
Design vehicle	19 m semi-trailer with 13 m turn radius
Design speed	30 kph
Standard crossfall	3%
Maximum longitudinal gradient	10%
Minimum longitudinal gradient	0.3 - 0.5% minimum
Pavement	2 coat spray bitumen 150/150 sub/base
Carriageway	9 m (2 x 3.5 m lanes + 1 m shoulder)
Road trapezoidal drain	0.50 m BOD with 1V:1H side slope
Cut batter slope	214%
Fill batter slope	67%
3 m benching grade slope	3.3%

Public roads

The Namtu-Manton public road currently passes through the process plant site in an east–west direction. This road will be re-routed north of the process plant just outside the plant security fence. The bypass road will be constructed to a standard and design approved by the relevant government ministry. The bypass road adjacent to the plant fence will be floodlit.

Due to road conditions, 20 t weight restrictions exist between Namtu and Lashio. During the project implementation phase, WMM will seek to upgrade bridges and culvert crossings to transport maximum payloads between Namtu and Lashio (see Section 4.12.3).

The Lashio – Muse route involves travel on a modern four lane highway which has been recently upgraded.

4.11.2 Site security

A security department will be created to manage security of the project. Site access and security requirements for the project will include (but not limited to):

- Operational control of entry and exit points to the project area through conventional means such as a manned boom gate or similar.
- Fencing with dedicated security around the process plant, mine services area and accommodation camp.
- Conventional controls for explosives around the explosives magazine including security fencing and onsite security guards.
- Contractual conditions of contractor relating to the transport of hazardous reagents and consumables.

4.12 Concentrate transport and logistics

4.12.1 Transport route

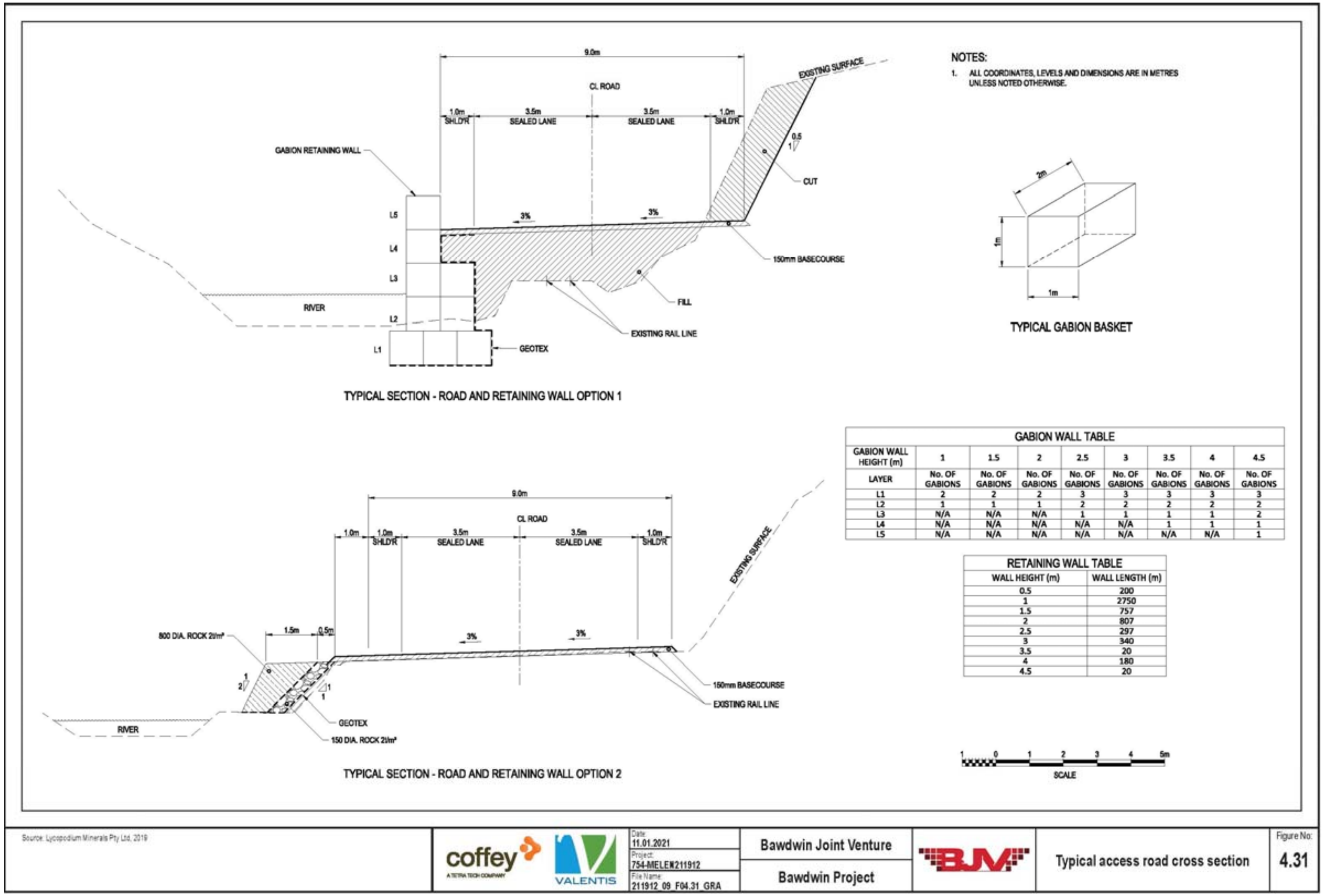
The concentrate is proposed to be exported to international markets. The concentrate export route is shown on

Figure 4.32.

The distances of the concentrate export transport route in shown in Table 4.31.

Table 4.31 Concentrate export route distances

Route	Distance	Maximum truck size
Bawdwin to Namtu	19 km	60 t
Namtu to Lashio	69 km	20 t
Lashio to Muse (near boarder with China)	172 km	50.5 t



GABION WALL TABLE								
GABION WALL HEIGHT (m)	1	1.5	2	2.5	3	3.5	4	4.5
LAYER	No. OF GABIONS	No. OF GABIONS	No. OF GABIONS	No. OF GABIONS	No. OF GABIONS	No. OF GABIONS	No. OF GABIONS	No. OF GABIONS
L1	2	2	2	3	3	3	3	3
L2	1	1	1	2	2	2	2	2
L3	N/A	N/A	N/A	1	1	1	1	2
L4	N/A	N/A	N/A	N/A	N/A	1	1	1
L5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1

RETAINING WALL TABLE	
WALL HEIGHT (m)	WALL LENGTH (m)
0.5	200
1	2750
1.5	757
2	807
2.5	297
3	340
3.5	20
4	180
4.5	20

Figure 4.31 Typical access road cross section

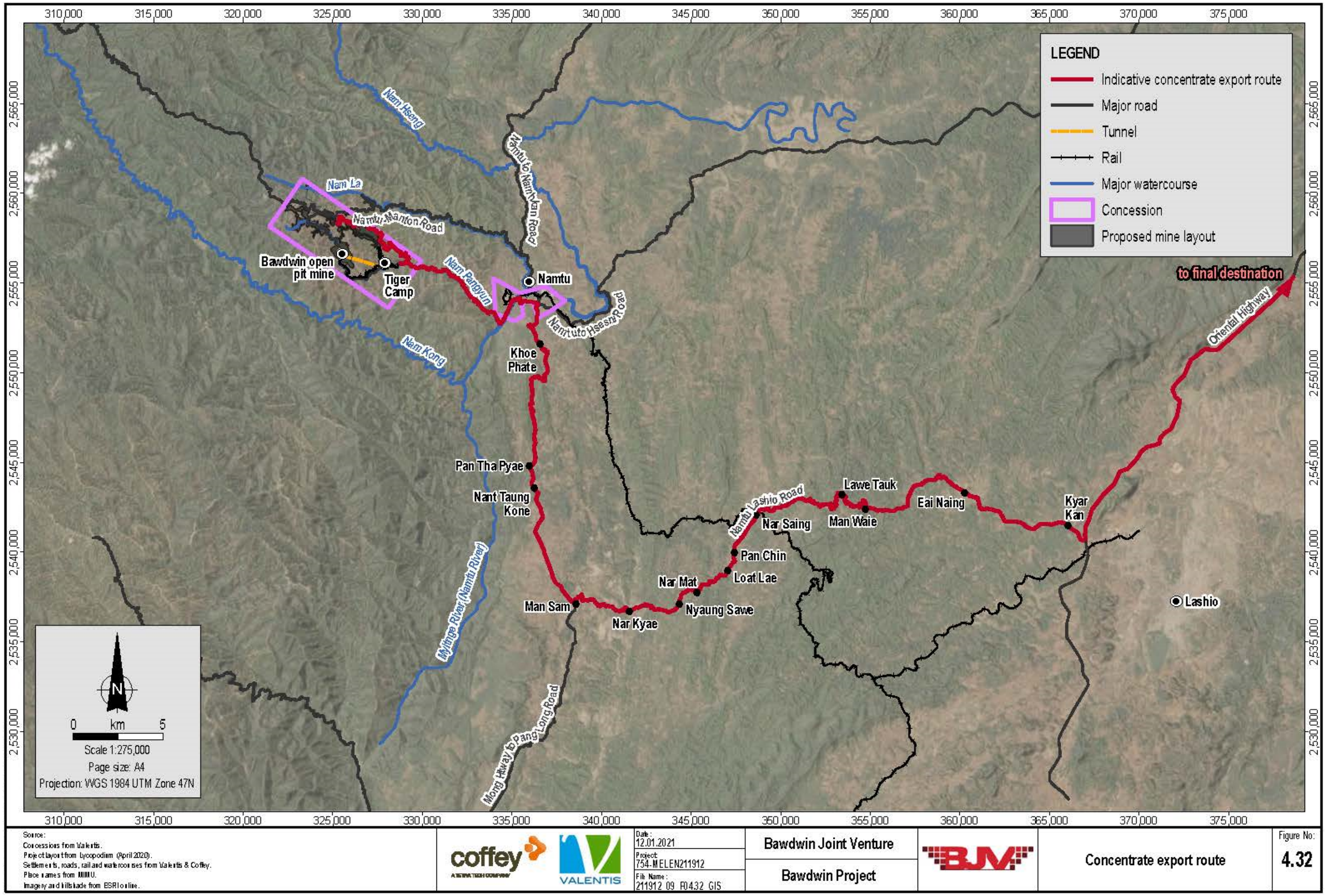


Figure 4.32 Concentrate export route

4.12.2 Truck movements

A total of 9,885 concentrate container movements per year, or 27 containers per day in each direction, will need to be moved by road transport. This equates to a total concentrate traffic movement of 54 movements per day. Due to the winding and narrow roads in some parts of Myanmar, particularly between Lashio and Namtu, and between Namtu and Bawdwin, it is likely that travel will be restricted to daylight hours only. Options to ship concentrate in by bulk sea freight will be assessed during the project implementation phase and a traffic management plan developed.

The average daily truck movements for transport of import of consumables and fuel and export of concentrate is shown in Table 4.32.

Table 4.32 Average daily truck movements for transport of import and export loads

	Average Daily Truck Movements			
	Concentrate	**Reagents and consumables (proportional to concentrate)**	**Fuel**	**Total**
Year 3	11.6	1.0	8	**20.6**
Year 4	51.4	4.4	8	**63.8**
Year 5	64.9	5.6	8	**78.5**
Year 6	65.0	5.6	8	**78.6**
Year 7	43.8	3.8	8	**55.6**
Year 8	49.9	4.3	8	**62.2**
Year 9	41.1	3.5	8	**52.7**
Year 10	53.8	4.6	8	**66.4**
Year 11	47.9	4.1	8	**60.0**
Year 12	49.3	4.2	8	**61.5**
Year 13	64.8	5.6	8	**78.4**
Year 14	78.2	6.7	8	**92.9**
Year 15	37.3	3.2	8	**48.5**
Mine Life Average	**50.7**	**4.4**	**8**	**63.1**

4.12.3 Export route road upgrades

The public road between Namtu – Mansam – Lashio will require sections upgraded to allow WMM to utilise vehicles weights up to the maximum Gross Combination Mass limits. The following provides a high-level breakdown of upgrades required. WMM will work with Ministry of Construction to plan upgrade of water crossings and road alignments to allow the maximisation of freight.

From Namtu to Mansam (23 km) the road will require the replacement of two concrete culvert bridges to 5.5 m length and to 60 t capacity with reinforced box culverts, replacement of several low load bearing capacity existing steel culvert road crossings with concrete pipe crossings and general widening of tight sectional curves.

From Mansam to Lashio (43 km) the road will require: replacement of several low load bearing capacity existing steel culvert road crossings with concrete pipe crossings; replacement of 1 wooden bridge to 8 m length and to 60 t capacity with reinforced box culverts, and general widening of tight sectional curves.

4.12.4 General logistics

Construction materials will mostly arrive via Yangon to Bawdwin mine using the multi lane highway network to Gotiek Gorge via Mandalay. This then becomes two lanes to Hsipaw. Hsipaw to Namtu is single lane pavement and is used by heavy vehicles. Some minor upgrades of the road between Hsipaw to Namtu is anticipated.

After the construction phase of the project is completed and the Lashio warehouse and laydown areas are cleared of the construction equipment and materials, the site will be used for bulk storage of reagents, flocculants and spares during operations.

Bulk consumables will predominately be delivered by the road transport via a backhaul service. This backhaul service would deliver in bulk diesel, reagents, flocculants, spares and consumables to the Lashio facility for storage and/or straight to Bawdwin site as required by operations.

4.13 Accommodation facilities

4.13.1 Construction accommodation

The accommodation camp used for construction and operation of the project will be built using a series of accommodation blocks. Each accommodation block will have up to sixteen rooms with ensuite ablution facilities for each accommodation block. The block dimensions will be approximately 50 m long by 7 m wide with all doors opening onto a central breezeway.

Other buildings provided will be:

- Kitchen / dry mess.
- Wet mess.
- Laundry.
- Gymnasium.
- Ablution block and ice room at mess location.
- Recreation building.
- Multi-purpose court.
- Administration building.
- Security gatehouse.

An area near the process plant was selected for the accommodation camp. By road, the distance between the process plant security gate and the construction camp security gate is 4.2 km. By pedestrian path, partly along the Namtu-Manton public road, the distance between the process plant and construction camp is 1.5 km.

The entire construction camp will be fenced with pedestrian and vehicular access gates provided. The administration building will be located at the gated entry to manage the operation of the construction camp. A light vehicle car park will be provided inside the fence next to the building. A large turnaround area outside the gates will allow supply vehicles to park and off-load supplies. A services compound will be provided for the electricity, water and sewer treatment facilities in proximity to the administration building.

The construction camp facilities have been considered on the basis that the building construction be either flat pack, stud framing or containerised.

Surface water runoff will be collected with open drains with culverted road crossings. Drains discharging to outlets at the site perimeter. Sediment movement is not expected to be significant as the site will have sealed road surfaces and rip-rap drains.

4.14 Supporting infrastructure

4.14.1 Buildings

A range of new buildings are proposed to be constructed for the project and will include:

- Administration building.
- Medical facility and emergency response.

- Change rooms and ablution facilities will be provided for both sexes throughout the site.
- Warehouse (fenced with open storage and laydown area).
- Workshop with overhead crane.
- Plant offices.
- Laboratory.
- Three reagent stores (20 days storage of all reagents).
- Crib room to serve meals to all plant operations and maintenance personnel.
- Security gatehouse.
- Control room.
- Customs office.

The building construction will include cladded steel structures for:

- Reagent sheds.
- Workshop.
- Warehouse.

Prefabricated structures with wall panels and roof structures mounted on concrete slabs and delivered as flatpacks for:

- Administration.
- Medical facility and emergency response.
- Change rooms.
- Plant office.
- Crib room.

Containerised buildings:

- Control room.
- Ablution blocks.
- Security gatehouse.
- Laboratory.
- Customs office.

4.14.2 Sewage treatment systems

Two stand-alone sewage treatment plants are proposed to service each of the process plant and accommodation camp.

Due to the mountainous terrain, high rainfall and limited available space, small footprint, packaged activated sludge bioreactor systems were selected rather than large footprint pond system.

An effluent loading of 150 litres and 180 litres per person per day respectively for construction and operations was assumed based on the Water Services Association of Australia Sewerage Code of Australia (WSA02).

The following sewage treatment plant configuration was selected:

- Construction / Operations Camp – 115 m^3/day activated sludge bioreactor.
- Process Plant – 95 m^3/day activated sludge bioreactor.

During the construction phase, the sewage load will be distributed between the Camp (morning and evening) and Plant (daylight hours). For operations phase the Camp sewage treatment plant will operate at full capacity during plant shutdowns when camp numbers increase for short periods of time.

Treated effluent may be discharged to the environment in accordance with Myanmar discharge criteria and resulting sludge will be disposed in the on-site landfill.

4.15 Existing buildings, infrastructure and operations

Historically, the Bawdwin deposits were worked by Chinese miners, mainly for silver, who dug short tunnels into the sides of the Nam Pangyun valley and ER valley. The ore was smelted onsite and slag disposed in dumps which have eroded and dispersed in the Nam Pangyun.

Industrial ore extraction and lead production began in the early 1900s. A narrow gauge railway was completed in 1909 (Plate 4.3), followed by the Tiger Tunnel in 1918, which allowed efficient access to the massive lead-zinc-silver China Lode orebody, with transport of ore to Namtu for concentration, smelting and refining.

The historical 12-level underground operation is based on the China Lode, with vertical access through the 522-m-deep Marmion Shaft (Plate 4.4). The 2.7-km-long Tiger Tunnel (Plate 4.5) intersects the underground mine workings at Level 6 and is the main access to the orebody. An underground electric tramway enabled ore transport through the tunnel to the Wallah Gorge railway terminal where it was unloaded (Plate 4.6) and stored in ore bins before transport to Namtu for processing.

An open pit mine (known as the Gossan Quarry) to access lower grade ore was operated from the early 1980s until 2009 (Plate 4.7). A waste rock dump is located southeast of the open pit mine at the head of ER valley. Further detail describing the existing buildings and infrastructure located at the Bawdwin site and the existing operations is provided in the following section.

4.15.1 Existing buildings and infrastructure

The central Bawdwin precinct is an area comprising a group of key buildings and structures from the Colonial period. Existing buildings and infrastructure are shown on Figure 4.33. These buildings and structures relate to both the mine operation and functioning of the wider community and together form a key heritage precinct at Bawdwin. The central Bawdwin precinct comprises:

- Compressor house consisting a large corrugated iron-clad building that housed the compressors that provided compressed air to the tools (e.g., rock drills) used in the underground workings.
- Mine office largely in its original condition and contains its original furniture and hard copies of old and recent company files.
- Post office. The post office is still in service and has changed little since 1946.
- Company store.
- The Bawdwin railway station and the adjacent railway line.

Plate 4.3 Narrow gauge railway, dating back to the early twentieth century

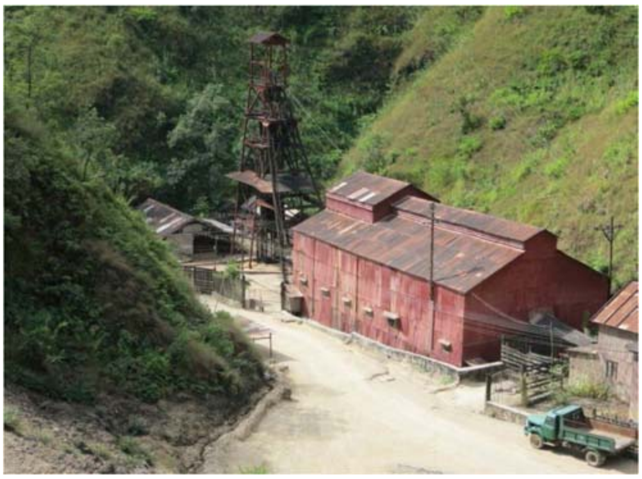


Plate 4.4 Marmion shaft head frame and winding shed, dating back to the early twentieth century

Plate 4.5 Tiger Tunnel portal, dating from 1914

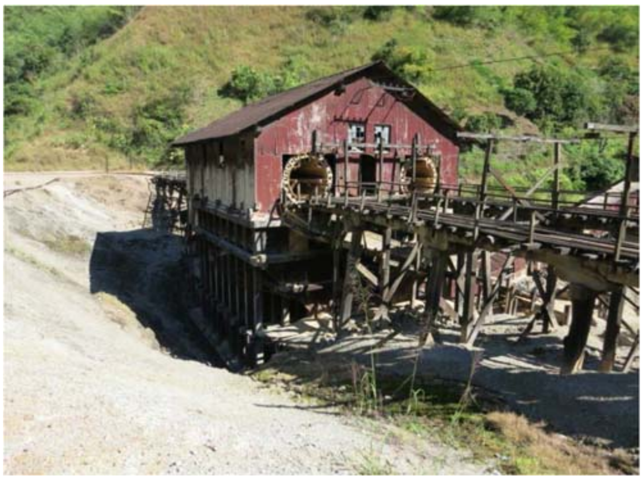


Plate 4.6 Wallah Gorge rotary ore dumper, dating back to the early twentieth century

Plate 4.7 Bawdwin open pit mine (Gossan quarry), dating from the 1980s

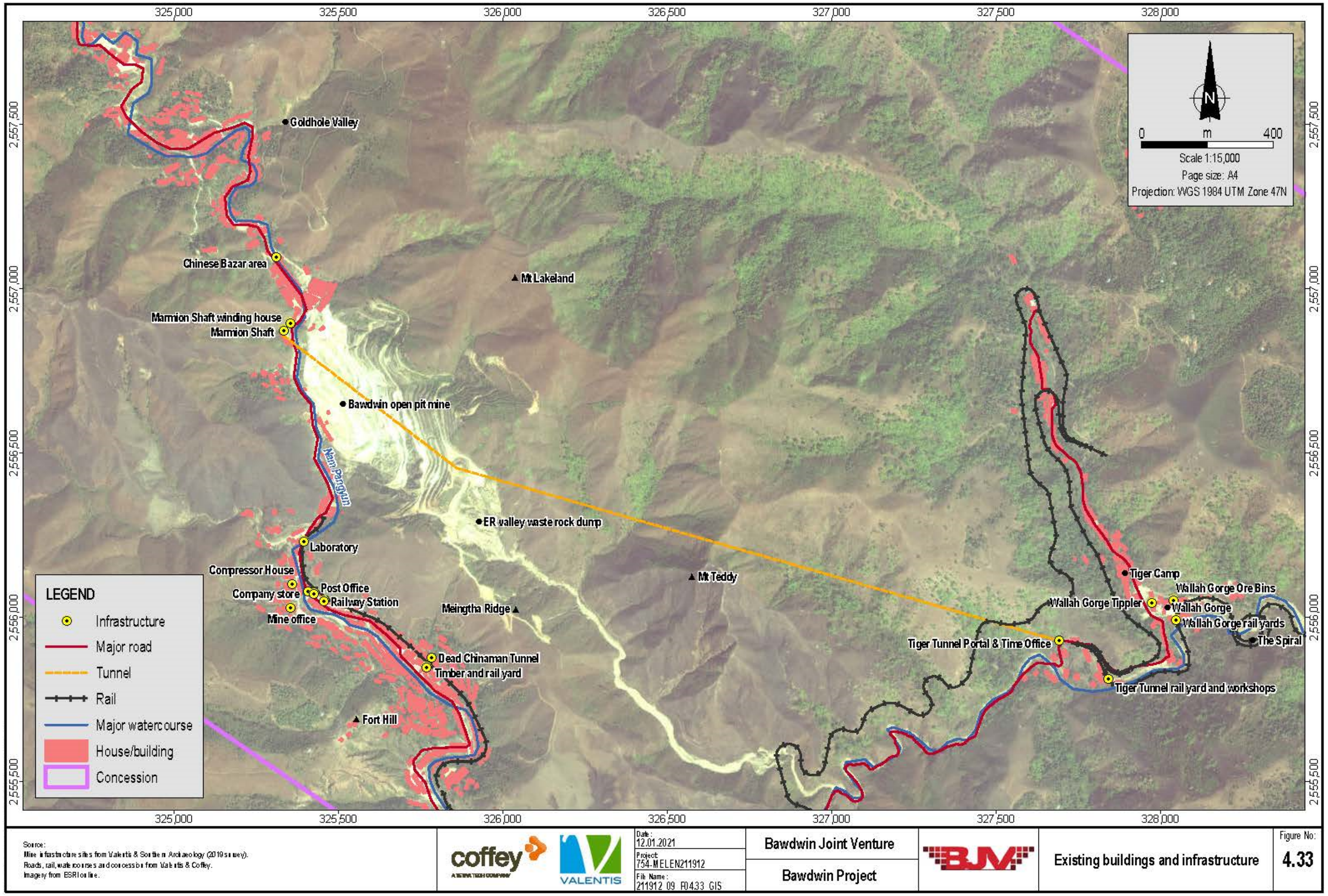


Figure 4.33 Existing buildings and infrastructure

- Mine Superintendent's and staff bungalows. Accommodation quarters for higher-ranked mine workers. Many of these bungalows remain in use.
- Dead Chinaman Tunnel. This tunnel, originally constructed and used by the Chinese miners, was refurbished by the British. This was the main access to the Bawdwin lodes before the Marmion Shaft and Tiger Tunnel were constructed.
- Bawdwin timber yard, which contains open-sided timber buildings that house several saw benches and two large drop saws, some of which are still in use today.

The Tiger Tunnel area comprises the Tiger Tunnel portal and electric railway, railway yards, electric substation, office, clubhouse, stone store and police station. The Wallah Gorge area includes the tippler (a pair of electrically powered rotating drums that emptied ore carts from the mines onto the conveyor belt to the storage bins), ore bins and Wallah Gorge Railyards from the colonial period.

The railway was constructed between 1905 and 1911 and allowed transfer of slag and ore from the mines at Bawdwin to the smelters at Namtu. The railway comprises two main sections – the section between Bawdwin and Namtu along the Nam Pangyun valley, which is mostly still operational; and the line between Namtu and Namyao that was abandoned in 2009. The section of railway between Tiger Camp and Bawdwin is currently in limited use since the ER Valley bridge was destroyed during flooding.

Ore concentration, smelting and refining was undertaken at the Namtu site from about 1911. The Namtu smelter complex is supplied with process water from Nam La. The Nam La flume, an earthen canal conveys water from the Nam La to the ridge above the Namtu smelter complex where it is reticulated to the site.

The railway is a 2-feet gauge line, comprising almost entirely timber sleepers (apart from some concrete replacements). The railway bridges are masonry or a mixture of masonry and steel. The route through the Nam Pangyun valley is picturesque as it traverses the valley sides and narrow gorges. The line includes several reverses to allow the line to change elevations sharply between Bawdwin and Wallah Gorge.

There are at least 19 religious places or sites were identified in the Bawdwin area including Buddhist temples and chapels, Chinese and Indian temples, and Christian churches.

Three villages are located around the existing mine as follows:

- Upper Bawdwin village – northwest of mine.
- Lower Bawdwin village – southwest of mine, denoted South Village.
- Tiger Camp – east of mine below Wallah Gorge.

The existing village buildings probably originated around the early 1900s and are predominantly light timber structures with thatch, timber or tin sheet cladding and tin metal roofs. Road access to the upper Bawdwin village is via the unsealed regional Namtu-Manton Road. The unsealed road continues along the creek through the upper village, through the mine and South Village and terminates at a soccer oval. A concrete footpath connects Bawdwin lower village to Tiger Camp allowing people to travel on foot or by motor scooter. Rudimentary services are provided for these villages. Low voltage power is reticulated with overhead lines. Fresh water is reticulated from the sediment pond downstream of the dam.

A concentrator plant was constructed at Bawdwin mine around 1980 to enable the low-grade oxide ore to be processed on site. The concentrator plant includes crushing, grinding and flotation separation units. Mineral concentrate was transported by rail to Namtu for smelting to refine lead, antimonial lead, and silver, with copper matte and nickel speiss as by-products. Zinc concentrate was shipped as unrefined product. Tailings from the 1980s concentrator plant were initially disposed to the Nam Pangyun, with later deposition in the Bawdwin underground mine workings. Production at the Bawdwin concentrator plant ceased in 2009 with the closure of the open pit operation.

4.15.2 Existing operations

Since December 2009, the Bawdwin mine and processing facilities have been in care and maintenance, with the workforce retained under the production sharing permit and contract conditions. Mineral exploration and feasibility studies were undertaken between 2017 and 2020.

In late 2020 WMM commenced work to resume mining of oxide ore under its existing mining license and permits, with production expected to commence in Q2 2021. This mining is separate to WMM's Bawdwin project for which this EIA is being prepared. Coffey & Valentis are not involved in planning of the resumed mining program or any related works.

It is understood that the mining will be carried out by Base Metal Mining Co Ltd (BMMC), which is a registered Myanmar contractor company, under contract to WMM.

Mining will take place in the existing open pit, which will be expanded. Oxide ore will be transported by existing road networks to the existing 32 Mile facility at Namtu for mineral processing at the existing processing plant. The mining may last a maximum of 4 years. All works will cease when the Bawdwin project commences operations.

4.16 Workforce and employment

4.16.1 Organisational structure and employment

WMM is committed to providing a workplace that values diversity and fairness and is free of discrimination and harassment. This commitment to diversity will be achieved through:

- Local participation policy.
- Equal employment opportunities applied to all agreements for the provision of and for services.
- Employment and development opportunities characterised by fairness which is for the benefit of all employees.
- Awareness of Myanmar laws and the rights and responsibilities with regards to employment and terms and conditions of employment.

An organisational structure for the project has been developed that details the workforce, including functions and roles, roster cycles and work hours. The organisational structure allows for personnel to perform their functions on roster cycles that provide appropriate coverage for the role and operational function.

A key strategy will be to transfer knowledge and build capacity in the local workforce. WMM will work with relevant authorities and organisations to create opportunities for local people in the provision of goods and services to the mining operation.

WMM will seek to maximise the proportion of available jobs that are allocated to members of local communities, through its Preferential Employment Policy. Where two or more equally skilled and experienced candidates are considered for an applicable position, WMM will preferentially seek to employ candidates in the following order:

1. Residents of local communities.
2. Residents of Shan State.
3. Other Myanmar citizens.
4. Expatriates.

It is anticipated that WMM will initially employ a small core group of experienced mine managers to fill key leadership roles. A larger number of experienced mining professionals will be sourced from South East Asia are likely to be employed to fill senior supervisory and/or skilled trade roles. Myanmar citizens with equivalent qualifications and experience will; however, be preferred over expatriates. The remainder of the workforce, for which skills are trainable or are entry level positions, will be sourced locally (and regionally) from within Myanmar and from industries that may not associated with the resources sector. These positions may include maintenance roles, heavy vehicle drivers, administrative roles, and plant operators.

Labour classifications that broadly reflects the qualifications and seniority of the position are defined in Table 4.33.

Table 4.33 Labour classifications and requirements

Labour Classifications	Requirements
Internationally experienced mine manager	• Tertiary or trade qualified, highly experienced (15 to 20 years) in the mining industry, competent senior leader. • Training not required. • Fly-in fly-out with on-site accommodation required
Experienced mining professional	• Tertiary or trade qualified; experienced (10 to 15 years) in the mining industry. • Training generally not required. • Successor to expatriate positions. • Seek to source from Myanmar and/or South East Asian regional origin. • Fly-in fly-out with on-site accommodation required
Myanmar national workforce	• Trade qualification and/or unskilled. • Limited or no mining experience. • Training and up-skilling required. • Successor to all expatriate positions once trained. • Local to Namtu, Bawdwin or regional to Namtu. • Live within the Bawdwin or Namtu community. • Accommodation not provided

The total construction workforce is estimated to consist of approximately 1,360 (including 100 expatriates and the remainder being Myanmar citizens).

The organisational structure for operations has ten departments as described below:

- Board of Directors – consisting of an executive director and directors representing each of the three joint venture partners.
- Corporate staff – based in Yangon that will include corporate, commercial, legal, investor relations management, and general administration staff.
- Site management – the General Manager Operations will be the statutory registered manager and operational responsibility for the operation and will be located on-site. There will be seven roles reporting directly to the General Manager consisting a Deputy General Manager; Technical Services Manager; Process Manager; Facilities Manager; Administration Manager; Safety, Health, Environment and Community (SHEC) Manager; and a Security Manager.
- Technical services – the department covers mining, production planning, surveying, and geology functions. The mining team is responsible for short and long-term mine planning as well as mining engineers, surveyors and geotechnical engineers. This team will also manage the contractual obligations and performance of the mining contractor. The geology team will encompass mine and resource geology to ensure that the mining operation is aligned with resource identification and estimation.
- Production – the production team is responsible for the metallurgical testing and processing of ore and the disposal and management of tailings.
- Maintenance – the maintenance team will be responsible for performing maintenance on fixed plant and encompasses mechanical, boilermaker, electrical and trades assistance personnel. The maintenance team

will be is responsible for the planning and execution of operational reliability plans, including planned maintenance and shutdowns.

- Facilities – the facilities team will be responsible for managing all site infrastructure and managing the camp service contractor.
- Administration – the administration team will provide administration support to the corporate office and Bawdwin site. Services include general administration, accounts, payroll, travel coordination, human resources, and information technology. The human resources team will be responsible for the provision of human resources support including recruitment and employee relations services and advice to the operation
- Safety, health, environment and communities (SHEC) – the SHEC team will provide, source, develop and deliver safety, emergency response and induction training across the operation, in addition to environmental monitoring and statutory reporting and provide paramedic services to site-based personnel. The department will also have the responsible for community and stakeholder relations.
- Security – the security team will ensure site security.

In addition, to the ten WMM departments there will be a Mining Contractor workforce that will report to the Mining Manager.

The total workforce for the project during operations is estimated to be 1,112 full time positions. The WMM is estimated to have a peak workforce of 523 employees for stable operations. The predicted workforce by function and labour classification is presented in Table 4.34.

Table 4.34 Predicted workforce by function

Department	Expatriate (International) Positions	Expatriate (Regional) Positions	National Positions	Total Positions
Board of Directors	5	-	4	**9**
Corporate	1	-	5	**6**
Management	2	-	1	**3**
Mining	7	14	61	**82**
Production	6	11	101	**118**
Maintenance	3	20	96	**119**
Facilities	1	1	57	**59**
Administration	1	-	33	**34**
Safety, Health, Environment and Communities	2	2	50	**54**
Security	-	-	39	**39**
Total	**28**	**48**	**447**	**523**

In addition to WMM employees, a large number of roles will be performed by contractor personnel, including, mining, operation of the laboratory and the operation of the accommodation camp Table 4.35. The mining contractor workforce will make up the largest of the contractor workforce on the site with 409 positions estimated.

Table 4.35 Predicted contractor workforce by function

Contractor	National Positions	Expatriate (Regional) Positions	Expatriate (International) Positions	Total Positions
Mining Contractor	378	28	3	409
Camp Services Contractor	146	1	-	147
Laboratory Contract	33	2	1	36
Total	**557**	**31**	**4**	**592**

Organisational charts for the WMM Mining department; production department; and Safety, Health, Environment and Communities (SHEC) department are shown in Figure 4.34,

Figure 4.35 and

Figure 4.36. The expected organisational structure of the Mining Contractor is shown in Figure 4.37.

4.16.2 Rosters and cycles

Rosters have been developed to provide adequate coverage for the operation considering the function and responsibility of each position, travel to and from site, fatigue management and first world industry practices. The WMM staff roster cycles are shown in Table 4.36.

The mining and process plant (ore processing) will operate (24 hours a day, seven days a week, 365 days per year). To achieve coverage of this continuous operation, the expatriate workforce will work 42:14-day roster cycle (12 hr shift). This roster meets international industry acceptable average hours, provides operational coverage and adequate handover.

The national workforce will work a 6:2-day roster (8 hr shift) with four crews required to provide 24-hour coverage. This roster reflects the current working conditions on the Bawdwin site. It is planned that the local operational workforce will be transported to work areas via regular bus services for example between Namtu and site.

There are some roles associated with the mining operations and process plant which will work a day shift only pattern (i.e., they will not be required to work night shift).

Table 4.36 WMM staff roster cycles

Type	Roster Cycle	Number of Personnel
Expatriate (international)	6 weeks on / 2 weeks off	25
Expat-Regional	6 weeks on / 2 weeks off	48
National	6 days on / 2 days off	447

4.16.3 Occupational safety and health

WMM will fully comply with the *Myanmar Occupational Safety and Health Law, 2019*.

WMM has an existing Occupational Safety and Health (OSH) Policy and several subject-specific policies relating to OSH:

- Fitness for Work Policy.
- Drug and Alcohol Policy.
- Lead Management Policy.

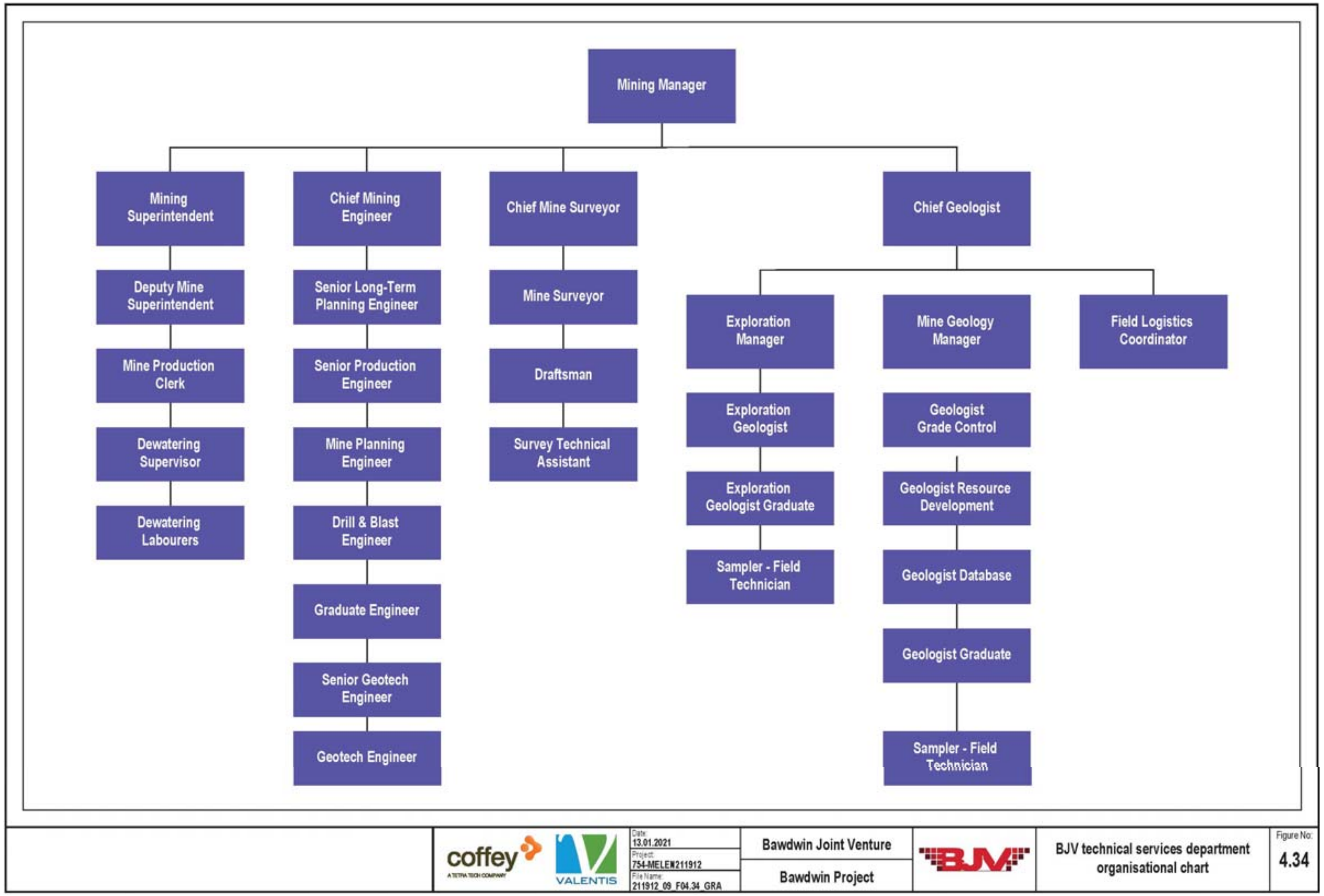


Figure 4.34 WMM technical services department organisational chart

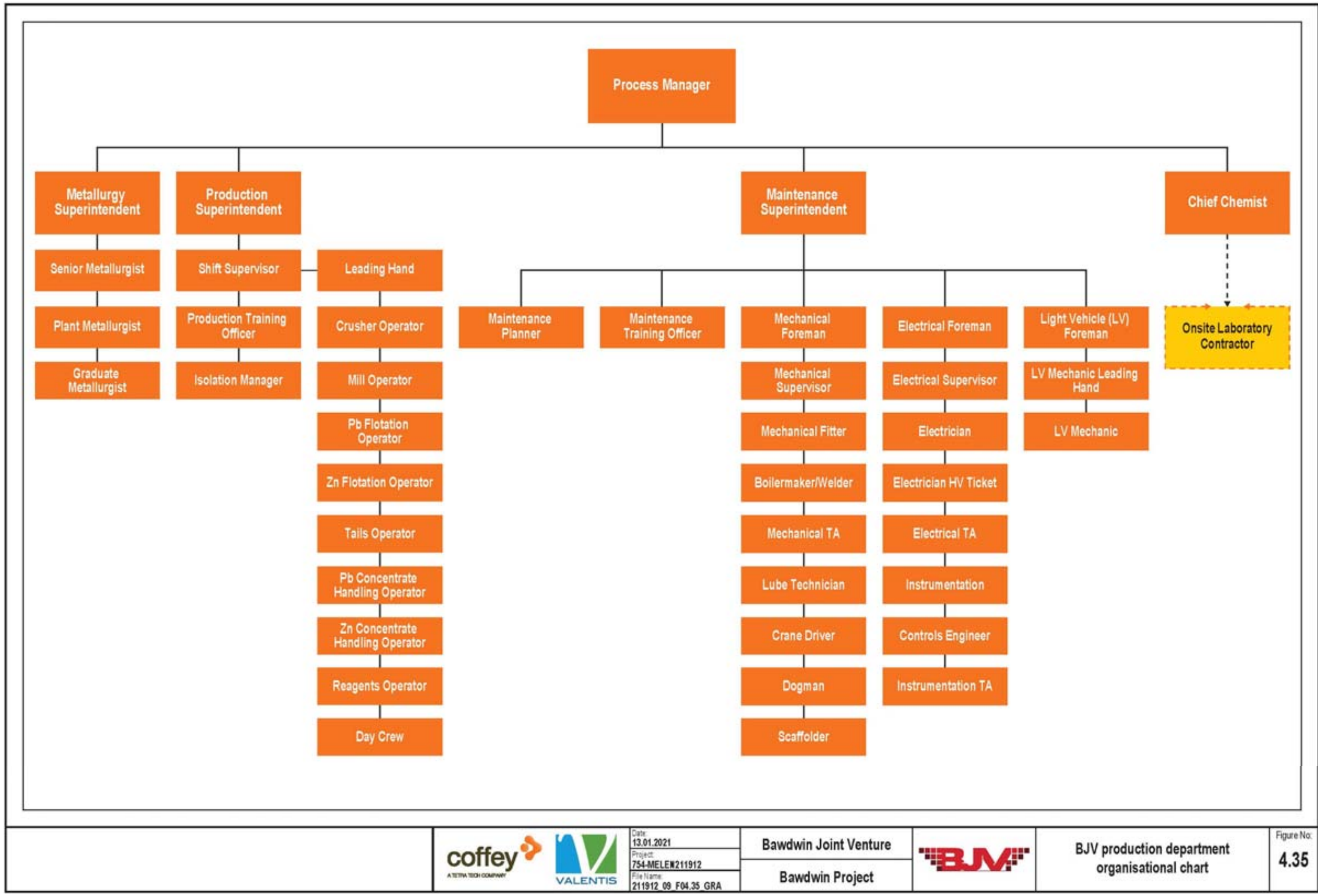


Figure 4.35 WMM production department organisational chart

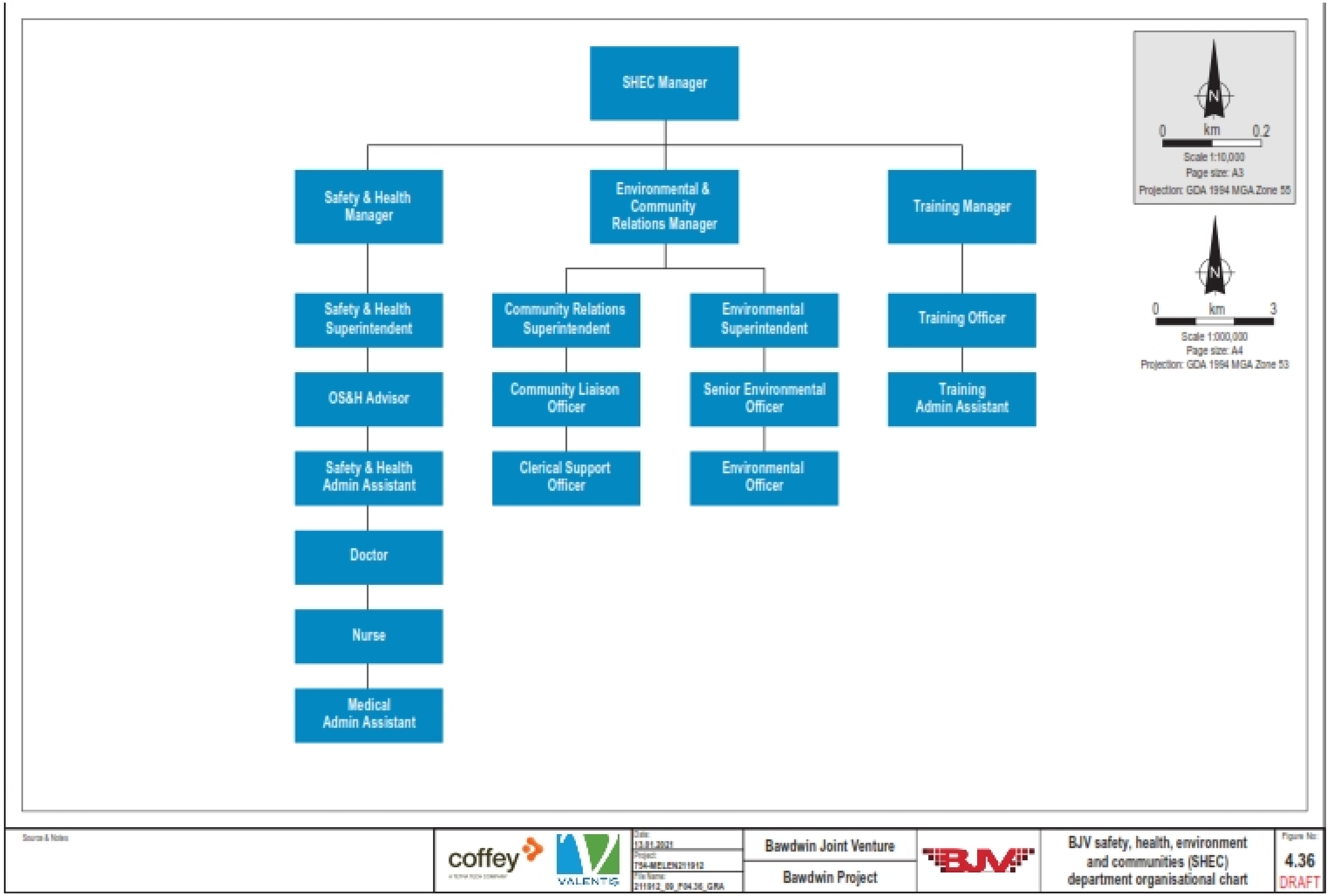


Figure 4.36 WMM safety, health, environment and communities (SHEC) department organisational chart

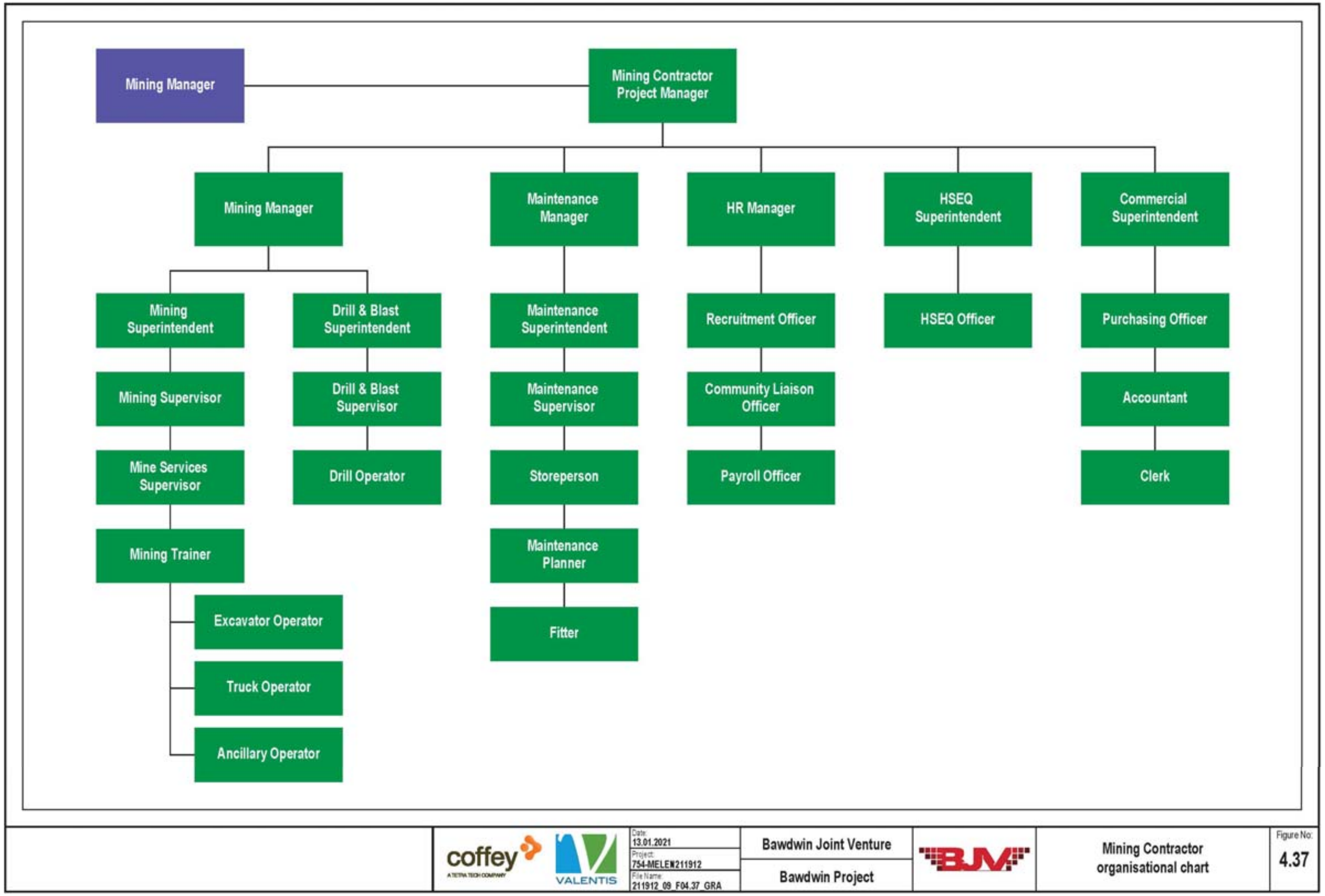


Figure 4.37 Mining Contractor organisational chart

The WMM OSH Policy is reproduced here.

Purpose

WMM is committed to providing a safe and healthy working environment and ensuring that all persons working on behalf of WMM return home safely after work. It is WMM's commitment and responsibility to establish a working environment where all employees, contractors and other stakeholders conduct themselves in a safe and healthy manner.

It is WMM's belief that all occupational illnesses and injuries are preventable, and the company will continuously strive to achieve that goal. The WMM OSH Policy provides the foundation for the company's commitment to continuously improving OSH performance.

Requirements

It is the duty of WMM managers and supervisors to ensure compliance is achieved and to provide workers with the tools, personal protective equipment, training and skills to work safely.

All employees, contractors and visitors entering WMM operational areas are responsible for complying with WMM's OSH requirements.

Commitments

To implement this policy, WMM will:

- Provide a working environment that is conducive to OSH.
- Place the management of OSH as a prime accountability of line management from the executive through management and employees.
- Comply with all relevant national, regulations, and other requirements as a minimum standard for WMM OSH practices and management procedures.
- Define OSH objectives on an annual basis and measure performance against those objectives.
- Maintain and continuously improve OSH management programs, standards and procedures to achieve the OSH objectives.
- Prevent occupational injuries, illness and other loss by adopting proactive hazard identification and a risk focused approach.
- Investigate all incidents to ensure remedial actions are identified and completed to prevent reoccurrence.
- Integrate OSH considerations into all designs and activities.
- Provide all necessary resources to enable compliance with OSH management procedures.
- Require all contractors to comply with WMM OSH policies and standards while undertaking work for WMM.
- Ensure that employees at all levels receive appropriate training and are competent to safely carry out their duties and accountabilities.
- Communicate and consult openly on OSH issues with all employees, contractors, OSH committees and other stakeholders to gain commitment to the implementation of the policy.
- Promote innovation and best practice to continually improve OSH performance.

WMM will develop a comprehensive OSH management system to give effect to the commitments in the WMM OSH Policy. Key aspects of this system will include:

- Develop a register of risks and focus on reducing risks to as low as a reasonably practicable.
- Form an OSH Committee involving workers' representatives to review OSH issues.
- Develop OSH standards and procedures.
- Appoint persons with responsibility for OSH.
- Develop an emergency response plan.
- Create an OSH team to provide guidance and monitoring of OSH performance, as shown in
- Figure 4.35.
- Create an emergency response team with responsibility for primary response to emergency situations.
- Provide training in applicable OHS procedures to relevant personnel.

4.17 Hazardous materials and waste management

Processes and procedures will be developed during detailed design to determine the most appropriate way to manage potentially contaminated materials due to historical mining activities (including demolition of existing infrastructure and buildings) in accordance with Myanmar rules and legislation.

Hazardous wastes produced during the construction and operations phases may comprise of the following:

- Oil and fuel filters.
- Waste oils, grease and lubricants.
- Hydrocarbon-contaminated soils from spills and leaks.
- Oily rags from workshop/vehicle maintenance tasks.
- Hydraulic hoses.

Alternatives for the treatment of hydrocarbon wastes onsite including bioremediation technology and "land farming" is also being examined.

WMM will implement the waste management hierarchy of avoid, reduce, reuse, recycle, treat and dispose. A waste collection service will be established and a landfill at a suitable location.

Organic waste treatment systems (containerised wastewater treatment plants) will be installed to process waste water from ablutions and other facilities at the Bawdwin accommodation village and the process plant. Treated sewage (sludge), a by-product of the wastewater treatment plant, will be removed from site every two to three months via and disposed at the site landfill.

Non-hazardous waste streams that will be produced during mining include:

- Domestic waste, including camp wastes and food scraps.
- Paper and cardboard packaging.
- Plastic packaging, containers and drink bottles.
- General construction waste, including timber, glass and scrap metal.
- Used tyres and old equipment.

The objective for non-hazardous waste management is to avoid or minimise potential adverse impacts and risks to the environment, safety and human health through inappropriate management of non-hazardous waste.

The estimated weights of wastes produced during operations is presented in Table 4.37.

Table 4.37 Annual mass of wastes produced during operations

Type of Waste	Annual Waste Generation
Electronic waste	200 kg
Hydrocarbons including oil	500 tonnes
Fat produced from camp	180 kg
Tyres	150 tonnes
Rubber items (e.g., lined pipe chutes)	10 tonnes
PVC piping and fittings	2 tonnes
Steel (used in mill linings and pipes)	150 tonnes
Metal scrap from trash screen	160 tonnes
Glassware	2 tonnes

4.18 Rehabilitation and mine closure

The Myanmar Mines Rules (2018) requires holders of a large-scale mineral production permit to prepare a mine closure plan in consultation with relevant stakeholders with subsequent review every five years. Additionally, it requires that a fund for mine closure and rehabilitation has been raised and guaranteed before mineral production can commence.

A conceptual closure plan for the project has been prepared that describes decommissioning and rehabilitation concepts consistent with the level of detail available for this phase of the project (Attachment 4). This section provides a summary of the goals and concepts described in that plan.

4.18.1 Preliminary closure objectives and post-closure land use

The closure plan will define a set of closure objectives, addressing physical, biological and socio-economic aspects. Linked to these objectives, WMM will define conceptual post-closure land uses that can feasibly achieve the closure objectives, as well as closure completion criteria, which allow WMM and stakeholders to measure and assess whether closure objectives have been achieved.

At this stage, the closure plan is conceptual and WMM has identified preliminary closure objectives and land uses. Under Myanmar law, WMM is required to update the conceptual closure plan to a detailed plan within 3 years of physically commencing the Bawdwin project. Consultation will be carried out during that process to identify and agree suitable closure objectives, post-closure land uses and closure completion criteria.

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

For the purposes of determining a closure framework that comprises closure objectives, completion criteria and closure indictors (i.e., minimum measurable value to be achieved) the WMM facilities have been categorised into domains.

Preliminary post-closure land uses for each domain are summarised in Table 4.38, together with an outline of the approach to closure.

Table 4.38 Proposed end land uses for closure domains

Domain and Project Component	Preliminary Proposed Post-Closure Land Use	Closure Approach
Open pit	Open pit lake with exposed high walls surrounded by landscape rehabilitated similar to surrounding vegetation	• Construct plug(s) in Tiger Tunnel and other underground tunnels to impound groundwater and contribute to flooding of the open pit • Divert Nam Pangyun stream into the open pit to accelerate flooding

Domain and Project Component	Preliminary Proposed Post-Closure Land Use	Closure Approach
		• Create decant / discharge channel to reconnect with Nam Pangyun downstream of open pit
Underground workings	No land use possible	• Block access to Tiger Tunnel portal and other adits/workings as appropriate to prevent unsafe access
Tiger Tunnel	Preserve tunnel portal and railway in immediate vicinity as a heritage feature	• Conserve and maintain existing structures
Production-related infrastructure • ROM and primary crushing facility • Conveyor system and crushed rock stockpiles • Mine infrastructure area • Process plant • Haul roads • Raw water pipeline • Explosives magazine • Electrical power plant	Landscape that is similar to surrounding vegetation	• Decontaminate process plant and equipment, including ground beneath • Decommission and remove infrastructure where possible. • Address all other infrastructure as per Section 4.18.2 • Rehabilitate land to a condition similar to surrounding vegetation
Wallah waste rock dump	Landscape and profile that is similar to surrounding vegetation and valley sides. Landform that is stable under foreseeable future conditions.	• Design and construct to be stable under foreseeable seismic events • Install drains to divert water around WRD to minimise erosion of surfaces and infiltration of water • Encapsulate PAF with NAF to minimise oxidisation • Progressively rehabilitate benches as they become available. • Decommission and remove infrastructure where possible. • Rip and rehabilitate roads. • At cessation of operations, install a composite store and release / low permeability cover system as per Section 4.7.3. • Establish vegetation that is similar to surrounding slopes.

Domain and Project Component	Preliminary Proposed Post-Closure Land Use	Closure Approach
Tailings Facilities • 3 x TSFs • Spillways • Tailings pipelines	Landscape and profile that is similar to surrounding vegetation and valley sides. Landform that is stable under foreseeable future conditions.	• Design and construct to be stable under foreseeable seismic events • Rehabilitate TSFs A, B and C progressively as each reaches capacity. • Decommission and remove tailings management infrastructure where possible, unless required for monitoring and maintenance • Allow period for drying and consolidation of tailings. • Rehabilitate upper surface and embankment as per Section 4.8.8. • Install drains to divert water around TSFs to minimise infiltration of water • Install a composite store and release / low permeability cover to minimise infiltration of water • Seepage and surface water runoff to report to the open pit lake • Establish low-growing vegetation on cover and embankment that does not penetrate the low permeability cap.
Ancillary infrastructure • Accommodation camp • Administration buildings	Rehabilitated landscape that is similar to surrounding vegetation.	• Decommission and remove infrastructure where possible. • Address all other infrastructure as per Section 4.18.2. • Rehabilitate land to a condition similar to surrounding vegetation.
Access and infrastructure corridor • Access road from Namtu to near Tiger Camp in Nam Pangyun Valley • Freight transfer facility near Lashio	Landscape and profile that is similar to surrounding vegetation and valley sides.	• The future of the access road depends heavily on whether stakeholders agree that they can provide a beneficial post-closure use. • If it is decided to remove the road, it will be as per Section 4.18.2. • WMM will comply with cultural heritage commitments regarding historical infrastructure, which are still to be agreed. • The freight transfer facility at Lashio will have value in the future be sold or transferred to a third party. Company infrastructure will be removed, as needed.

4.18.2 Forward works

Further works that will contribute to the mine closure design and plan are proposed and are outlined in Table 4.39.

Table 4.39 Forward works relating to the mine closure design and plan

Item	Purpose	Detail
Geotechnical evaluation for closure safety bund around pit	• Determine feasibility of constructing a closure safety bund surrounding the pit.	Evaluate geotechnical parameters to identify suitable set-back distance from the pit crest to ensure long-term stability of bund.
Refinement of closure pit water quality model	• Hydrological and geochemical mass balance modelling by CSA indicates that decant water quality from the main pit will be of acceptable quality. However, it is unclear whether CSA model (estimate of total flow in Nam Pangyun and stream water quality) takes account of residual post-closure seepage and spillway surface discharge from TSF C.	Review and revise if necessary the closure pit water quality model (developed by CSA) to take into account residual post-closure seepage and spillway surface water discharge from TSF C.
Evaluation of Tiger Tunnel and pit water interactions at closure and feasibility of 'plugging' the Tiger Tunnel.	• Investigate potential pathways for water to drain away from the pit. • Investigate implications of instability or failure of crown rib (separating pit floor from Tiger Tunnel). • Investigate feasibility (geohydrological, geotechnical, civil) and design options for plug(s) of Tiger Tunnel to minimise releases of water to the Nam Pangyun at closure.	• Conduct a preliminary review of potential intersections of old workings with the ultimate pit wall and identify potential drainage paths via: - Fissures in crown into Tiger Tunnel below. - Old workings daylighting in the ultimate pit wall. • Identify feasibility of maintaining a crown rib and the suitable vertical thickness of crown rib or any other support requirements to provide for separation of the pit base and Tiger Tunnel at closure. • Review and identify optimum location of plugs to minimise free drainage of water away from pit. • Geotechnical investigation of rock conditions around tunnel and civil engineering design of plugs to ensure feasibility and long-term stability. • Assess overall feasibility of proposed closure approach from a geohydrological point of view.
Aligning TSF closure with the Global Tailings Standard and ICOLD standards and guidelines.	• To ensure compliance with international good practice in design, construction, operation and closure of TSFs.	Incorporate requirements of Global Tailings Standard and ICOLD standards into design, construction management plan, operational management plan and detailed closure plan.

Item	Purpose	Detail
Determine feasibility of TSF closure design of a store and release cover and incorporate requirements into construction and operation plans.	• To determine whether adequate quantities of suitable NAF rock, soils and topsoils are available to construct the store and release covers for the TSFs. • To develop plans and designs for the recovery and stockpiling of cover materials.	• Preliminary assessment of availability of required cover materials. • Preliminary identification of soil storage locations. • Initial assessment of materials quantities and cost. • During detailed design phase: – Develop detailed specification of cover system. – Identify required quantities of cover materials. – Inventory available soil resources through field survey – Design soil stockpiles and incorporate stockpiling requirements into construction plans.
Post-closure surface water discharge quality from TSFs	• To predict the quality of post-closure discharge of surface water via the TSF spillways for TSF A (which receives TSF B discharge) and also TSF C.	• Assess water quality parameters including geochemistry of surface water quality discharging from TSF A (including TSF B) which will report to the Nam La and TSF C which will report to the pit lake. • Calculate likely pollutant load and assessment of impact to Nam La from TSF A/B. • Calculate likely impact on pit lake water quality from TSF C.
Revegetation and rehabilitation	• The feasibility of rehabilitating and revegetating disturbed land to produce grassland/bush that mimics existing landscape needs to be determined. This includes assessing quantities and suitability of growth media available on site.	• Engage government bodies on post-closure land use. • Conduct a preliminary review of soil depths and volumes from areas which soils can be harvested safely and practically. • Preliminary identification soil storage locations. • During early operations develop rehabilitation program and establish revegetation trials with input of skilled local persons and external experts.

4.18.3 Decommissioning

Decommissioning will commence after mining operations have ceased and is expected to take around two to three years. It will involve the removal of infrastructure, facilities, equipment and services, unless otherwise agreed with stakeholders.

The conceptual closure plan conservatively assumes that all WMM assets at Bawdwin which are not required after relinquishment will be demolished. WMM may possibly come to an agreement to transfer some infrastructure to a third party, if this is mutually beneficial and can be adequately maintained so that ongoing post closure activities such as periodic monitoring and maintenance of permanent structures can be sustained for the life of the structures. This will be determined with relevant stakeholders to ensure that prerequisite approvals have been obtained prior to closure and the point of transfer.

In general, the following will be undertaken during the decommissioning phase:

- Remove mobile equipment.
- Dismantle or economically demolish remaining equipment, infrastructure and services.
- Remove salvageable materials from site and sell as scrap for recycling. Such materials will probably include items such as steel pipework, framework, beams and sheeting.
- Remove and dispose of non-salvageable, non-contaminated materials in designated landfills or voids. Such materials will probably include concrete foundations, miscellaneous building materials and tyres.
- Decontaminate the process plant and excavate any contaminated soil, which will be disposed in the final cell of the TSF.
- Fracture concrete structures and foundations to promote infiltration and cover with NAF material.
- Incinerate hazardous materials such as hydrocarbons.
- Leave in situ cabling and pipework located at depths greater than 600 mm below the final ground surface.
- Complete final profiling of waste management facility and other landforms.
- Leave in situ subsurface pipelines if they cannot be economically salvaged or where their recovery is likely to result in adverse environmental impacts. Plug and cap all subsurface pipelines.
- Rip and/or excavate roads and other hard surfaces

4.18.4 Rehabilitation

WMM will aim to progressively areas that are no longer required for operational purposes, so as to minimise the area to be rehabilitated following cessation of operations.

It is expected that final physical rehabilitation and establishment of vegetation will take up to five or six years from the cessation of operations, a process that will overlap with decommissioning. However, the timespan for final rehabilitation will be influenced by the drying time required for tailings in TSF C, to facilitate access for subsequent placement of capping materials.

WMM will commission a nursery operation to supply plants for rehabilitation. This may be operated by WMM or may be run as a community contract. WMM will provide or contract labour needed for rehabilitation and maintenance.

During the closure phase, long-term surface water management infrastructure will be put in place. This may involve adaptation of operational surface water management infrastructure but is likely to also involve construction of additional surface water management features. Such features will be designed to be sustainable and require little maintenance.

4.18.5 Monitoring and maintenance

Following rehabilitation of each domain, it will be subject to a period of monitoring and maintenance. Any deficiencies in rehabilitation will be corrected and special attention will be paid to maintenance of surface water management infrastructure, to avoid erosion.

The success of rehabilitation of each domain will be monitored, to check progress towards achievement objects and completion criteria. A further period of site-wide post-closure monitoring and maintenance will be undertaken to demonstrate that closure completion criteria have been achieved and can be sustained.

Bawdwin Project

Environmental Impact Assessment
Chapter 5 – Existing environment

October 2023

Bawdwin Project

Prepared for

Win Myint Mo Industries Co., Ltd.

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5 Existing environment

This chapter describes the existing environment (baseline environment) in the project area and surrounds. It provides a baseline biophysical, biological and social environment of the area. The information presented in the existing environment has been gathered through a program of data collection activities that has included both desktop and onsite investigations. The existing environment has been described sufficiently to enable the effects and impacts of the proposed operations (detailed in Chapter 6) to be assessed and is presented in the sections below by environmental aspect.

5.1 Geology, landform and soils

This section describes the existing geology, landform and soils in relation to the Bawdwin Project and assesses the sensitivity of related environmental values.

5.1.1 Method and study area

The information in this section draws primarily from the Baseline Soil and Water Assessment study conducted by Coffey (2020). The section also sourced information from available literature sources. The Coffey baseline study characterised regional geology, landform and soil characteristics. This was informed by a site inspection and visual observation of the landform features and soil characteristics as well as a soil sampling program to investigate the physical and chemical properties of the soils.

The soil sampling program involved broad scale in-field measurements of metal concentrations and a targeted sampling program with laboratory analysis of soils for key project locations. The in-field measurement program involved collection of shallow soil samples across an area of 17 km^2 covering the Bawdwin open pit area, Tiger Camp and surrounding valleys. Sampling comprised collection of 2,114 soil samples in a gridded soils assessment between May and July 2019 to investigate the total metal concentrations in soils. The total metal concentrations were analysed via x-ray fluorescence (XRF) in the field. The targeted soil sampling program was conducted in November 2017 and November 2018, and included collection of samples from 21 sites at three key project locations: Tiger Camp, Football Field and Accommodation Camp. The soil samples were analysed for a suite of potential contaminants in the laboratory, including total metals, organic compounds, pesticides and nutrients. Appendix C provides detailed information on sampling and analytical methods.

Figure 5.1 shows the location of the geology, landform and soils study area, including the soil sampling locations.

5.1.2 Regional geology

Bawdwin is located in the northern margin of the Shan Plateau. The Shan Plateau is a large massif (i.e., a mountain system bounded by faulting) that forms the eastern part of Myanmar and part of the Indo-Malayan mountain system. The average elevation of the plateau ranges between 750 and 1,200 m above sea level.

The Shan Plateau lies on the Shan-Thai Block (one of the southeast Asian continental blocks that rifted from Gondwana), east of Sagaing Fault, a strike-slip fault extending 1,200 km through the length of Myanmar (Searle et al., 2007). The Shan-Thai Block comprises Cambrian to Triassic material, including the late Precambrian wackes (type of sedimentary sandstone) and mudstones that dip to the southeast (Searle et al., 2007). These are overlain by Cambrian volcanics and a thick succession of Upper Permian-Mesozoic carbonates (Gardiner et al., 2017).

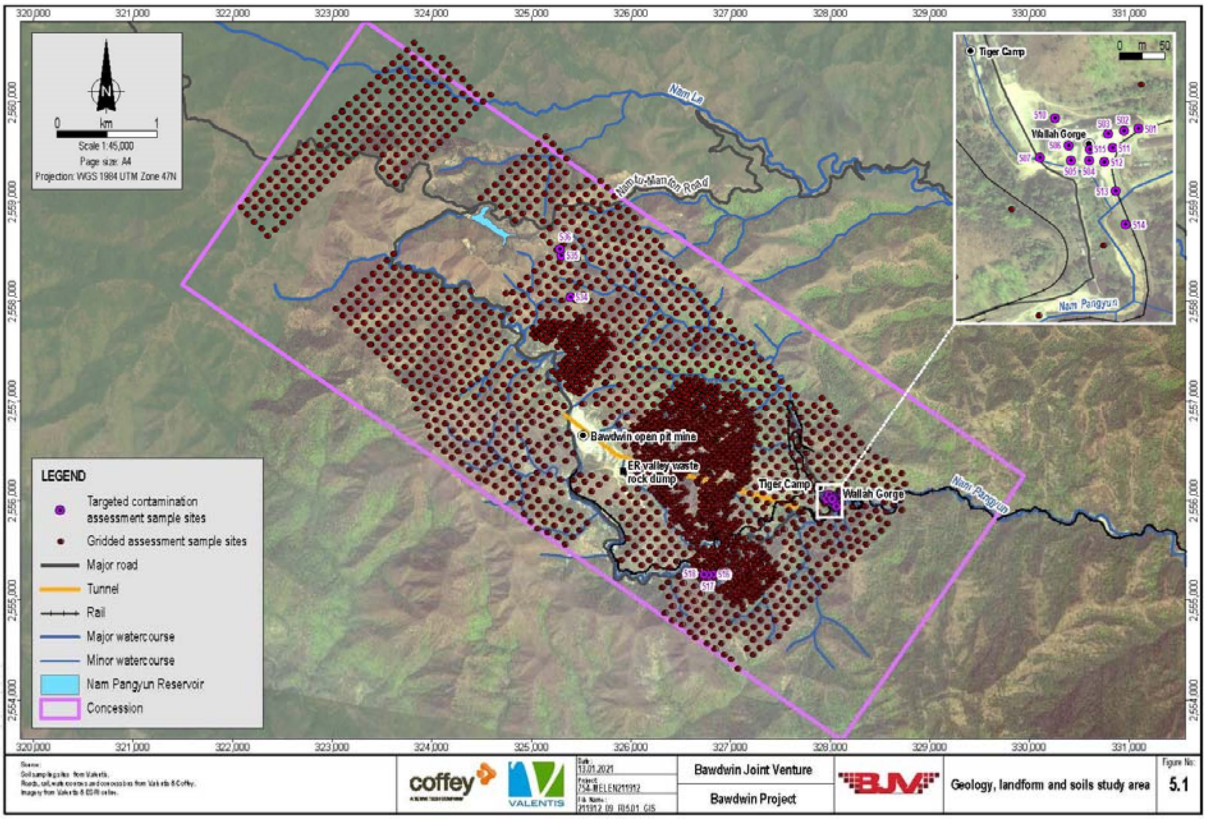


Figure 5.1 Geology, landform and soils study area

The Bawdwin area is underlain by the co-depositional Pangyun and Bawdwin Volcanic Formations and contains significant faulting (large-scale planar fracturing of rock). The Bawdwin Volcanic Formation, which comprises volcaniclastic tuffs and agglomerates along with intrusive rhyolite porphyries, grades into the sandstones and quartzites of the Pangyun Formation. The rhyolite intrusions are up to 4 km long, 400 to 1,400 m in width, and up to 800 m in depth (Gardiner et al., 2017).

The massive sulphides that comprise the three main ore bodies at Bawdwin (Shan, Chinaman and Meingtha Lodes) are surrounded by a halo of lower grade ore to the east and north. The main ore bodies lie within a 2.5 km long, by 200 m wide, northwest-southeast-trending zone of mineralisation within the Bawdwin Fault Zone (Gardiner et al., 2017). The Chinaman Lode is the largest deposit and is the only main body to outcrop at the surface. The main ore bodies primarily comprise galena and sphalerite, with other sulfidic inclusions (including pyrite and chalcopyrite) (Gardiner et al., 2017). The Chin Lode is located to the north and is characterised by its distinct mineralogy, notably having higher copper concentrations.

The Bawdwin area lies within an area of moderate seismic activity and could expect to experience a maximum seismically-induced peak ground acceleration of approximately 0.15g to 0.2g (% of gravity) with a recurrence interval of 50 years (BJV, 2019).

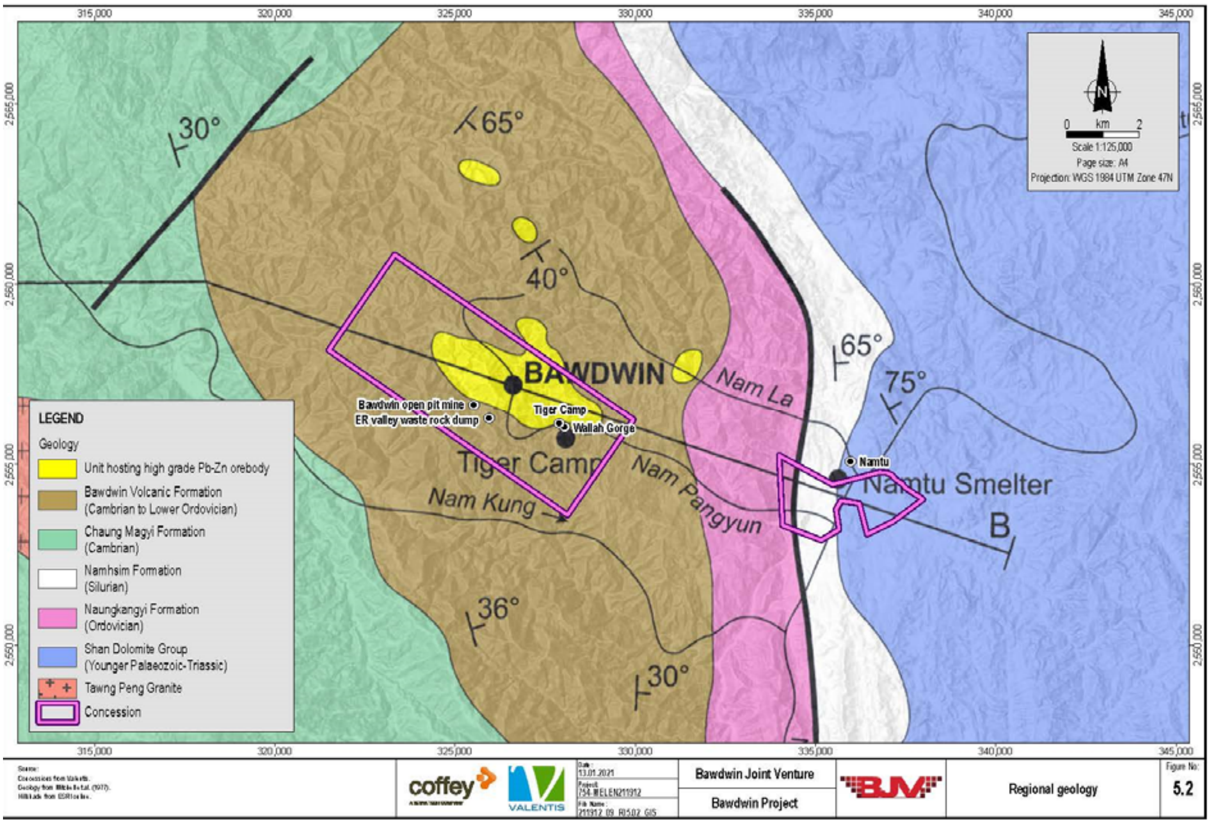


Figure 5.2 shows a regional geological map of the Bawdwin area while

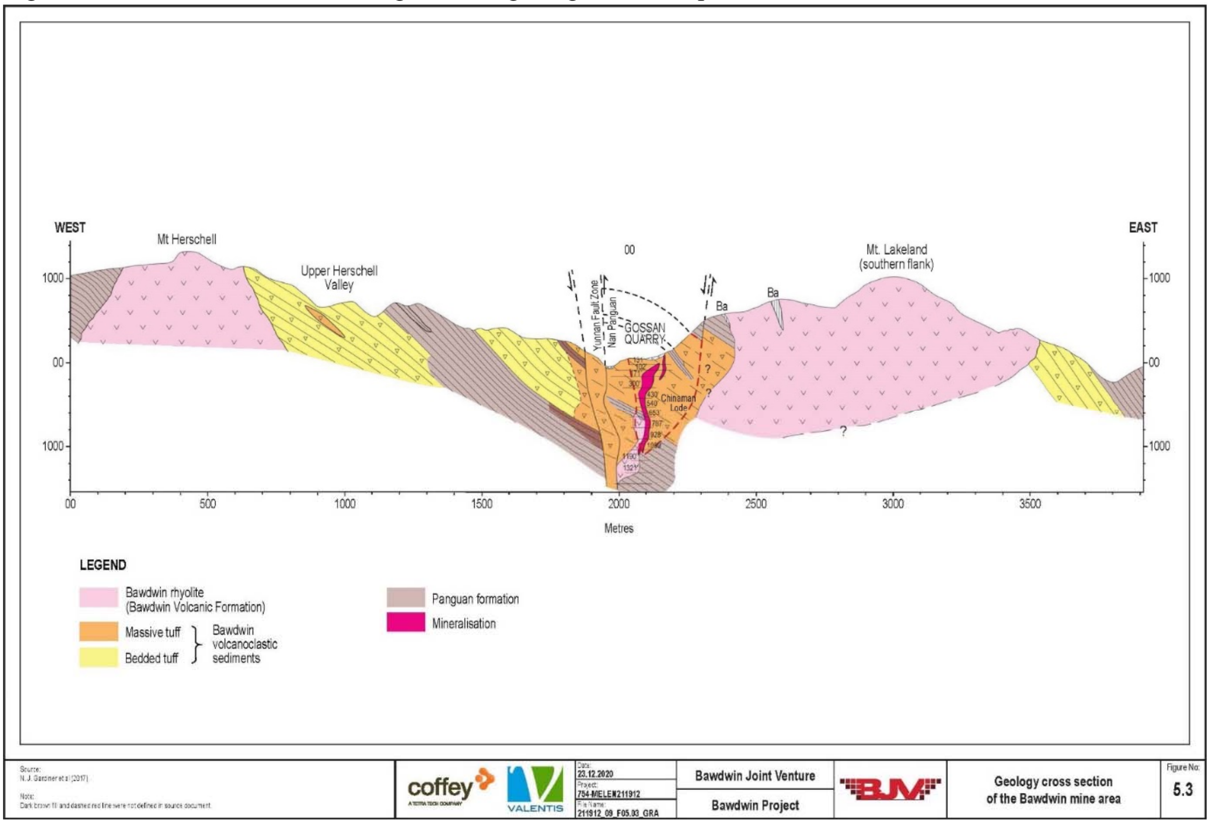


Figure 5.3 shows a corresponding geological cross section of the area.

5.1.3 Landform

Landform refers to a recurring pattern of topography within the landscape. Landform is based on elevation and relief, which influence environmental characteristics and processes including erosion, landslip, soil type and ecosystem functioning.

The majority of the project is situated in the steep and mountainous Nam Pangyun catchment, which includes the Nam Pangyun valley, ER valley, Wallah Gorge and associated tributaries (see Figure 5.1). Some infrastructure elements of the project also occur in the neighbouring catchment to the northeast, which is called the Nam La catchment. Elevations within the study area range from 720 to 1,431 m above sea level. The majority of the terrain slopes are in excess of 20% with many areas sloping more than 30% (BJV, 2019). Most of the study area landform is best described as mountainous terrain with deeply incised valleys. In the northern and western corners of the study area upgradient of the Nam Pangyun headwaters, there are areas of undulating hills and valleys that are less steep than the rest of the study area.

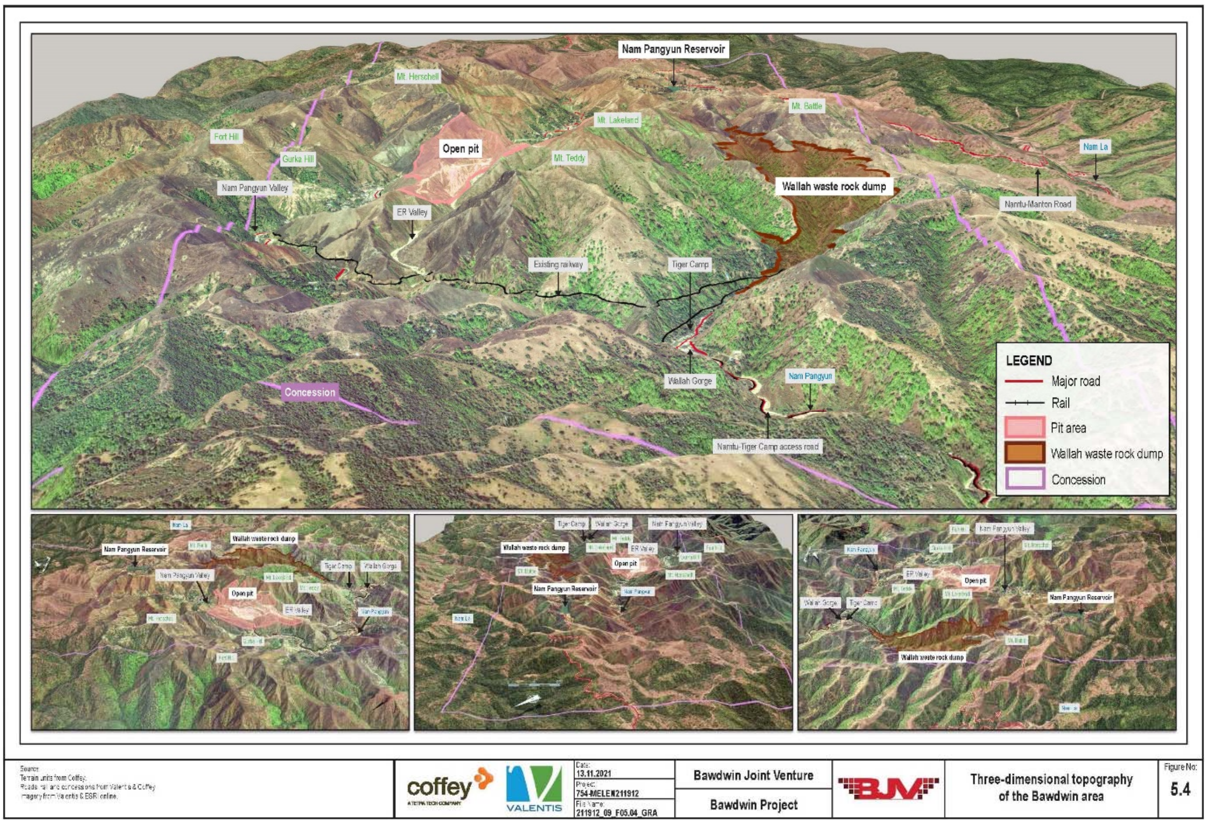


Figure 5.4 shows the three-dimensional topography of the study area.

The study area is almost completely devoid of natural forest vegetation due to historical mining and processing activities at Bawdwin. The landscape is characterised by fragmented grassland and scrub cover on the upper mountains and hillsides with rocky outcropping occurring lower in the valley in the Nam Pangyun streambed and adjacent cliffs (

Plate 5.1). To the south of the Myitnge River at Namtu the topography becomes flatter with only gentle undulations.

The Nam Pangyun is confined within a narrow and meandering gorge, which is bordered by steep mountains with narrow ridgelines. Towards the lower catchment and the confluence with Myitnge River, the valley broadens and the valley floor becomes covered with thick layers of deposited waste rock and slag from years of mining operations upstream in the catchment.

The Bawdwin mine area has a highly modified landform in the lower valley due to the existing open pit (which is about 600 m by 300 m wide), access roads and slag/waste rock disposal areas.

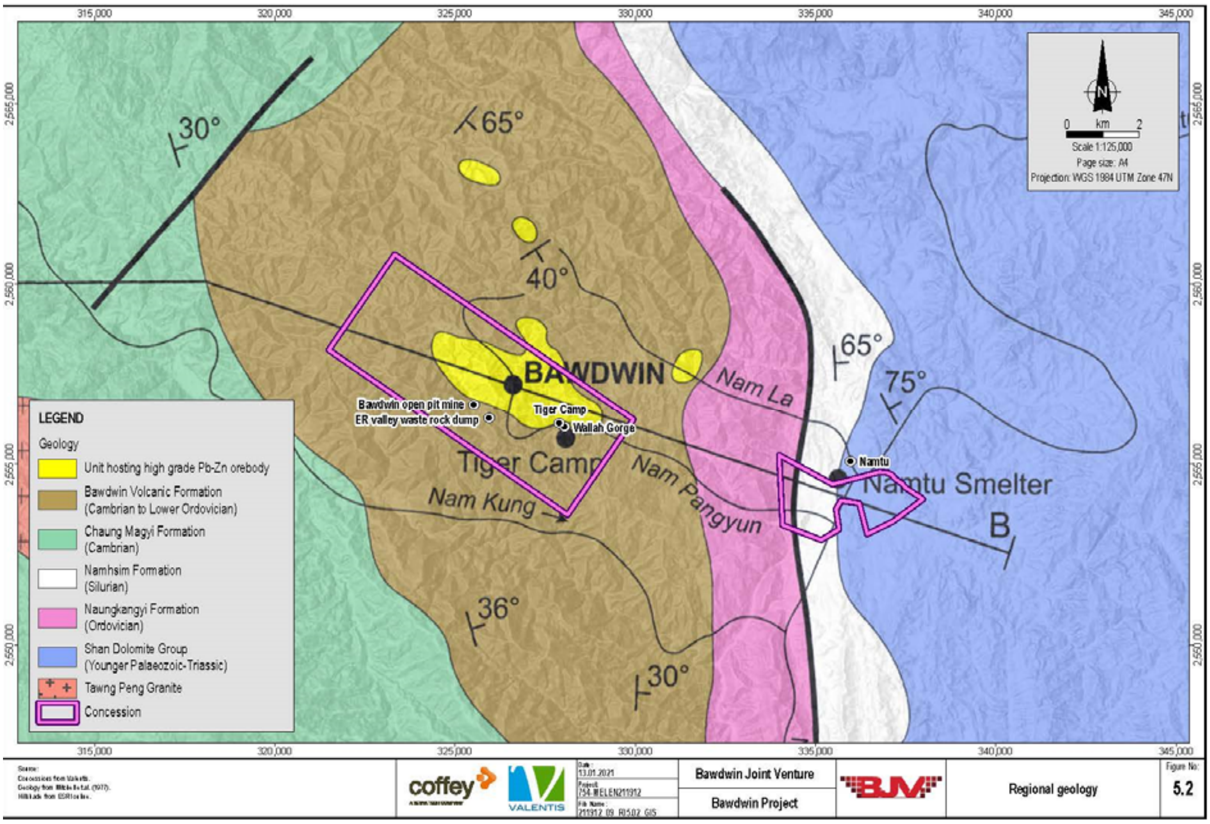


Figure 5.2 Regional geology

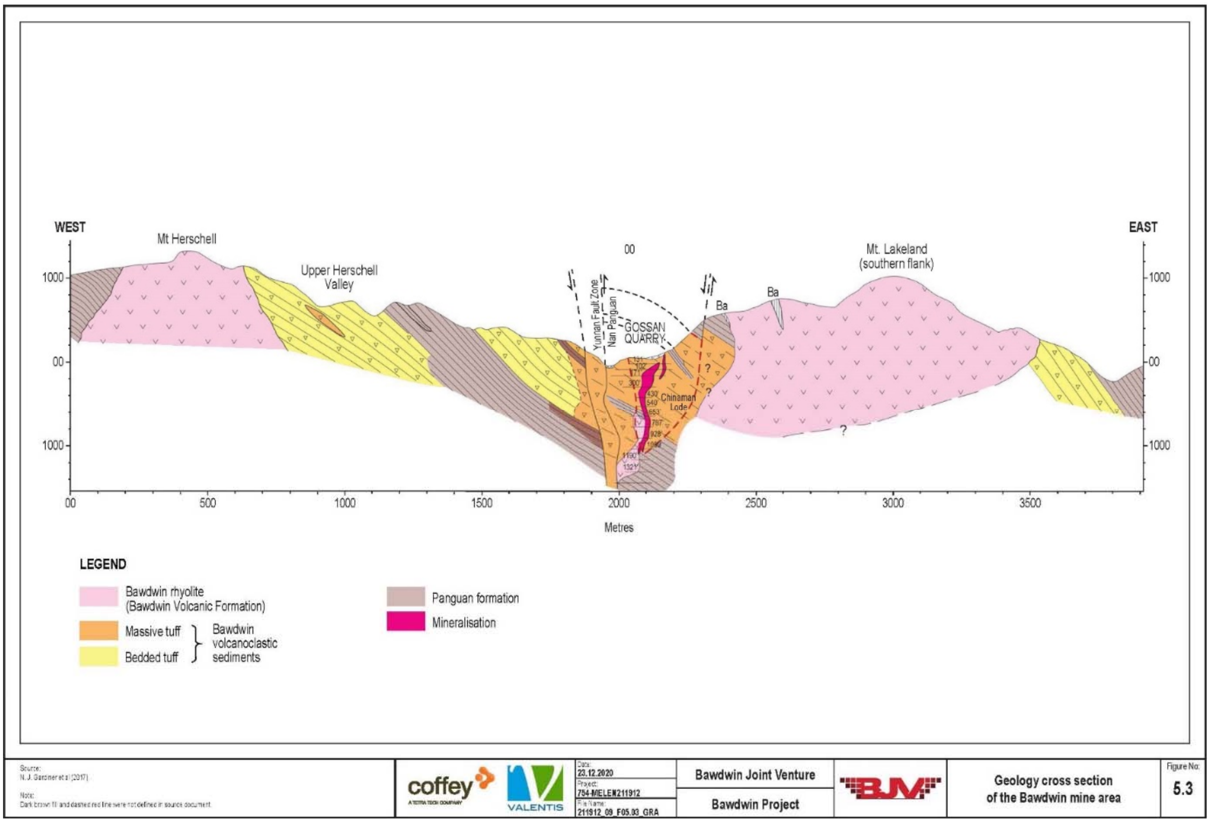


Figure 5.3 Geology cross section of the Bawdwin area

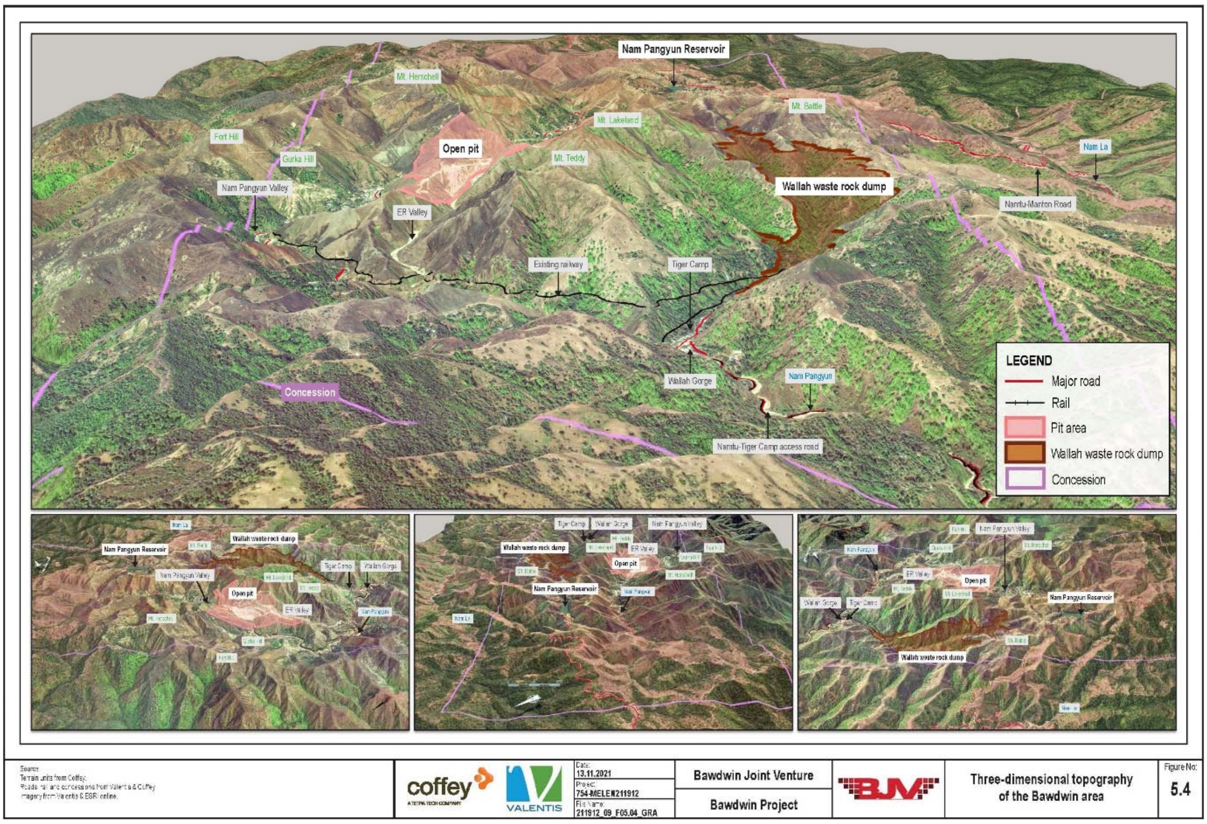


Figure 5.4 Three-dimensional topography of the Bawdwin area

Despite the steep slopes and lack of forest cover, there is little evidence of large landslips in the Nam Pangyun, ER and Wallah valleys. Smaller localised slips or slumping; however, regularly occurs, often associated with surface expressions of groundwater. This may be due to the soil profile being thin on the steeper mountain slopes. There is, however, evidence of landslips on the upper slopes of a Nam Pangyun tributary to the west of Bawdwin. Figure 5.5 shows the locations of these landslips. Unstable terrain in these headwater areas is likely associated with the emergence of groundwater from springs in the landscape (Appendix C).

5.1.4 Soils

This section describes the physical and chemical properties of soils in the study area. This section focuses on the characterisation of topsoil and subsoil, which are the more productive upper layers of the geological profile.

Topsoil corresponds to what is termed the 'A Horizon' and subsoil corresponds to the 'B Horizon'. Each horizon is a parallel layer of soil whose physical, chemical and biological characteristics differ from the layers above and below it. The A Horizon (or topsoil) is the uppermost layer, which is a relatively thin layer (10 to 30 cm) of organic matter and minerals. The A Horizon is primarily where the vegetation root zone occurs and where organisms live. The B Horizon (or subsoil) sits below the A Horizon and is often metres thick. It typically comprises mostly clay with iron minerals and some organic matter. The B Horizon sits above lower horizons that comprise the parent material of the soils such as regolith and bedrock.

Topsoil and subsoil characteristics

Site investigations conducted as part of the project DFS found that the soil horizon (combined A and B horizon) is generally thinner where slopes are steeper and thicker where slopes are less steep and where soil stability is greater.

The soil horizon across the study area comprised orange-brown and brown soil, with a very thin organic-rich brown surface layer. The soil comprised silty and sandy material of various sizes. Underlying the soil horizon, there was a thick zone of saprolite (i.e., rock that has been highly weathered but also significantly chemically altered compared to its parent material) and laterite (i.e., soil and rock rich in iron and aluminium formed by intense and prolonged weathering) on the crests and mid-slopes of the surrounding valleys. The saprolite and laterite zone varied from highly weathered rock to completely weathered residual soil (i.e., weathered soil that has been weathered in its original location without being transported).

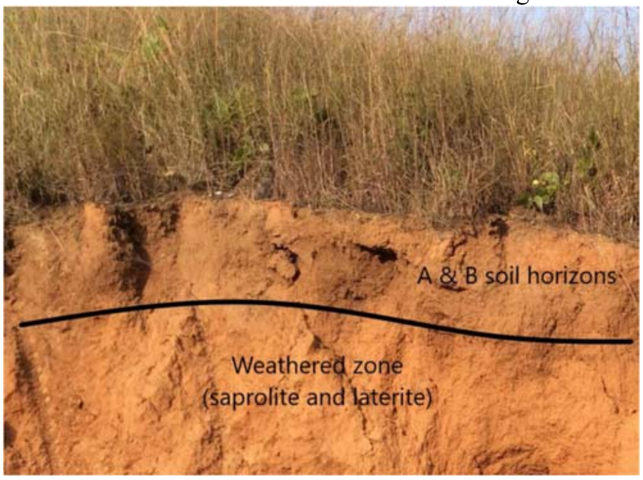


Plate 5.2 shows an exposed A and B soil horizon overlaying the saprolite and laterite weathered zone on an upper valley slope to the west of Bawdwin. Previous assessments have identified the saprolite/laterite weathering zone to be as much as 20 to 50 m thick on the ridges around Bawdwin but absent in the valley floor (BJV, 2019).

Soils in the study area are primarily completely weathered tuff (rock made from volcanic ash) and sandstone material, which are distinct from the localised alluvial and colluvial deposits that are present on the valley floors. Alluvial deposits are loose, unconsolidated soils that have been eroded and transported by surface water flow and comprise a variety of materials including silts, clays, sands and gravels. Colluvial deposits are similar to the alluvial deposits but also include material transported and deposited by a combination of downslope creep and slumping and wind and rain erosion.

The gridded soil assessment further classified soils by the dominant mineralogy of the B Horizon sample as either haematite, kaolinite or quartz, which distinguishes the different underlying lithology. Figure 5.6 shows the distribution of the dominant B Horizon mineralogy across the study area. Most of the study area is dominated by hematite with smaller zones of quartz in the central and eastern study area. The open pit mine lies at the junction between hematite and quartz zones. In the southeast of the study area, including around Tiger Camp, the dominant B Horizon mineralogy is kaolinite.

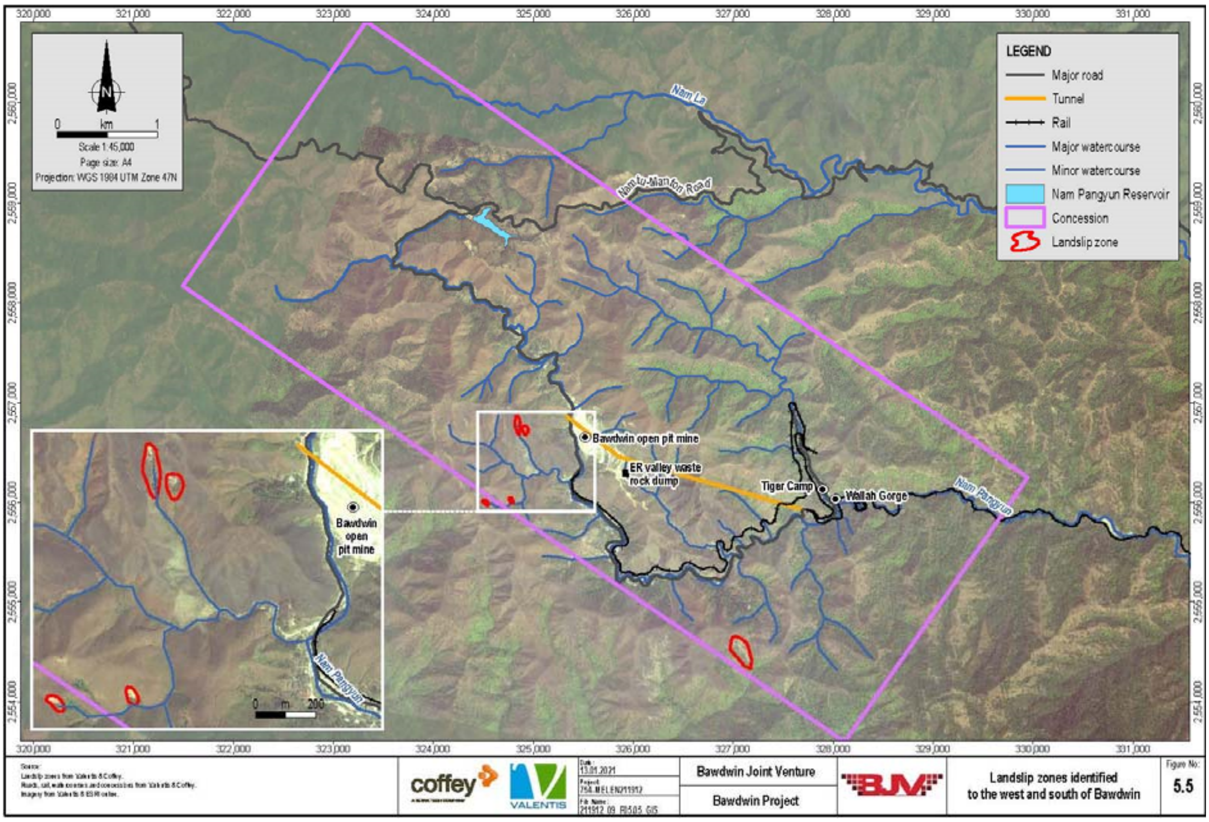


Figure 5.5 Landslip zones identified to the west of Bawdwin

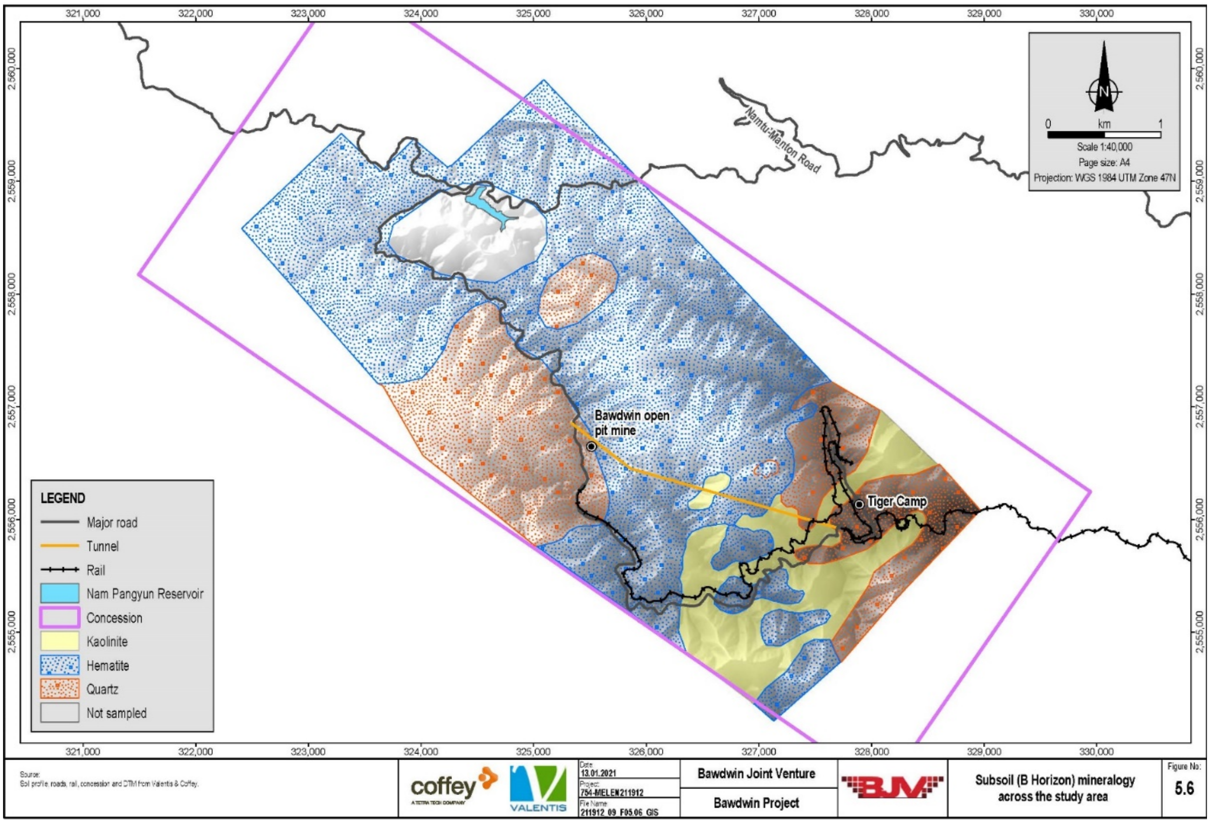


Figure 5.6 Subsoil (B Horizon) mineralogy across the study area

The soil and weathering characteristics mentioned above are consistent across the study area and broader mountainous region. The exceptions are the Tiger Camp area and some parts of Bawdwin where previous waste rock and slag material has been disposed and/or where fill material has been imported to provide areas of level ground. The fill material at Tiger Camp was a dry, friable, pale orange-brown, gravelly sand and was inferred to be waste rock associated with the former use of the area for stockpiling, crushing and loading ore onto trains. The fill material appeared to be devoid of organic matter and may be dispersive and susceptible to erosion. It is likely that this layer of fill material is more than 10 m thick in places.

Plate 5.3 shows the fill material at Tiger Camp.

Three sites within the tailings storage facility footprint were sampled for particle size distribution as part of the project definitive feasibility study (Knight Piésold, 2020) (see Figure 5.1). The sample depths ranged from 3 to 6 m below the surface (i.e., subsoil). The results showed that the two sites at the southern end of the tailings storage facility comprised predominantly (i.e., typically more than 80%) gravels and sands with smaller proportions of silt and clay. The site at the northwestern boundary of the facility comprised mostly (more than 80%) sands and silts with some clay present, but very little gravel.

Soil quality

Metals

The Bawdwin area has naturally high metals concentrations associated with regional minerology and also elevated concentrations of metals due to centuries of mining, ore processing and disposal of mine waste material. Given the potential for metal concentrations in the environment to be at levels of concern and the potential for some metals to bioaccumulate, this section establishes the existing concentration ranges and averages of key potential metal toxicants.

Metal levels in soil were characterised by analysis of over 2,000 soil horizon samples across a 17 km^2 area (Figure 5.7 to Figure 5.11). Samples were collected from between about 0.1 to 0.2 m below the ground surface, and were predominantly from the A Horizon.

Myanmar does not have soil quality standards or guidelines. This section therefore adopts soil quality guidelines from Australia to act as a reference for characterising existing soil quality in the study area. The adopted guidelines are the Australian National Environmental Protection Measure (2013) Schedule B1 Guideline on Investigation Levels for Soil and Groundwater (NEPM, 2013).

The NEPM (2013) guidelines include ecologically-based soil criteria that act as an initial screening tool for assessing potential soil quality issues. These criteria are in the form of ecological investigation levels (EILs), which apply to selected contaminant concentrations in the top 2 m of soil (which corresponds to the root zone and habitation of many species). An EIL is the concentration of a contaminant that, if exceeded, should prompt further investigation to better understand risks to the soil ecosystem. The EILs are not related to human health effects.

The guidelines include provisions for developing site-specific EILs for several key contaminants and these require collection of a range of physico-chemical soils data (e.g., cation exchange capacity, clay content) that were not collected as part of the sampling at Bawdwin. Given this and that the NEPM (2013) guidelines are based on Australian soil conditions, the EILs are used to provide a general indication of the soil quality at Bawdwin in the absence of Myanmar standards or guidelines.

Plate 5.1 Exposed rock in slopes of the Nam Pangyun valley between Bawdwin and Tiger Camp

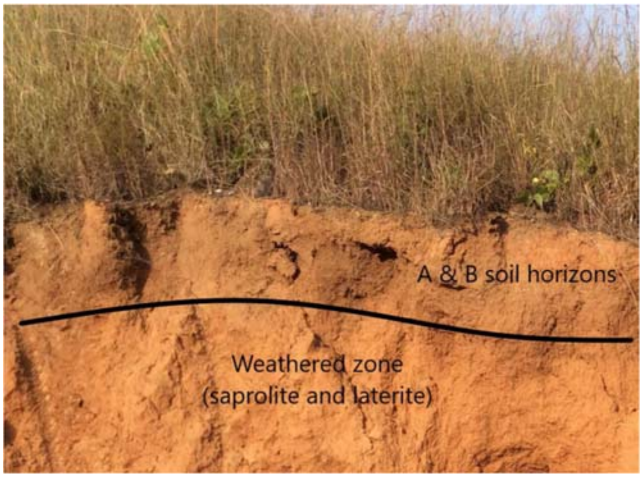


Plate 5.2 Exposed A and B soil horizon on an upper valley slope west of Bawdwin with weathered laterite/saprolite layer beneath

Plate 5.3 Tiger Camp soil profile showing fill material (foreground) and natural soils (background)

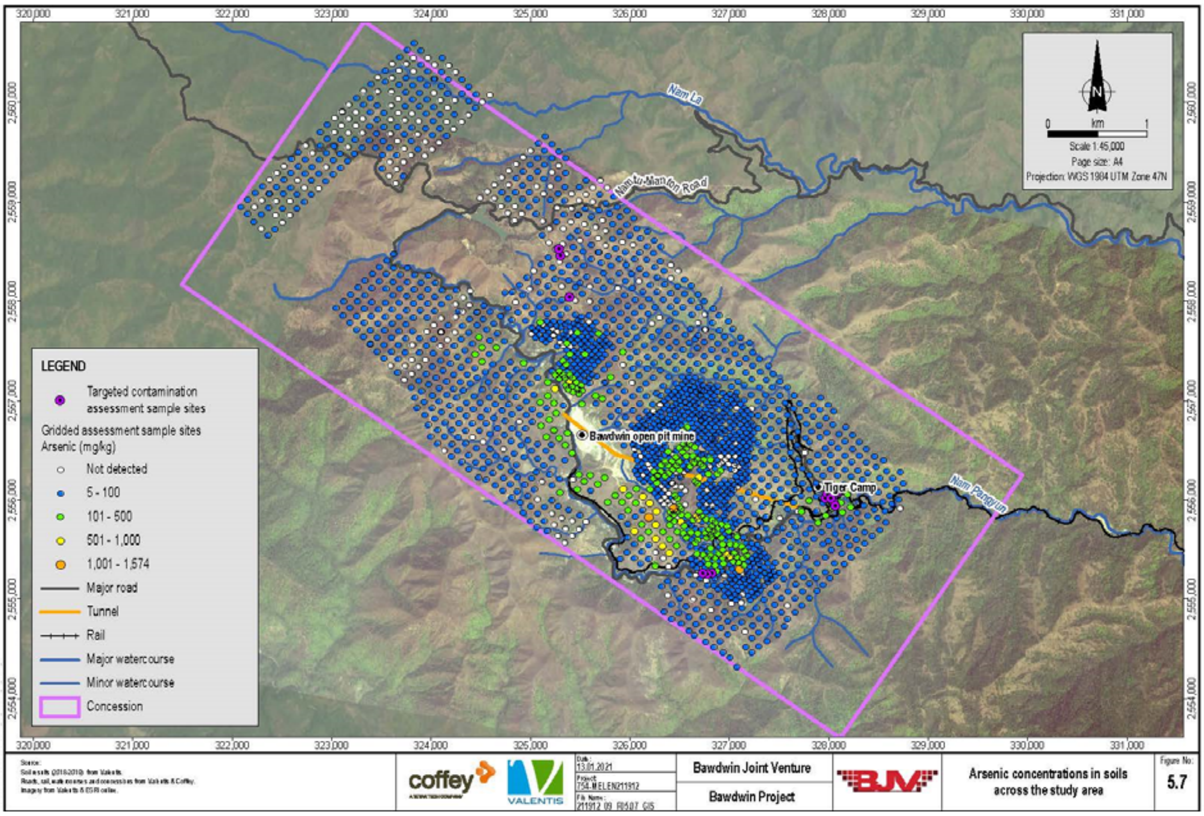


Figure 5.7 Arsenic concentrations in soils across the study area

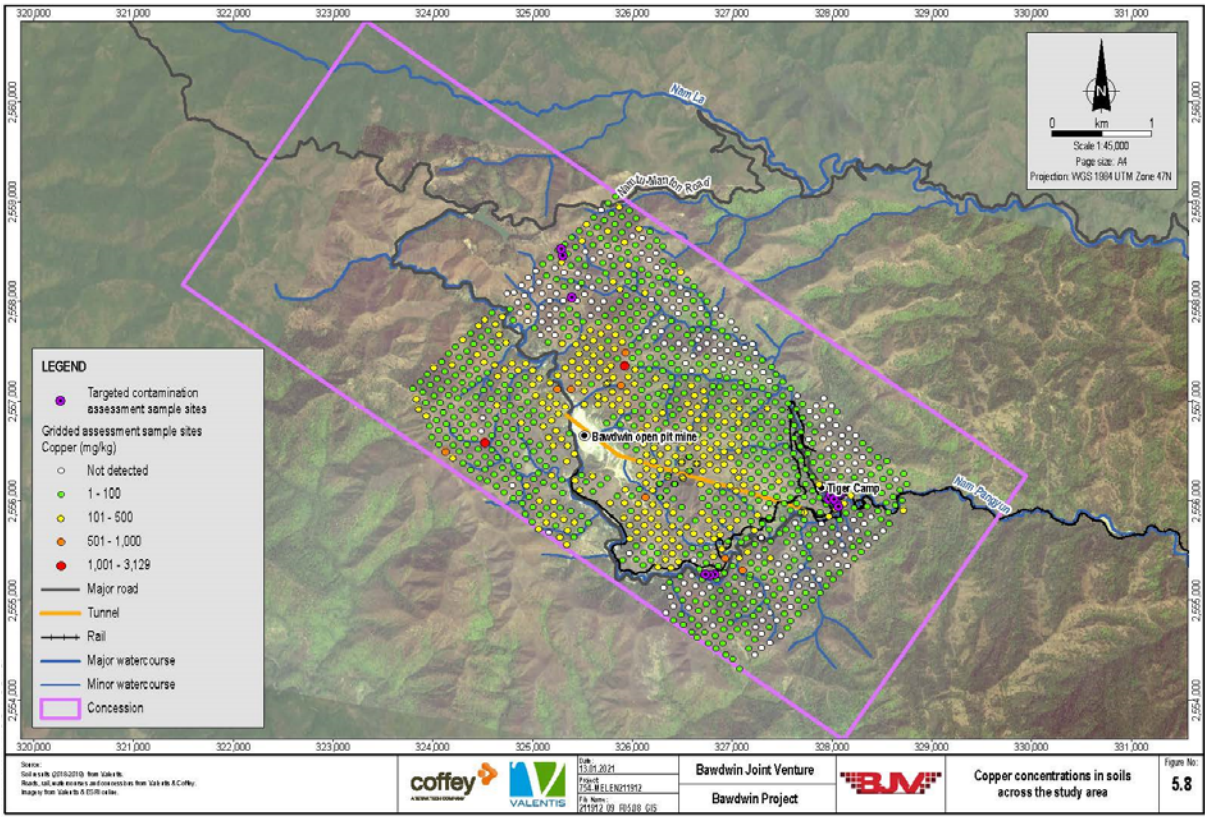


Figure 5.8 Copper concentrations in soils across the study area

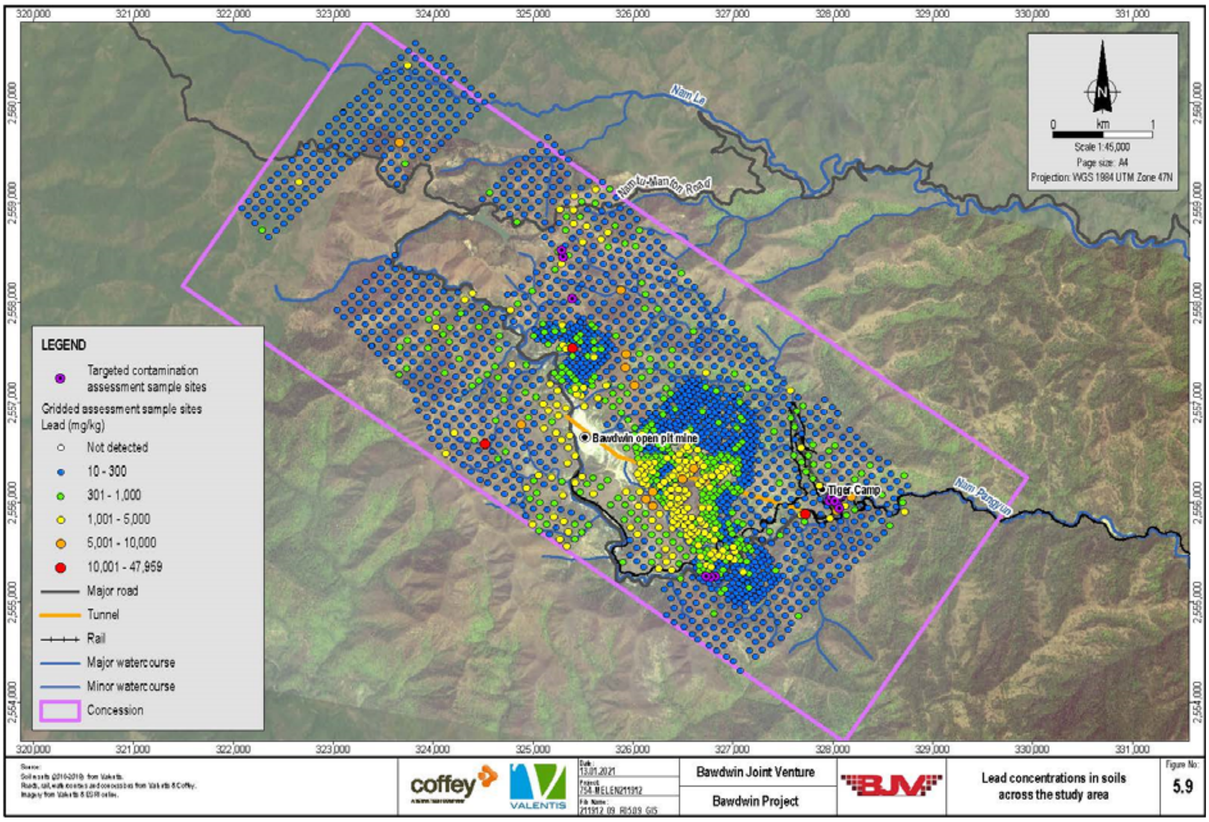


Figure 5.9 Lead concentrations in soils across the study area

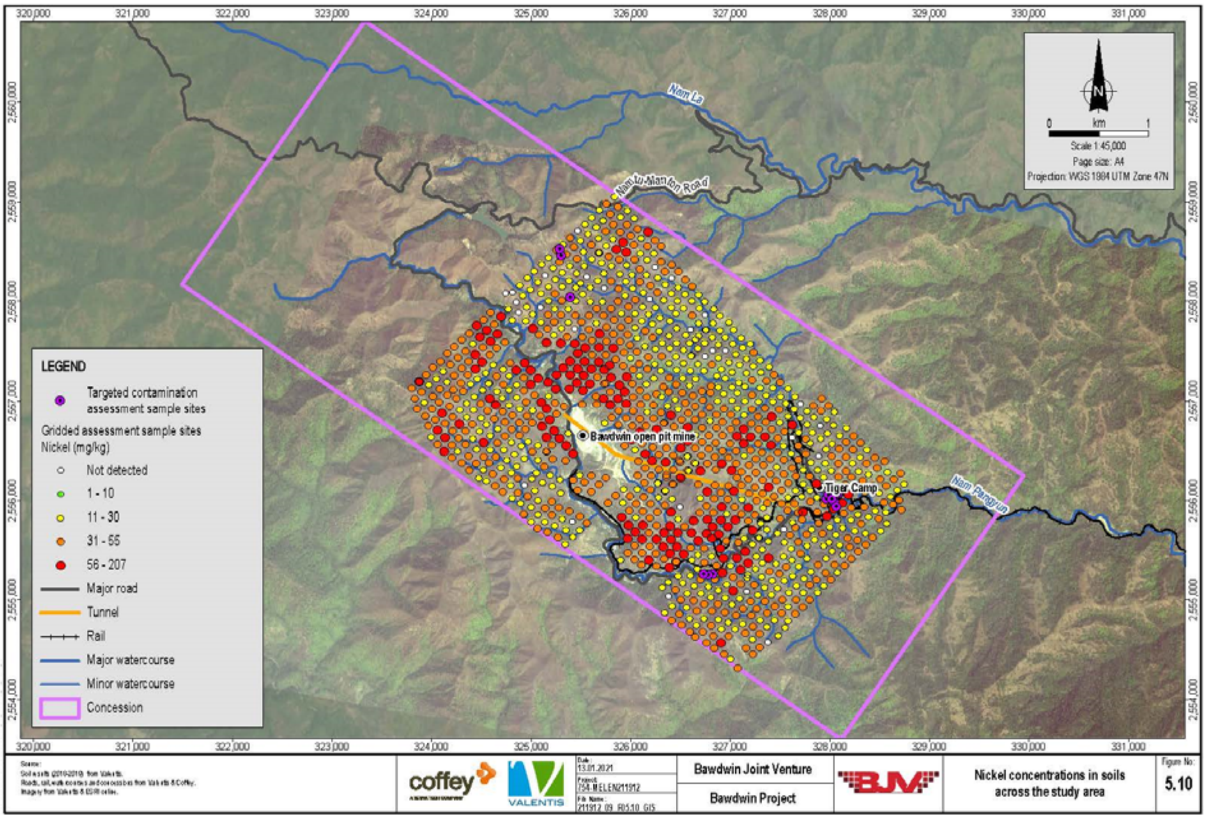


Figure 5.10 Nickel concentrations in soils across the study area

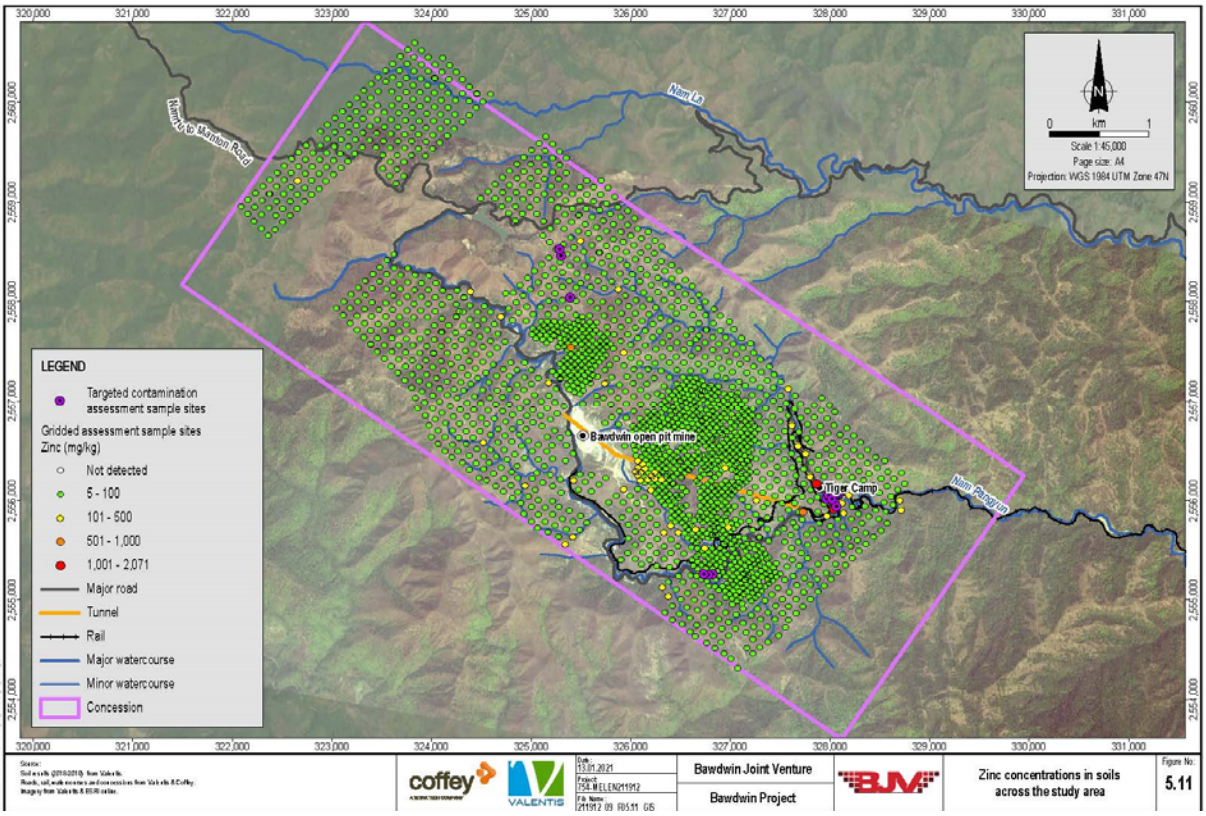


Figure 5.11 Zinc concentrations in soils across the study area

In the guidelines, EILs are provided for different levels of ecosystem protection based on different land use types. Three levels of EIL, in order of highest level of protection/most stringent to lowest level of protection/least stringent, are given for protection of ‘national park and areas with high ecological value’, ‘urban residential and public open space’, and ‘commercial and industrial’ land uses. Given the Bawdwin mine setting, EILs for the protection of the latter two land uses are adopted (although noting that the area is not ‘urban residential’ but it does comprise areas of ‘public open space’ and residential use).

Using the approach outlined in the NEPM (2013) guidelines, EILs were derived for comparison to soil quality results from the study area as follows:

- **Lead** – EILs were derived by using the generic added contaminant limits (ACL) of 1,100 and 1,800 mg/kg for protection of ‘urban residential and public open space’ and ‘commercial and industrial land uses’, respectively, as outlined in Table 1B(4) of the guidelines for contaminants that have been in soils for at least two years. An ACL is the added concentration of a contaminant above which requires further investigation of impact on ecological values. A background lead concentration of 10 mg/kg was assumed based on the lowest concentration detected across the study area. By summing the background concentration and the ACL for each land use type, EILs of 1,110 and 1,810 mg/kg were adopted for ‘urban residential and public open space’ and ‘commercial and industrial land uses’, respectively.

- **Arsenic** – EILs were derived by adopting the generic EILs prescribed in Table 1B(4) of the guidelines for contaminants that have been in soils for at least two years. The adopted EILs are 100 and 170 mg/kg for ‘urban residential and public open space’ and ‘commercial and industrial land uses’, respectively.

- **Chromium** – EILs were derived by adopting the most conservative ACLs prescribed in Table 1B(3) of the guidelines for contaminants that have been in soils for at least two years. That table includes a range of ACLs depending on the % clay content. As % clay was not measured, the most conservative ACLs were used. Using this approach, and a background chromium concentration of less than detection (i.e., assumed zero for the purpose of the calculation), EILs of 190 and 310 mg/kg were adopted for ‘urban residential and public open space’ and ‘commercial and industrial land uses’, respectively. The EILs for chromium in the guidelines is for trivalent chromium (chromium in an oxidation state of three), whereas soils from Bawdwin were analysed for total chromium (all oxidation states). Therefore, this comparison has particularly limited applicability without knowing the proportion of trivalent chromium in the soils.

- **Nickel** - EILs were derived by adopting the most conservative ACLs prescribed in Table 1B(3) of the guidelines for contaminants that have been in soils for at least two years. That table includes a range of ACLs depending on the cation exchange capacity. As cation exchange capacity was not measured from the soil samples, the most conservative ACLs were used. Using this approach, and a background chromium concentration of less than detection (i.e., assumed zero for the purpose of the calculation), EILs of 30 and 50 mg/kg were adopted for ‘urban residential and public open space’ and ‘commercial and industrial land uses’, respectively.

- **Copper** – EILs were derived by adopting conservative ACLs outlined in Table 1B(2) of the guidelines for contaminants in soils for at least two years. That table prescribes a range of ACLs based on soil pH. Conservatively, the ACL corresponding to the lowest pH recorded (pH 6.5) in the study area was adopted. Using this approach and an assumed background concentration of less than detection (i.e., assumed zero for the purpose of the calculation), EILs of 280 and 400 mg/kg were adopted for ‘urban residential and public open space’ and ‘commercial and industrial land uses’, respectively.

- **Zinc** – EILs were derived by adopting conservative ACLs outlined in Table 1B(1) of the guidelines for contaminants in soils for at least two years. This table prescribes a range of ACLs based on soil pH and cation exchange capacity. As cation exchange capacity of soils at Bawdwin was not measured, conservatively the lowest cation exchange capacity was adopted and the lowest recorded pH of 6.5 was adopted. Based on this approach and an assumed background zinc concentration of 5.4 mg/kg (based on the lowest recorded concentration across the study area), EILs of 235 and 365 mg/kg were adopted for ‘urban residential and public open space’ and ‘commercial and industrial land uses’, respectively.

The NEPM (2013) guidelines do not have generic ACLs or EILs for other metals.

Table 5.1 presents a summary of the metals concentrations measured at the sites across the study area for the gridded soils assessment. Table 5.2 presents a summary of the metals concentrations measured at three locations, Tiger Camp, Football Field and Accommodation Camp, for the targeted soil contamination assessment.

For simplicity, the metalloid arsenic is included in the mention of 'metals' throughout this section. For reference, the results tables also include the adopted EILs as outlined above. In Tables 5.1 and 5.2, exceedance of the EIL for urban residential and public open space is shown in italics and exceedance of the EIL for commercial and industrial land use is shown in bold.

Table 5.1 Summary of soil total metals concentrations (mg/kg) and relevant EILs (gridded soils assessment)

	Arsenic	Chromium	Copper	Iron	Lead	Manganese	Nickel	Zinc
Average	46.4	15.4	84.9	20,948	438	379	*38.2*	29.9
Median	23	<LOD	46	20,649	128	247	*34*	20.7
Maximum	***1,574***	111	***3,129***	203,948	***47,959***	8,437	***294***	***2,071***
Minimum	<LOD	<LOD	<LOD	<LOD	10	<LOD	<LOD	5.4
EIL – urban residential and public open space	100	190	280	N/A	1,110	N/A	30	235
EIL – commercial and industrial	170	310	400	N/A	1,810	N/A	55	365

N/A denotes no applicable EIL
All concentrations are in mg/kg
'LOD' denotes 'limit of detection'
Exceedance of the EIL for urban residential and public open space is shown in italics.
Exceedance of the EIL for commercial and industrial land use is shown in bold.

Table 5.2 Summary of soil total metals concentrations (mg/kg) and relevant EILs (targeted soil contamination survey)

	Arsenic	Chromium[a]	Copper	Iron	Lead	Manganese	Nickel	Zinc
Tiger Camp (range)	49.8 – **5,730**	<LOD	59.7 – **4,410**	11,100 – 47,400	**2,340** – **47,500**	314 – 1,400	29.9 – **1,020**	**1,100** – **15,600**
Football field (range)	85.8 - **172**	<LOD	30 - 130	14,500 – 22,700	*1,180* – **3,080**	322 - 823	5.1 - 16.5	170 - **425**
Accommodation camp (range)	21.3 - 54.9	<LOD	74.2 – **1,010**	23,800 – 29,800	*1,800* – **6,510**	135 - 222	6.7 - 8.3	42 - 140
EIL – urban residential and public open space	100	190	280	N/A	1,110	N/A	30	230
EIL – commercial and industrial	170	310	400	N/A	1,810	N/A	55	360

N/A denotes no applicable EIL
All concentrations are in mg/kg
Exceedance of the EIL for urban residential and public open space is shown in italics.
Exceedance of the EIL for commercial and industrial land use is shown in bold.
[a] results for hexavalent chromium only.

Table 5.1 shows that, from the gridded soils assessment, the maximum recorded concentrations of arsenic, copper, lead, nickel and zinc exceed the EIL for commercial and industrial land use (and the more stringent EILs for urban residential and public open space). The average and median concentrations of nickel also exceed the EIL for urban residential and public open space but were below the EIL for commercial and industrial land use. Maximum concentrations for arsenic, copper, lead and zinc exceed the EILs by more than an order of magnitude.

Table 5.2 shows similar elevation of the above-mentioned metals in soils from the targeted contamination assessment but, with the exception of lead, which was elevated above EILs at all three locations (Tiger Camp, Football Field and Accommodation Camp), the elevated concentrations of most metals were generally restricted to the Tiger Camp area. Maximum concentrations of arsenic, nickel and zinc were notably greater at Tiger Camp during the targeted contamination assessment compared to the sites included in the gridded soils assessment.

Figures 5.7 to 5.11 show the concentrations of arsenic, copper, lead, nickel and zinc in soils at each site across the study area. Iron and manganese are not shown in figures as there are no EILs for these metals and they are of lower ecotoxicity than the other metals.

Figures 5.7, 5.9 and 5.11 show that the highest concentrations of arsenic, lead and zinc are clustered around the open pit, particularly downslope to the east, and in the Tiger Camp area. This is reflective of the many years of waste rock and slag disposal in these areas, mineral handling and the use of waste rock fill material. Figures 5.9 and 5.11 show that the highest copper and nickel concentrations were more widely spread around the study area. While only several sites had copper concentrations exceeding the EILs, most of the sites had nickel concentrations exceeding the EILs. As many of the sites where nickel concentrations exceeded EILs were more than a kilometre upstream of mining activities, this suggests the elevated concentrations are naturally occurring.

The comparison of the soil metals concentrations to EILs highlights the widespread elevated concentrations of metals in soils at Bawdwin, most likely due to long running mining and processing of ore and disposal of waste rock and waste slag. Lead, in particular, is at extremely high concentrations.

Inorganics

Table 5.3 presents the summary results for pH, electrical conductivity, sulfate and chloride from the targeted contamination assessment at Tiger Camp, Football Field and Accommodation Camp. Collectively, these parameters provide information on the inorganic properties of the soils. The results show that the pH range was slightly broader at Tiger Camp than the other two locations. The recorded pHs between 6.5 to 7.6 indicates a healthy 'neutral' pH range, where most nutrients are typically readily available to plants (Queensland Government, 2020). Maximum electrical conductivity (1,690 µS/cm) was more than an order of magnitude greater at Tiger Camp than the other two locations, which is reflective of the significantly higher sulfate and chloride anion maximum concentrations at that site. Soil conductivities greater than 1,000 µS/cm generally cause problems to growth of many plant species (Agriculture Victoria, 2020). Higher sulfate and chloride anions (along with higher metals concentrations – see section 'Metals' above) at Tiger Camp are a result of the highly mineralised waste rock used as fill material at the site. For example, high concentrations of sulfate ions are likely to be a result of chemical weathering of sulfide-bearing minerals of the parent rock.

Table 5.3 Summary of soil pH and electrical conductivity

Site	pH (range)	Electrical conductivity (µS/cm) (range)	Sulfate (mg/kg) (range)	Chloride (mg/kg) (range)
Tiger Camp (range)	6.5 – 7.62	59 – 1,690	97 – 7,700	<2.5 – 77
Football field (range)	6.98 – 7.12	24 – 49	15 – 38	5 – 6
Accommodation camp (range)	7.11 – 7.18	7 – 9	<10 – 16	<2.5 – 3

Nutrients

All soil samples from the targeted contamination assessment were analysed for nitrate, ammonia and total Kjeldahl nitrogen. Total Kjeldahl nitrogen provides a measure of nitrogen present in organic form plus ammonia and ammonium forms of nitrogen. The nitrate concentration range was highest at Tiger Camp and ammonia concentration range was highest at the Football Field. Total Kjeldahl nitrogen concentrations in fill material at Tiger Camp ranged from 37 mg/kg to 1,170 mg/kg. Total Kjeldahl nitrogen content was higher in natural soils at the football field (ranging from 1,370 mg/kg to 2,020 mg/kg). Total Kjeldahl nitrogen at the accommodation camp site ranged from 415 mg/kg to 968 mg/kg. Table 5.4 presents the nutrients results.

Table 5.4 Summary of soil nutrients concentrations

Site	Nitrate (mg/kg) (range)	Ammonia (mg/kg) (range)	Total Kjeldahl nitrogen (mg/kg) (range)
Tiger Camp (range)	0.11 – 26.8	<0.4 (all samples)	37 – 1,170

Football field (range)	0.62 – 6.49	3.5 – 12.7	1,370 – 2,020
Accommodation camp (range)	0.08 – 1.39	<0.43 (all samples)	415 – 968

Organic compounds and other contaminants

There were no reported concentrations of the following organic compounds above limits of detection at any of the sample sites from the targeted contamination assessment:

- Total petroleum hydrocarbons (TPH).
- Benzene, toluene, ethylbenzene, xylene, and naphthalene (BTEXN).
- Monocyclic aromatic hydrocarbons (MAHs).
- Polycyclic aromatic hydrocarbons (PAHs).
- Chlorinated hydrocarbons and solvents.
- Halogenated benzenes.
- Phenols.

In addition, no fungicides, herbicides or pesticides were detected at any sites. Asbestos was also not detected at any sites sampled. This reflects the lack of large-scale agricultural practices and use of asbestos in the study area.

5.1.5 Summary

The Bawdwin area is underlain by the co-depositional Pangyun and Bawdwin Volcanic Formations, hosting the three main sulphide ore bodies within a 2.5 km by 200 m zone of mineralisation within the Bawdwin Fault Zone.

The landform of the study area is characterised by mountainous terrain, deeply incised valleys and slopes mostly in excess of 20%. Less steep undulating hills and valleys are found to the northern and western corners of the study area, and gentle undulations are present closer to Namtu, south of the Myitnge River. There is little evidence of large landslips, however smaller localised slips or slumping may occur.

Site investigations and characterisation of the soils in the study area show:

- The soil comprised silty and sandy material of various sizes with a zone of saprolite and laterite on the crests and mis-slopes of valleys. Soils in the study area are primarily completely weathered tuff and sandstone material.
- Most of the study area is dominated by hematite with smaller zones of quartz in the central and eastern study area. The open pit mine lies at the junction between hematite and quartz zones. In the southeast of the study area, including around Tiger Camp, the dominant B Horizon mineralogy is kaolinite.
- There are elevated metal concentrations in soil samples across the study area. These are attributed to the naturally occurring presence of elevated metal concentrations and from historical mining activities.
- Many years of waste rock and slag disposal, mineral handling and the use of waste rock fill material are reflected in the high concentrations of arsenic, lead and zinc found around the open pit, downslope to the east, and in the Tiger Camp area. Soils from Tiger Camp typically had the highest concentrations of metals, elevated inorganic properties (pH, electrical conductivity, sulfate concentration and chloride concentration), and the highest concentrations of nitrate.

5.1.6 Sensitivity of landform and soils values

This section builds on the characterisation of landform and soils in Sections 5.1.3 and 5.1.4 and describes the sensitivity of landform and soils values in terms of their importance, vulnerability and resilience. Sensitivity in this context is a quantification of how sensitive the landform and soil values are to change as a result of the project. Sensitivity is based on the importance of the value, the vulnerability of the value to change, and the resilience of the value in terms of its ability to overcome changes and maintain its inherent value.

No geological values are identified because geology is a process and the values associated with geological process are in the form of landform and soils at the surface that support ecosystems and land uses. This section discussed geology to provide context to the understanding of the landform and soil characteristics in the study area.

This section only addresses landform and soils values from an immediate ecological or land use point of view (i.e., vegetation and land use supported by, or potentially supported by the landform and soil). Other related values such as those for biodiversity more broadly, human health, visual landscape amenity, surface and groundwater, and cultural heritage depend to an extent on landform and soil, but those aspects are each addressed in specific sections as each has a specific context.

To characterise the sensitivity of landform and soil values, three terrain units have been defined based on their different attributes and associated values. The three terrain units identified in the study area are:

- **Steep mountain terrain**: This includes most of the terrain in the study area and is dominated by steep mountains, and narrow ridges and crests.
- **Lower mountain slopes and valley floors**: This includes the lower slopes and floors of the Nam Pangyun, ER and Wallah valleys.
- **Undulating hills of the northern and western study area:** This includes areas of less steep, undulating terrain in the northern corner of the study area around the Nam Pangyun Reservoir where most of the elevation ranges from approximately 1,200 to 1,300 m above sea level, and in the western corner of the study area where elevation ranges from 1,300 to 1,400 m above sea level.

Figure 5.12 shows the approximate extents of these terrain units.

Table 5.5 outlines the importance, vulnerability and resilience definitions and ratings criteria used for assessing the sensitivity of each terrain unit.

Table 5.6 outlines the importance, vulnerability and resilience of the terrain units.

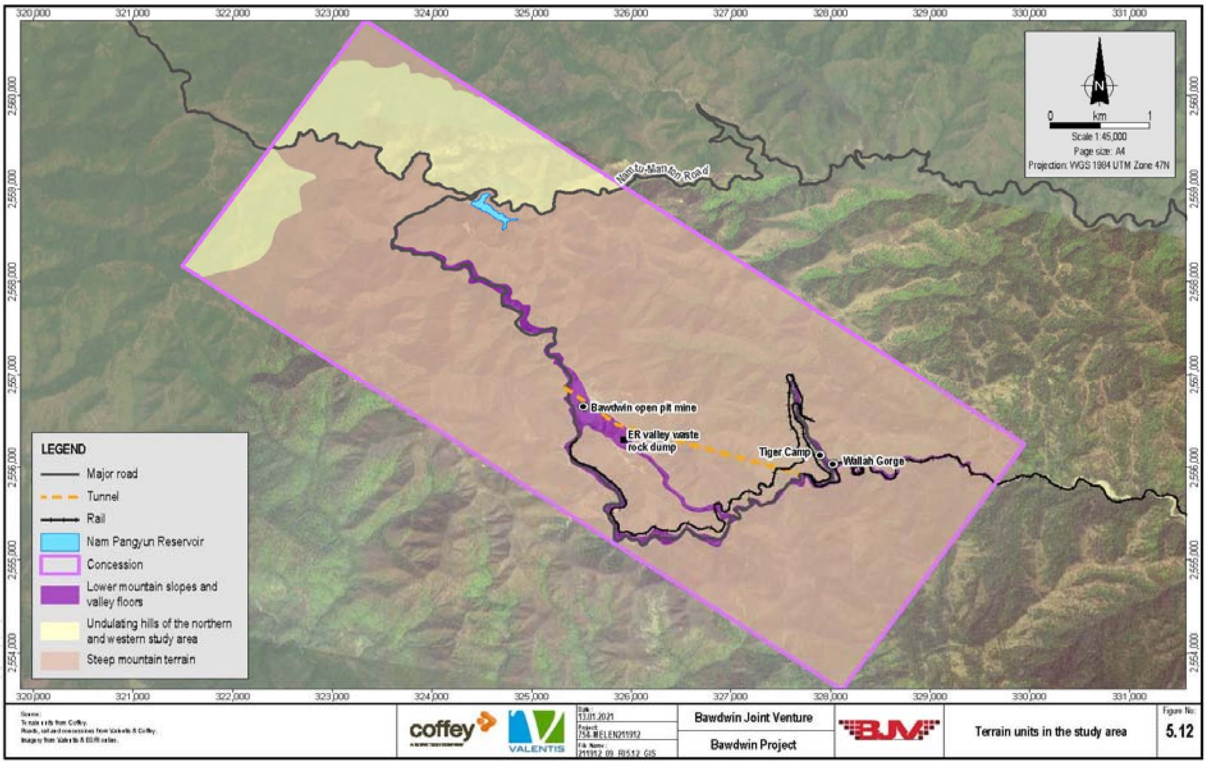


Figure 5.12 Terrain units in the study area

Table 5.5 Importance, vulnerability and resilience definitions and ratings criteria

	Definition	Ratings criteria		
		Low	**Medium**	**High**
Importance	The value that is associated with the terrain unit in its current form. This includes the ability of the terrain unit to support ecosystems and beneficial land uses. Land use types are not ranked in terms of importance as each land use may have different importance to different people.	Has limited or no potential to support soil ecosystems, vegetation or land uses.	Supports some beneficial uses or has medium potential to support soil ecosystems, vegetation or land uses.	Supports, or has the ability to support, soil ecosystems, vegetation and a range of land uses.
Vulnerability	The extent to which the terrain unit is susceptible to change. This includes the existing condition of the terrain unit in terms of its physical and chemical properties and how readily additional change may cause deterioration or loss of associated ecosystems or land use value.	Low susceptibility to landslip and erosion. Low existing soil contamination.	Medium susceptibility to landslip and erosion. Medium level of existing soil contamination.	High susceptibility to landslip and erosion. High level of existing soil contamination.
Resilience	The extent to which the terrain unit can adapt or recover from change. In this context, this relates to how readily the terrain unit could naturally recover from change or be rehabilitated.	Limited or no capacity to adapt to change and the associated ecosystem value or land use cannot be regained.	Some resilience to change. Some of the associated ecosystem value or land use can be regained.	Easily adaptable to change and most or all of the associated ecosystem value or land use can be regained.

Table 5.6 Importance, vulnerability, resilience and sensitivity of the terrain unit

Terrain unit	Importance	Vulnerability	Resilience	Sensitivity
Steep mountain terrain	**Low** Terrain not currently an important area for building construction or agriculture and not likely to be in the future due to steepness. Supports limited vegetation growth and ecosystems due to pre-existing vegetation clearance, thin soil profile and erosion.	**Medium** Medium to high susceptibility to landslip, prone to erosion and vulnerable to additional loss of topsoil. Highly contaminated soils around the Nam Pangyun, ER and Wallah valleys. Soils have lower contaminant concentrations further away from these areas within the study area.	**Medium** Due to the steepness it will likely be very difficult to rehabilitate landslip, erosion or additional contamination. Limited potential to regain associated ecosystem value and beneficial land use.	**Medium**
Lower mountain slopes and valley floors	**Medium** Important area for building construction and supports growing of gardens for food. . Supports limited vegetation growth and ecosystems due to thin soil profile and erosion.	**Low** Relatively low susceptibility to landslip but prone to erosion, particularly where fill material has been used. Thin soil profile but generally thicker than steep mountain ridges, crests and the steep mid to upper slopes. Highly contaminated with heavy metals from previous slag and waste rock disposal and fill material.	**High** Due to the widespread existing contamination and lack of vegetation it is likely this terrain unit would be able to withstand additional contamination without further loss of value or beneficial use. The valley floors would be easier to rehabilitate than the slopes.	**Medium**
Undulating hills of the northern and western study area	**High** Not currently an important area for building construction but could be in the future due to flatter terrain. Supports higher quality vegetation and has potential for supporting more vegetation growth and agriculture.	**Medium** Medium susceptibility to landslip but high susceptibility to erosion if disturbed and vegetation cleared. Soil profile likely thicker and more stable due to greater vegetation cover and more gentle slopes. Soils have lower levels of contamination than other terrain units.	**Medium** Due to low levels of existing contamination and erosion, extensive rehabilitation may be required to regain associated value and beneficial use, however, may be more readily achievable due to the flat topography.	**Medium**

5.1.7 Uncertainties and limitations

The key uncertainties and limitations of this section are:

- The locations of project infrastructure has been altered as feasibility studies have progressed. As a result, targeted soil testing has not been completed at all locations, for example, along the proposed road corridor between Namtu and Tiger Camp.
- The Australian Guidelines (NEPM, 2013) on Investigation Levels for Soil have been adopted to describe existing soil quality in the absence of Myanmar guidelines. The Australian guidelines are designed for Australian soils and may have lower applicability to Myanmar given the different geological and climate conditions and ecosystems. In addition, the guidelines are largely generic values with some minor incorporation of site-specific conditions (e.g., reference site concentrations, pH) and their use should only be viewed as a high-level preliminary screening exercise. The use of the guidelines is for indicative purposes only.
- The sampling grid does not cover the whole study area, but a large enough proportion of it to provide inference of spatial trends.

5.2 Groundwater

This section describes the existing groundwater environment of the project. A baseline groundwater study was conducted by Coffey and Valentis between 2017 and 2020 for the project to characterise the hydrogeological setting, groundwater quality and groundwater resources in the Bawdwin study area. Characterisation of baseline groundwater conditions and definition of groundwater values forms the basis for assessing potential impacts of the project on the groundwater environment in Chapter 6. The baseline report is presented in Appendix C.

Additional groundwater investigations were completed by CSA Global to inform the Definitive Feasibility Study (DFS) for BJV (BJV, 2020). The investigation by CSA Global (2020) involved characterising the hydrology and hydrogeology of the Bawdwin area. This report is presented in Appendix B.

The information presented in this section is a consolidated summary of information presented in both reports to characterise the existing hydrogeological conditions in the Bawdwin area.

5.2.1 Method and study area

The groundwater study area was defined based on the surface water catchments that host the mine area and infrastructure corridor. The study area is large enough to capture any potential project effects to groundwater, as well as provide sufficient regional context to understand the values associated with the groundwater features. The catchments that comprise the groundwater study area include:

- Nam Pangyun.
- Nam La.

These catchments are shown on Figure 5.13.

Baseline groundwater investigations have been undertaken in three phases within the study area:

- Preliminary groundwater assessment.
- Baseline groundwater monitoring program.
- Hydrogeological investigations to support the definitive feasibility study for the project.

The methods applied during the baseline investigations are described further in the following sections. A summary of results is presented in Section 5.2.3. These results form the basis for establishing a conceptual groundwater model for the study area (see Figure 5.16).

To provide context for the following discussion, the following key terms are defined:

- **Aquifer** – an aquifer is an underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials (gravel, sand, or silt).
- **Saprolite aquifer** – an aquifer within a chemically weathered rock that forms in the lower zones of soil horizons and represents deep weathering of the bedrock surface.
- **Fractured rock aquifer** – where groundwater is stored in the fractures, joints, bedding planes and cavities of the rock mass and water availability is largely dependent on the nature of the fractures and their interconnection.

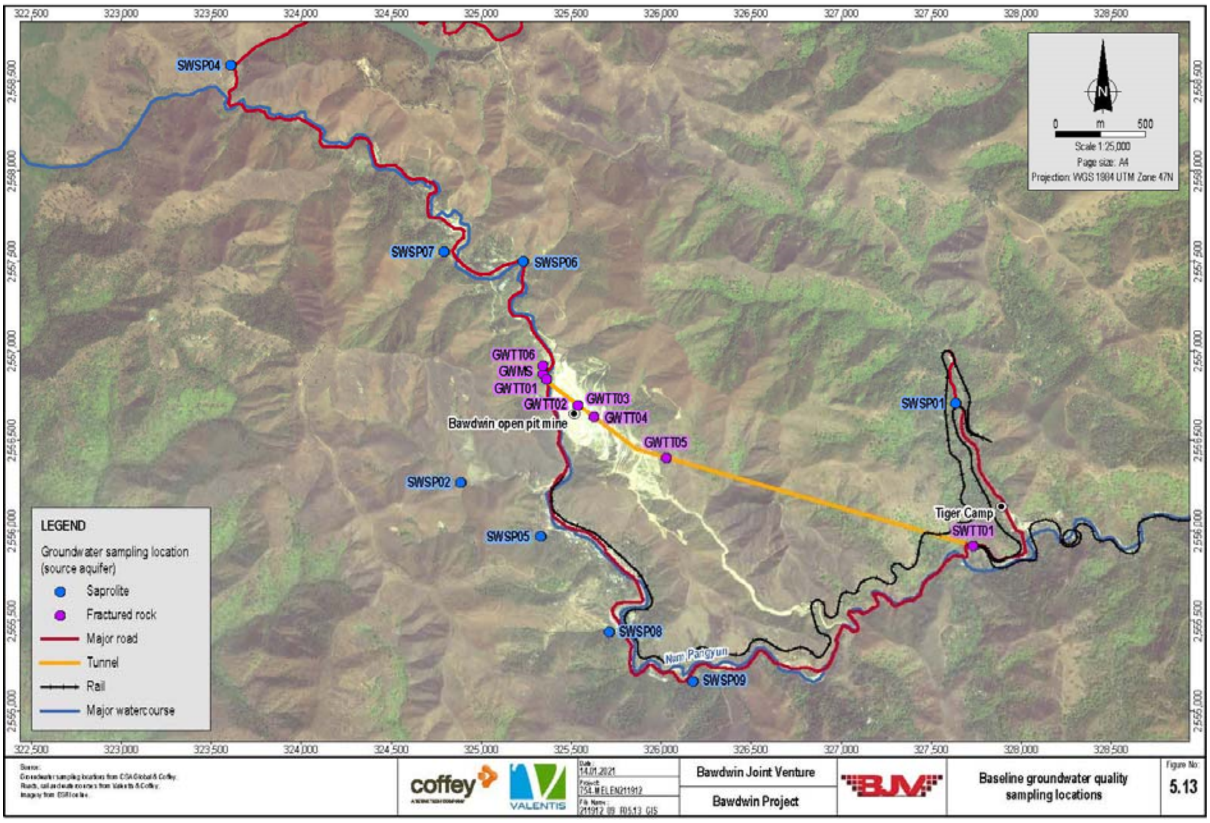


Figure 5.13 Baseline groundwater quality sampling locations

Preliminary groundwater assessment

A preliminary groundwater assessment was conducted by Coffey during 2017, which included an initial desktop assessment of available information to gain an understanding of the geological and hydrogeological setting, climate, groundwater receptors and likely existing water quality and water level impacts from historical mining and ore processing activities at Bawdwin and Namtu. A site visit was conducted by a Coffey hydrogeologist in November 2017 to support the initial development of a hydrogeological conceptual model, collection of field measured water quality parameters and representative samples of selected springs and groundwater discharge from the underground mine, and establish the groundwater study area.

Water samples were collected in standard laboratory supplied 60 mL un-preserved polyethylene containers at 11 locations for laboratory analysis. In addition, field parameters were measured at 15 locations using a calibrated pH meter and a calibrated EC meter. HACH test strips were used to measure hardness and alkalinity in the field, and also as a check to confirm pH.

Baseline groundwater monitoring program

A baseline groundwater quality monitoring program was developed by Coffey to assess existing groundwater quality conditions and groundwater occurrence in the saprolite aquifer and the underlying fractured rock aquifer in the study area.

Coffey hydrogeologists conducted a site visit during November 2018 to identify suitable groundwater and surface water sampling locations and develop a more detailed understanding of the hydrogeological setting. Dedicated groundwater observation wells could not be installed during the initial baseline quality monitoring period due to a suitable drill rig and well construction materials not being available.

Once drilling resources became available during 2019, a groundwater level investigation was undertaken by CSA Global, which focussed on assessing groundwater levels in the fractured rock aquifer around the Bawdwin mine pit and other key infrastructure development areas.

Groundwater quality

A preliminary monitoring round of groundwater quality was conducted by Coffey hydrogeologists and Valentis environmental monitoring specialists during the November 2018 site visit. Valentis continued to conduct routine groundwater quality monitoring in line with the established monitoring program during the 2018 and 2019 baseline monitoring period.

Baseline groundwater quality in the saprolite aquifer was assessed by sampling spring discharge at nine springs surrounding Bawdwin and Tiger Camp, and one spring in the Nam La catchment. Sample locations are provided in Table 5.7 and shown on Figure 5.13.

Baseline groundwater quality in the fractured rock aquifer was assessed based on representative samples of groundwater inflowing to level 6 of the underground mine. These samples of groundwater were collected from eight locations, which provided an opportunity to characterise groundwater quality arising from various levels and mineral districts of the underground mine, including workings in the three main lodes that were historically mined. The samples therefore represent groundwater quality at different depths in the fractured rock aquifer (Table 5.7).

Groundwater discharge rates from the underground mine workings via the Tiger Tunnel were measured at a square-notch weir on the Nam Pangyun downstream of SWTT01 at a daily frequency (as a minimum) during the baseline monitoring period, which spanned the period between October 2018 to September 2019.

Table 5.7 Groundwater quality sample locations

Location ID	Sample Type	Source Aquifer	Description	Easting	Northing	Monitoring Events
SWSP01	Spring flow	Saprolite	Bawdwin potable water supply spring	327,635	2,556,713	8

Location ID	Sample Type	Source Aquifer	Description	Easting	Northing	Monitoring Events
SWSP02	Spring flow	Saprolite	One of two water supply spring	324,884	2,556,269	8
SWSP03	Spring flow	Saprolite	Spring north of Namtu used as contingency potable supply to Nam La flume	334,535	2,556,928	8
SWSP04	Spring flow	Saprolite	One of two spring sources at head of Nam Pangyun	323,608	2,558,592	8
SWSP05	Spring flow	Saprolite	Bawdwin potable water supply spring	325,329	2,555,969	4
SWSP06	Spring flow	Saprolite	Spring fed creek draining valley with waste rock	325,233	2,557,498	4
SWSP07	Spring flow	Saprolite	Spring for potable and domestic, near chicken farm	324,790	2,557,553	1
SWSP08	Spring flow	Saprolite	Spring collection box for potable and domestic supply spring near church	325,708	2,555,437	1
SWSP09	Spring flow	Saprolite	Bawdwin potable water supply spring near graveyard	326,174	2,555,163	1
GWMS	Underground mine seepage	Fractured rock	Water pumped from lower levels of Marmion Shaft to Tiger Tunnel (Level 9)	325,343	2,556,874	7
GWTT01	Underground mine seepage	Fractured rock	Seepage from Level 4 and Level 5 (Chinaman Lode)	325,361	2,556,844	5
GWTT02	Underground mine seepage	Fractured rock	Seepage from Level 2 and Level 3 (Chinaman Lode)	325,536	2,556,701	5
GWTT03	Underground mine seepage	Fractured rock	Tiger Tunnel flow at Crosscut 856S (Chinaman Lode)	325,536	2,556,701	5
GWTT04	Underground mine seepage	Fractured rock	Tiger Tunnel flow at Crosscut 1126S (Chinaman Lode)	325,624	2,556,635	5
GWTT05	Underground mine seepage	Fractured rock	Tiger Tunnel flow at Crosscut 2786W (Meingtha Lode)	326,025	2,556,407	5
GWTT06	Underground mine seepage	Fractured rock	Level 6 North Drive ND166W (Chinaman Lode)	325,343	2,556,920	5
SWTT01	Underground mine seepage	Fractured rock	Tiger Tunnel flow at tunnel portal entrance	327,733	2,555,918	8

Samples were collected using an unpreserved, open sample bottle held with a gloved hand. A new sample bottle was used at each location to decant the sample into laboratory supplied sample bottles pre-dosed with preservatives (where appropriate). Water samples analysed for dissolved metals were filtered in the laboratory prior to analysis.

Collected samples were transported under chain of custody to PT Intertek Utama Services, a Komite Akreditasi Nasional (KAN) accredited laboratory in Jakarta, Indonesia for analysis. Samples were analysed for the following parameters:

- Total dissolved solids (TDS), pH, hardness.
- Fluoride, ammonia, cyanide.
- Volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), total recoverable hydrocarbons (TRH), benzene, toluene, ethylbenzene, xylene and naphthalene (BTEXN).
- Pesticides (organochlorine and organophosphorus) and herbicides.
- Major cations: calcium (Ca), magnesium (Mg), sodium (Na), potassium (K).
- Major anions: sulfate (SO_4), chloride (Cl), carbonate (CO_3), bicarbonate (HCO_3).
- Metals – filtered and unfiltered: Ag, Al, As, Ba, Be, Bi, Cd, Co, Cu, Fe, Hg, Li, Mn, Ni, Pb, Sb, Se, Sn, Sr, Th, U, V, Zn, CN, Cr(VI).
- Nutrients: total nitrogen, total Kjeldahl nitrogen (TKN), Nitrate (NH_3), total phosphorus.

Groundwater levels

Groundwater levels in the bedrock aquifer were assessed by CSA Global during 2019 and 2020 using a combination of exploration boreholes retro-fitted with PVC casing and purpose-drilled groundwater monitoring wells. As additional groundwater monitoring boreholes were installed in the vicinity of the existing open pit mine and proposed mine infrastructure development areas, they were added to the groundwater monitoring network.

A total of 23 groundwater level monitoring locations were installed and monitored on a weekly basis between March 2019 to March 2020 using an electronic water level probe. Automated groundwater level loggers installed in three of the hydrogeological boreholes (BYD003a, HYD005 and HYD007) are also monitored to measure groundwater levels on a near-continuous basis (data collection period January to May 2020). Boreholes HYDRO3A, HYDRO5, HYDRO7 and BWRCD003 continue to be monitored.

Groundwater level monitoring locations and construction records are provided in Table 5.8 and their locations shown in

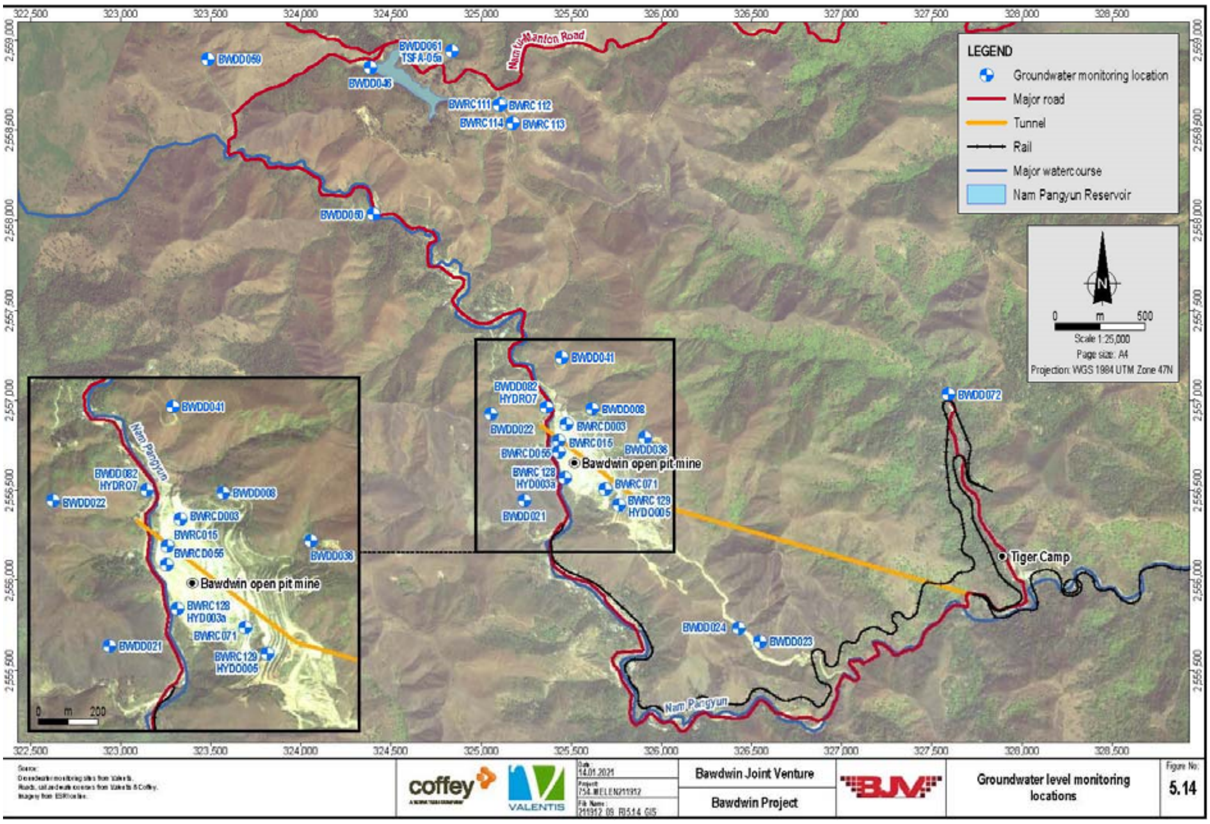


Figure 5.14.

Table 5.8 Groundwater level monitoring network details (Appendix B)

Borehole ID	Elevation mRL	Total Drilled Depth (m)	Blocked Depth (m)	Plain PVC casing depth (m)	Slotted PVC Casing Depth (m)
BWDD008	1,101	271.3	120	-	0 - 135
BWRCD003	1,017	197.9	90	-	0 - 93
BWRC015	992	138	89	-	0 - 84
BWRCD055	989	102	67	-	0 - 77
BWRC071	1,051	108	98	-	0 - 97.5
BWDD021	1,060	368.3	365	0 - 365	-
BWDD022	1,165	285.7	150	-	0 - 150
BWDD023	948	201.2	154	-	118.4
BWDD024	940	145.5	120	-	-
BWDD036	1,183	159	159	-	0 - 159
BWDD041	1,117	230	230	-	0 - 230
BWDD046	1,215	30	30	-	0 - 30
BWRC111	1,247	84	30.1	-	-
BWRC112	1,243	126	30.75	-	-
BWRC113	1,227	132	119.3	-	-
BWRC114	1,239	120	106.3	-	-
BWRC128 (HYD003a)	982	180	180	0 - 120	120 - 180
BWRC129(HYD005)	1,105	200	200	0 - 100	100 - 200
BWDD059	1,205	50	49.9	-	0 - 50
BWDD061	1,205	35	32.6	0 - 3	3 - 32.6
BWDD050	1,116	50	50	-	0 - 50
BWDD072	848	53	33.5	-	0 - 33.5
BWDD082 (HYD007)	997	43.4	43.3	-	0 - 43.3

Aquifer hydraulic properties

Hydrogeological investigations completed by CSA Global included a program of aquifer hydraulic testing. The site investigation programme included drilling of hydrogeological boreholes at seven locations.

A summary of the hydrogeological borehole locations and drilling details is presented in Table 5.9. Due to significant problems with fractured ground and underground drives causing borehole collapse, it was only possible to install casing in three of the hydrogeological boreholes (HYD003a, HYD005 and HYD007). These boreholes were installed with 63 mm diameter PVC casing.

Table 5.9 Summary of hydrogeological borehole details

Borehole ID	Drillhole ID	Elevation (mAOD)	Borehole Inclination (°)	Total Depth (m)	Comment
HYD001	BWRC127	1,120	85	200	Casing broken at depth in hole.
HYD002	BWRC130	1,033	90	200	Borehole collapsed - could not install casing.
HYD003	BWRC126	982	90	36	Borehole abandoned - intersected underground drive.

HYD003a	BWRC128	982	90	180	Casing successfully installed.
HYD004	BWRC132	1,013	90	30	Borehole abandoned due to unstable ground conditions at surface.
HYD004a	BWRC133	1,013	90	24	Drilling ceased at 24m due to significant fracturing.
HYD005	BWRC129	1,105	90	200	Casing successfully installed
HYD006	BWRC131	999	90	150	Dry -intercepted multiple existing underground drives. Borehole collapsed
HYD007	BWDD082	997	85	198	Casing successfully installed.

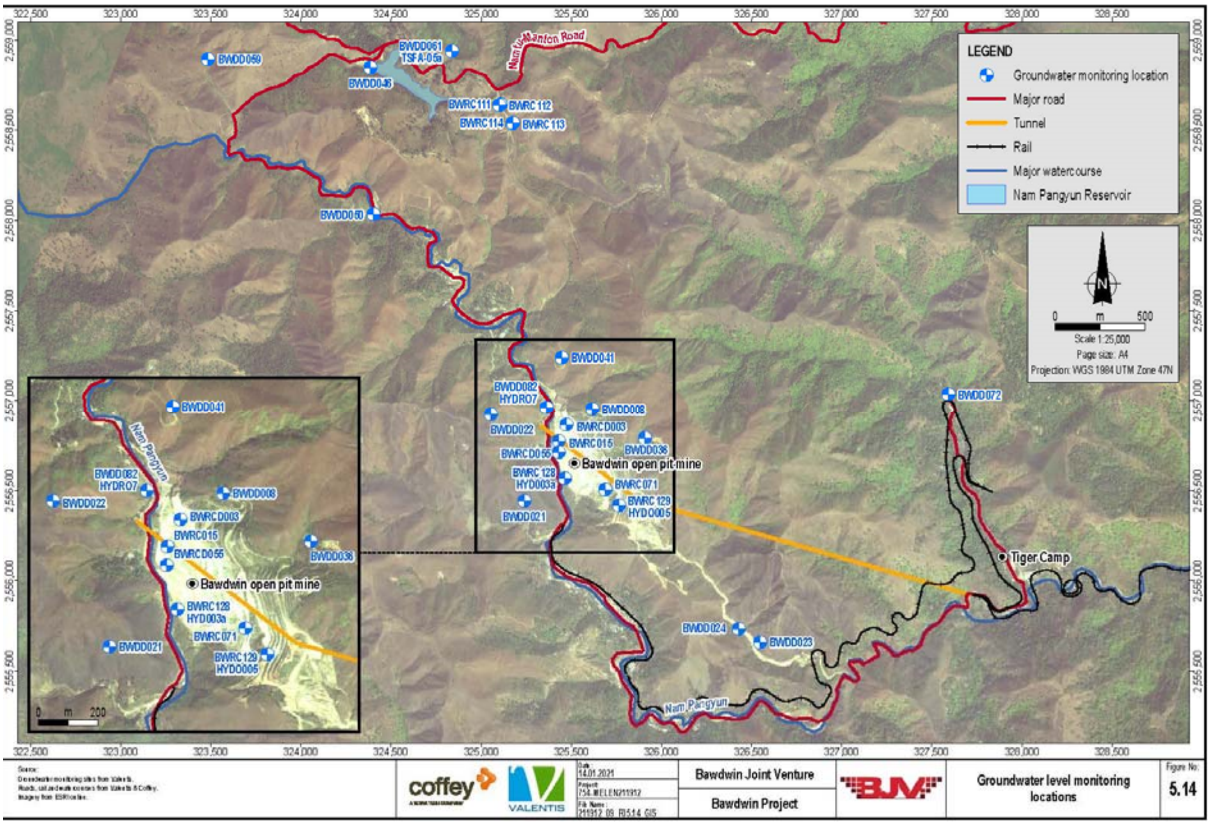


Figure 5.14 Groundwater level monitoring locations

A range of methods were adopted to estimate representative hydraulic parameters for the various lithologies and geological structures encountered during drilling. The hydraulic testing included:

- Airlift testing of hydrogeological boreholes in the vicinity of the open pit (HYD002, HYD003a, HYD004a and HYD005). An airlift test utilizes compressed air directed down a borehole to continuously lift water from the hole. Observations of water volumes, rates and water levels within the borehole are monitored during and after the test to estimate aquifer hydraulic properties.
- A pumping test of hydrogeological borehole HYD007. This involves a well being pumped at a controlled rate. Water-level response (drawdown) is measured in one or more surrounding observation wells and optionally in the pumped well itself. Observations from pumping tests are used to estimate the hydraulic properties of aquifers, evaluate well performance and identify aquifer boundaries.
- Falling head tests of three of the newly drilled hydrogeological boreholes (HYD003a, HYD005 and HYD007). A falling head test is conducted in a monitoring well to measure the hydraulic conductivity of the screened lithology. The test is conducted by adding or removing a slug of water or a solid object of known volume and monitoring the rising or falling water level response.
- Packer testing of 19 boreholes installed as part of geotechnical investigations of the plant, tailings and waste dump. This technique is used during the drilling of a borehole to measure the hydraulic conductivity of the lithology. Inflatable packers are lowered down the borehole to isolate the depth interval to be measured.

Groundwater quality assessment criteria

Groundwater quality screening criteria adopted to assess the groundwater resource within the study area comprised of the National drinking water quality standards for Myanmar (NSC, 2018) and National Environmental Quality (Emission) Guidelines (MOECAF, 2015).

As Myanmar does not have water quality standards for aquatic ecosystem protection, water quality results are discussed with reference to Australian and New Zealand water quality guidelines (ANZG, 2018).

National drinking water quality standards (Myanmar)

This standard was developed by technical Committee for Food Stuff – Standardization Technical Sub-committees and it was approved according to the (1/ 2018) by the National Standardization Council meeting held on 27th November 2018. These drinking water quality standards have been widely adopted by regulators and industry in Myanmar.

The standards provide water quality criteria for microbiological quality (Table 5.10), physical parameters and inorganic substances with aesthetic limits (Table 5.11), and inorganic substances and pesticides with health based limits (Table 5.12).

Table 5.10 NDWQ standards - microbiological (Table I, NSC, 2018)

Water Source Type	Maximum Permissible Limit	
	E. coli	Total faecal coliforms
Treated pipe water	0	0
Untreated pipe water	0	10
Treated water in distribution system	0	0
Unpiped water	0	10
Bottled drinking water	0	0
Emergency water supply	0	3

Table 5.11 NDWQ standards – aesthetic guidelines (Table II and III (B), NSC, 2014)

Parameter	Unit	Maximum Permissible Limit
Table II – Physical quality		
True colour unit (TCU)	Pt.co scale	15
Taste and odour	-	Acceptable / No objectionable taste and odour
Turbidity	NTU	5
Table III (B) – Chemical quality not of health significance (inorganic)		
Aluminium	mg/L	0.2
Ammonia (nitrogen)	mg/L	1.5
Calcium	mg/L	200
Chloride	mg/L	250
Total hardness (as $CaCO_3$)	mg/L	500
Hydrogen sulfide	mg/L	0.05
Iron	mg/L	1.0
Magnesium	mg/L	150
pH	mg/L	6.5-8.5
Sodium	mg/L	200
Sulfate	mg/L	250
Total dissolved solids	mg/L	1,000
Zinc	mg/L	3
Electrical conductivity	µs/cm	1,500

Table 5.12 NDWQ standards – health guidelines for inorganic compounds and pesticides (Table III (A) and V, NSC, 2018)

Parameter	Unit	Maximum Permissible Limit
Table III (A) – Chemical quality of health significance (inorganic substances)		
Antimony	mg/L	0.02
Arsenic	mg/L	0.05
Barium	mg/L	0.7
Boron	mg/L	2.4
Cadmium	mg/L	0.003
Chromium	mg/L	0.05
Copper	mg/L	2.0
Cyanide	mg/L	0.07
Fluoride	mg/L	1.5
Lead	mg/L	0.01
Manganese	mg/L	0.4
Mercury (total)	mg/L	0.001
Nickel	mg/L	0.07
Nitrate (as NO_3)	mg/L	50
Nitrite (as NO_2)	mg/L	3
Selenium	mg/L	0.04
Uranium	mg/L	0.03

National Environmental Quality (Emission) Guidelines (2015)

The National Environmental Quality (Emission) Guidelines were published by the Myanmar Ministry of Environmental Conservation and Forestry (MOECAF, 2015). These guidelines are based on the International Finance Corporation (IFC) Environmental Health and Safety (EHS) Guidelines (IFC, 2007), which provide the technical guidance on good international industry pollution prevention practice for application in developing countries.

The guidelines provide criteria that apply to projects that either have direct or indirect discharge of process wastewater and stormwater to the environment. The industry-specific effluent levels summarised in Table 5.13 have been adopted, along with other internationally recognised screening criteria, to assess the baseline groundwater conditions.

Table 5.13 Ore and Mineral Extraction Specific (Mining) Emission guidelines (NEQEG, 2015)

Parameter	Unit	Emission Guideline for Mining
Arsenic	mg/L	0.1
Cadmium	mg/L	0.05
Chemical oxygen demand	mg/L	150
Chromium (hexavalent)	mg/L	0.1
Copper	mg/L	0.3
Cyanide	mg/L	1
Cyanide (free)	mg/L	0.1
Cyanide (weak acid dissociable)	mg/L	0.5
Iron (total)	mg/L	2
Lead	mg/L	0.2
Mercury	mg/L	0.002
Nickel	mg/L	0.5
Zinc	mg/L	0.5
pH	S.U.	6-9
Temperature	°C	<3° differential
Total suspended solids (TSS)	mg/L	50

Australia and New Zealand water quality guidelines

The Australian and New Zealand water quality guidelines (ANZG) provide default guideline values (DGVs) for different levels of freshwater ecosystem protection, with more stringent DGVs corresponding to higher levels of protection. For this section, DGVs have been adopted for toxicants (dissolved metals) in ‘slightly-to-moderately disturbed freshwater ecosystems. While some sections of surface waters in the study area would be considered ‘highly disturbed freshwater ecosystems’, comparison to the DGVs for slightly-to-moderately disturbed freshwater ecosystems allows for understanding the existing water quality (including where highly contaminated) with respect to more typical, healthy freshwater ecosystems and reference sites that have not been heavily impacted.

5.2.2 Groundwater environment

Regional hydrogeology

The Bawdwin mine site is located within the Shan groundwater zone as defined by the National Water Resources Committee's Ayeyarwady State of the Basin Assessment (NWRC, 2017).

The project area is predominantly located within the mountainous sandstone and limestone zone, which includes the Upper Cambrian Pangyun Formation (Figure 5.15).

This aquifer zone accounts for 13% of the Shan Plateau and is characterised by metamorphosed limestones and interbedded sandstones. Karst features do exist in limestone areas (such as the Ordovician Pindaya Group). Elsewhere, folding and faulting have induced fracture zones that may provide local aquifers of sufficient yield for domestic supply or small-scale irrigation.

The aquifers that exist in this zone are considered to be of lower groundwater resource potential, but given their mountainous setting, they are expected to contribute to groundwater recharge across the region. Estimates of groundwater recharge have been based on other areas in Myanmar ranging from 10% to 15% of annual rainfall, equating to recharge of 160 mm to 285 mm.

Groundwater use in the wider Shan groundwater zone is predominantly from springs flowing from mountain ranges and shallow wells in the alluvial aquifers where they exist. Remote communities in hilly areas utilise gravity-fed village water supply systems that source water from springs with an estimated 73 systems installed in Shan State providing a water supply to more than 156,000 people (NWRC, 2017). Approximately 57% of households depend on groundwater for domestic supply, sourced predominantly from springs and dug wells (NWRC, 2017). Plate 5.4 shows a groundwater discharge point in ER Valley, and Plates 5.5 and 5.6 show collection points where groundwater from springs is collected in Bawdwin.

There is little existing data is available on the aquifer conditions, water resources, or water quality for these aquifers. Groundwater contamination is likely, particularly near villages where agricultural chemicals have been used, including fertilisers, herbicides and pesticides (NWRC, 2017). Many centuries of mining activity are also noted as likely sources of groundwater and surface water contamination, including the Bawdwin Mine (NWRC, 2017).

Local hydrogeology

Hydrogeological units

The preliminary hydrogeological conceptual model developed by CSA Global incorporates the primary water bearing zones that are likely within the study area. Two hydrogeological units were defined: a saprolite or highly weathered unit, and the underlying, fresh bedrock unit.

While these hydrogeological units have been based predominantly on observations within the upper Nam Pangyun catchment in the vicinity of Bawdwin, these groundwater systems are characteristic of mountainous regions and can be reasonably expected to extend across the region, including in the Nam La catchment and surrounding catchments. Parent rock geology varies both within the study area and beyond. Despite the presence of limestone and karst features in the Shan Plateau, none are found in the Bawdwin Concession, with the nearest limestone approximately 6 km to the east of Bawdwin. Variability in parent rock geology may be reflected in key aquifer characteristics, such as the depth of weathering, aquifer hydraulic properties, fracturing and other features which control groundwater movement. Key aquifer characteristics in the study area are described below.

Plate 5.4 Spring in ER Valley

Plate 5.5 Spring flow collection point at SWSP02 that contributes flow to the Bawdwin supply pipe network

Plate 5.6 Community supply point in Wallah Valley connected to a spring further up the valley

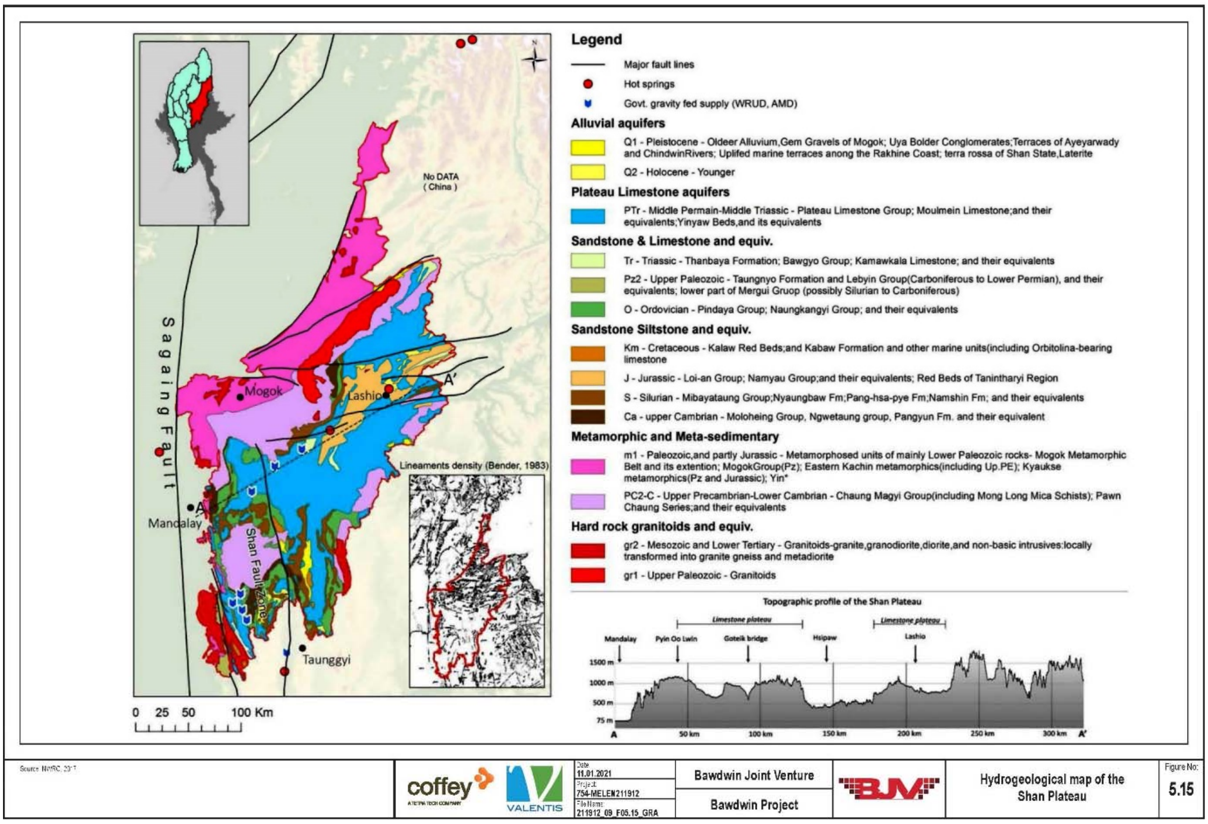


Figure 5.15 Hydrogeological map of the Shan Plateau

Saprolite

The saprolite hydrogeological unit has been estimated to be in the order of 20 to 50 m thick on the ridges and upper slopes, thinning on the mid slope and is generally absent from the valley floors. This weathered profile hosts localised aquifer systems that receive rainfall recharge on the upper slopes and hilltops, and transports groundwater downslope following the natural topography, where it discharges via springs and seeps. A component of vertical infiltration to the underlying fractured rock aquifer is also expected.

While the saprolite is unlikely to represent a regionally extensive aquifer, this weathered horizon provides important drinking water supply to Bawdwin villages, Tiger Camp and many of the other villages within the wider study area. Short groundwater residence times (in the order of weeks to months) produce good quality (low salinity) drinking water to villages, and most springs were noted to flow year-round.

Saprolite typically retains the structure of the parent rock (faults, fractures and shear zones) which can create structural controls on groundwater flow within the saprolite aquifer.

Fractured Bedrock

The bulk hydraulic conductivity of the basement rocks is generally low, with groundwater flow occurring through secondary porosity features such as fractures, joints and shear zones. Secondary porosity typically reduces with depth with most groundwater flow occurring in the top 50 m of the bedrock zone. Regionally mapped faults and shear zones are expected to provide preferential flow paths within the fractured rock aquifer, potentially extending to greater depths.

Groundwater levels are typically within the fractured rock over much of the study area, with water levels typically at greater depths in the upland areas and closer to surface in the valleys, extending into overlying alluvial deposits. Groundwater levels in the pit area are impacted by current on-going dewatering from the existing underground mine.

Hydrogeological model

A conceptual hydrogeological model is a consolidated understanding of the groundwater systems that are present at a site, as well as the key interaction that occur with the surrounding environment. A conceptual model is typically conveyed in diagrams and figures and is based on the understanding of the hydrogeological processes developed from field observations, baseline monitoring data, geomorphology, and other related information.

CSA Global developed a hydrogeological conceptual model for the study area based on the results of groundwater investigations that they undertook in 2019-2020. The conceptual model is shown in Figure 5.16. It offers a high-level representation of the groundwater system that is present. Aspects such as hydraulic properties, groundwater levels and flow direction, and recharge and discharge depicted in the model are described in detail in the following sections.

Hydraulic properties

Each of the hydrogeological units described above have a range of hydraulic properties that define how groundwater will move through them. One of the key hydraulic properties for understanding groundwater movement is hydraulic conductivity, which is a measure of the host rock’s permeability and ability to transmit water.

Hydraulic conductivity values were estimated for each of the hydrogeological units based on the results of a testing program completed by CSA Global. These field tests typically remove or inject water during drilling at different depths and record the subsequent rise or fall of the water level in the borehole over time, to estimate the rock’s permeability.

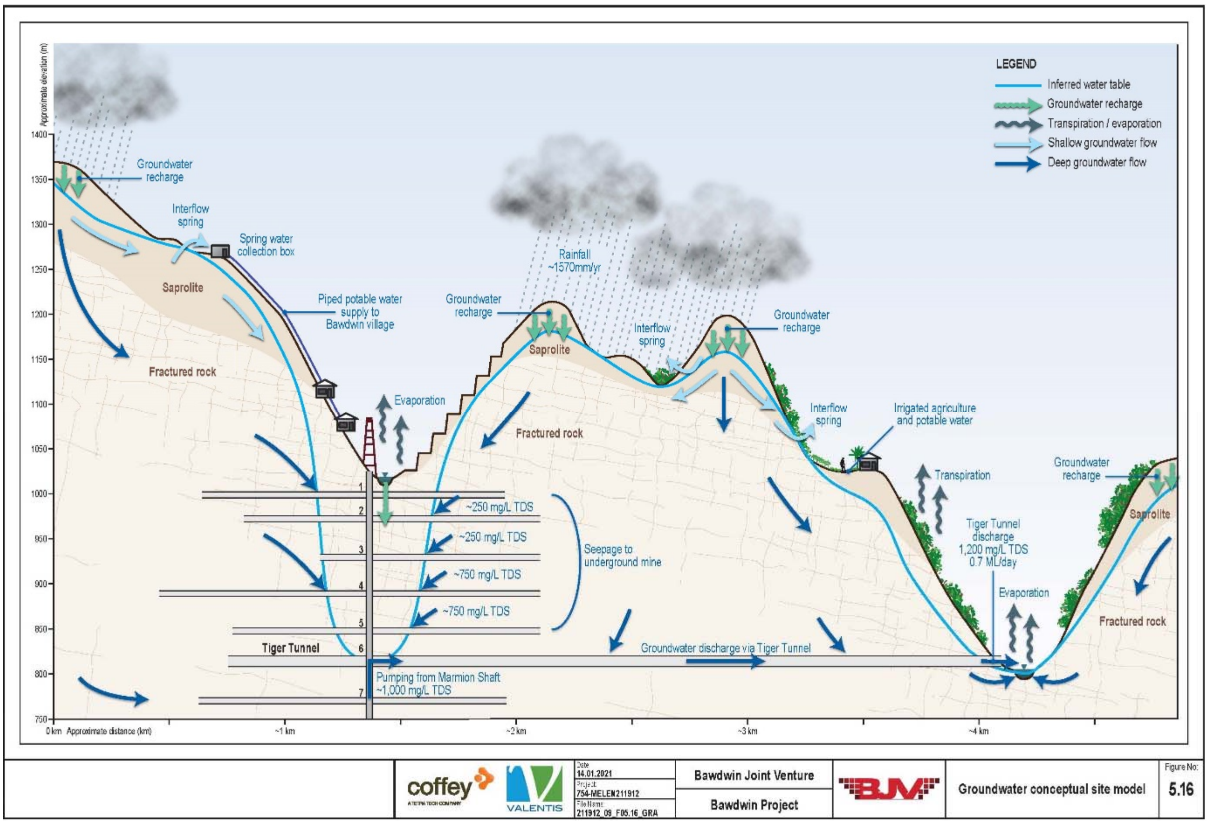


Figure 5.16 Groundwater conceptual site model

Results of these tests conducted in the vicinity of the proposed Bawdwin open pit and the TSF area have been assessed by CSA Global to derive regional hydraulic conductivity values for each of the hydrogeological units summarised in Table 5.14.

Table 5.14 Representative regional aquifer hydraulic properties (BJV, 2020)

Hydrogeological Unit	Hydraulic Conductivity (m/day)	Specific Yield
Saprolite unit		
Saprolite	0.5	25%
Bedrock unit		
Pangyun Sandstone	0.02	0.5%
Bawdwin Tuff	0.001	0.5%
Porphyry - Rhyolite	0.03	0.5%
Highly fractured bedrock/Faults	1	

Within the bedrock hydrogeological unit, hydraulic properties of the Pangyun sandstone, Bawdwin Tuff and porphyry (rhyolite) displayed distinct values. The hydraulic conductivity of the saprolite aquifer was estimated by CSA Global at 0.5 m/day. This was consistent with the estimated range of 0.09 to 0.90 m/day based on literature values for units with comparable characteristics (Welch and Allen, 2014).

Due to logistical constraints and available methods of hydraulic testing it was not possible to derive specific yield values for the each of the formations and, therefore, specific yield values were predominantly derived by CSA Global from literature values and their experience in similar environments.

It is recognised that the hydrogeological investigation focussed on the existing open pit, an area which is influenced by faulting, fracturing and historical mining activities. These factors are likely to have resulted in higher hydraulic conductivity and specific yield values than what would be found elsewhere in the surrounding region.

Groundwater levels and flow direction

Groundwater flow paths and groundwater residence times in the saprolite aquifer are expected to be very short, in the order of weeks to months. Groundwater flows from the upper slopes where rainfall recharge predominantly occurs, towards the bottom of the valley, generally following the surface topography. The saprolite aquifer typically thins and becomes absent on the mid to lower slope where groundwater discharges to the ground surface through springs and groundwater seeps.

Under natural conditions, groundwater levels and flow directions within the underlying fractured rock aquifer would be expected to follow a similar flow path from topographic high points towards valley floors. Groundwater flow paths will be influenced by the presence and connection of fracture zones both vertically and horizontally. Both medium (shallow) and long (deep) groundwater flow paths are expected to exist in the fractured rock aquifer with groundwater residence times likely to range from months to years.

In the Bawdwin region, groundwater levels and flow direction are expected to be complex and influenced by previous mining activities as well as the ongoing dewatering of the underground mine.

Groundwater level monitoring results indicate that groundwater levels range from less than 2 m below ground level to approximately 150 m below ground level, with levels typically at greater depths in the upland areas and closer to the surface in the valleys (BJV, 2020). This is a typical hydrogeological pattern of hilly and mountainous areas. Groundwater elevations range from 1,247 mRL in the north of the project area at BWRC111 to approximately 848 mRL in the valley in the vicinity of the proposed pit at BWDD072 (BJV, 2020;

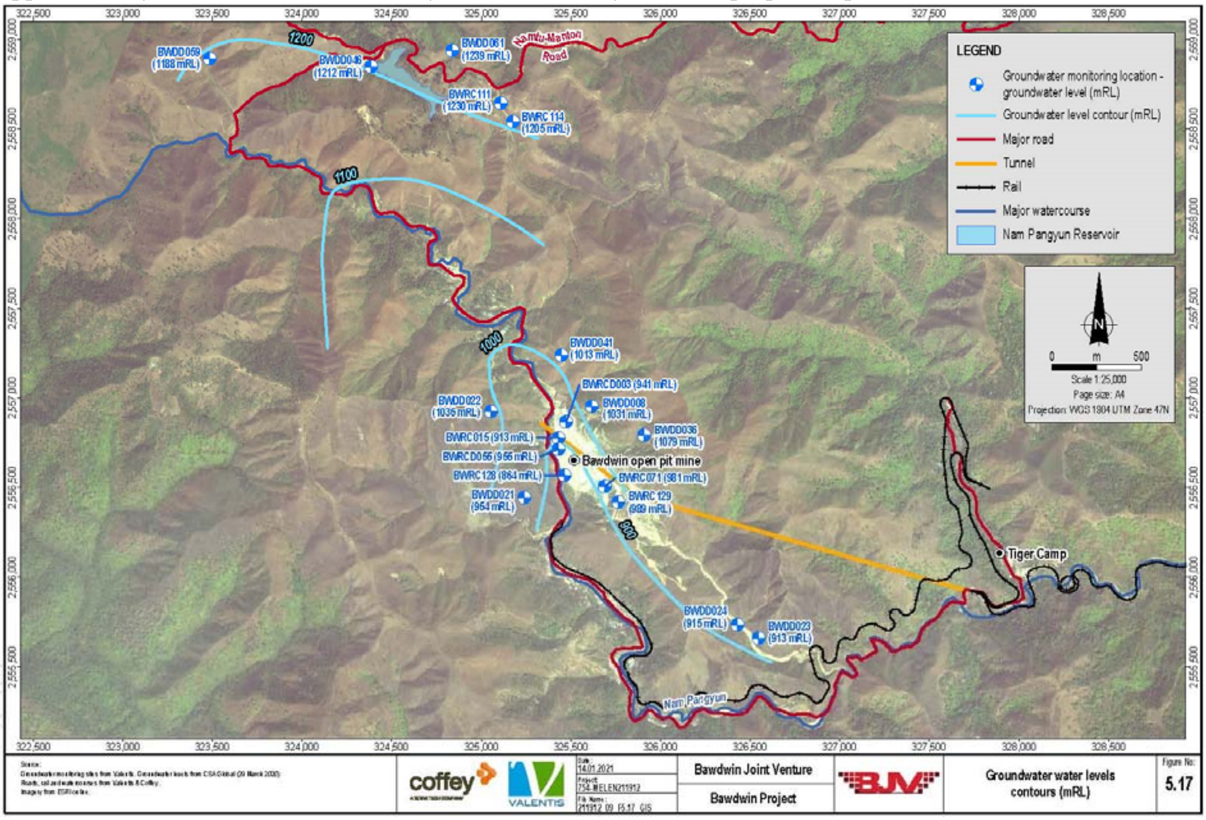


Figure 5.17).

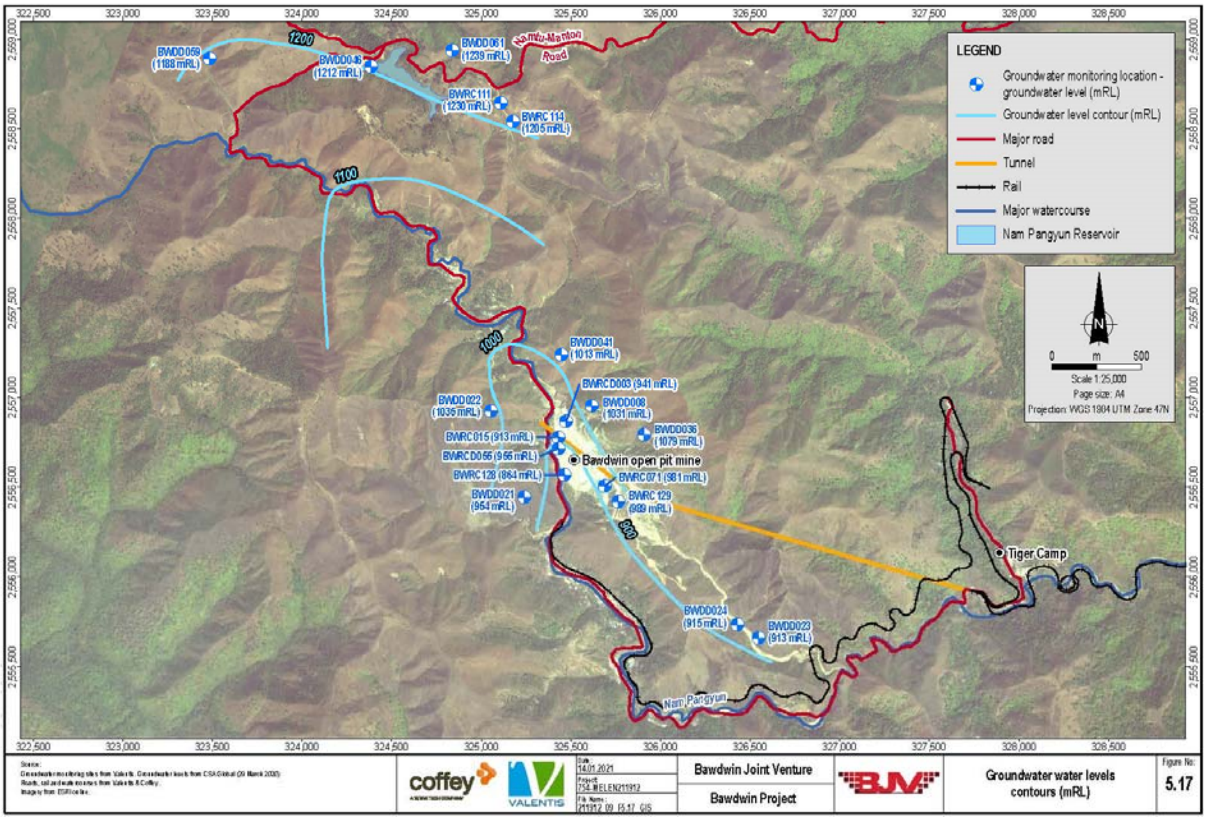


Figure 5.17 Groundwater water levels contours (mRL)

Recharge and discharge

Groundwater within the study area is recharged predominantly by rainfall infiltration, the majority of which occurs during the wet season which typically runs from May to October.

The combination of high rainfall rates, steep topography, and limited vegetation leads to a large portion of rainfall reporting directly to surface water as runoff. An assessment of measured groundwater level response to rainfall was completed by CSA Global in order to estimate the proportion of rainfall recharging groundwater. Based on this assessment, and literature values of groundwater recharge for other parts of Myanmar, groundwater recharge has been estimated to be in the order of 10% to 15% of total rainfall (BJV, 2020).

Although not directly measured, it is thought that groundwater recharge occurs to some degree across the whole study area with highest recharge rates likely to occur on the higher exposed ridgelines and hilltops, where evapotranspiration will be lower due to the thin and rocky soil profiles, and the lack of vegetation. Recharge to the fractured rock aquifer is likely to occur both as direct rainfall recharge (where rock outcrops) and also via vertical infiltration through the saprolite. Groundwater level monitoring data indicates a seasonal level fluctuation of up to 5 m with lowest groundwater levels in early June, coinciding with a slight time lag after the end of the dry season. This fluctuation contributes to the seasonal flow of some springs higher upslope.

Within the upper Nam Pangyun catchment, upstream of the Tiger Tunnel portal, surface water from the Nam Pangyun is thought to provide a degree of recharge to the fractured rock aquifer, as dewatering of the underground mine workings has resulted in the water table being drawn down below the base of the stream (discussed further below). This is likely to be a phenomenon limited to the upper Nam Pangyun catchment. Elsewhere, watercourses draining the surrounding catchments, such as the Nam La, receive groundwater discharge from the bedrock aquifer year-round.

Groundwater from the saprolite aquifer will discharge vertically into the underlying fractured rock aquifer, or to the surface at the break of slope (interflow spring), or for geological reasons such as where structural features of the parent rock as barriers to groundwater flow. Discharge from the saprolite via springs near valley floors occurs year-round with consistent flow (as reported by local users), whereas some springs further upslope are seasonal, with flow ceasing during the dry season due to the decreases in the water table level.

The underground mine is dewatered to a depth of approximately 200 metres below the ground surface level at Marmion Shaft, equivalent to a reduced level (RL) of 794 m above sea level (m ASL). This level is maintained by continuous pumping to keep the mine dry at Level 6, and by drainage to the Tiger Tunnel from the levels above. The discharge flows through the Tiger Tunnel and exits at Tiger Tunnel portal, approximately 300 m west of Tiger Camp (surface elevation of 818 m ASL), where it discharges to the Nam Pangyun at a rate of approximately 6 ML/day. Discharge from the Bawdwin mine represents a major groundwater discharge for the fractured rock aquifer.

Groundwater - surface water interaction

Under natural conditions vertical hydraulic gradients within the bedrock aquifer are likely to reverse downslope towards the valley floor promoting the upward discharge of groundwater either via springs or as baseflow to streams. Perennial streams (such as the Nam Pangyun and Nam La) would typically receive groundwater baseflow all year. This baseflow contribution accounts for most of the observed stream flow during dry months. Surface water quality results from the Nam La indicate increasing TDS concentrations downstream combined with a slight enrichment of bicarbonate and magnesium ions, which suggests that the Nam La is receiving groundwater discharge from the bedrock aquifer and spring discharge from the saprolite aquifer.

In the Nam Pangyun catchment, the interaction between groundwater and surface water has been altered by the presence of historical underground mine voids and continued dewatering via the Tiger Tunnel. Dewatering activities have lowered groundwater levels within the bedrock aquifer resulting in a reduced contribution of groundwater baseflow in the vicinity of Bawdwin. Baseflow contribution of groundwater to surface water streams is likely returned further down topographic gradient to the southeast in the vicinity of Tiger Camp. Groundwater discharge from the saprolite aquifer via springs positioned higher in the landscape around Bawdwin contribute flow to the Nam Pangyun, either seasonally or year-round, which is unaffected by drawdown in the underlying bedrock aquifer.

Groundwater quality

As groundwater moves through an aquifer its quality and chemical composition changes as it dissolves salts and metals from the minerals that comprise the host rock. The degree to which groundwater quality is naturally affected by this interaction depends on a range of factors, such as groundwater residence time (discussed above) and host rock mineralogy.

Naturally elevated concentrations of some metals are expected in groundwater, particularly in the Nam Pangyun catchment which host the Bawdwin ore deposits. However, extensive historical mining activities have led to groundwater contamination of salts and the presence of dissolved metals at high concentrations. Historical mining activities that have impacted groundwater quality, particularly in the fractured rock aquifer, include exposing highly mineralised areas to increased oxidation and groundwater recharge through the exposed open pit, infiltration through waste rock dumps and historical ore processing activities. It is difficult to differentiate the naturally elevated metal concentrations in groundwater to those that are related to historic mining.

Saprolite aquifer

Samples of spring water discharging from the saprolite aquifer were typically very fresh with very low concentrations of dissolved salts, with TDS concentrations across all monitoring events ranging up to 233 mg/L, well within desirable levels for potable water supply. Minor variations of TDS concentrations occurred over the monitoring period (Figure 5.18). These temporal changes are not strongly linked to seasonal climate cycles; however, maximum concentrations were reported during the dry season (January 2019).

Groundwater pH measured downstream of the surface expression point was typically natural to alkaline with average values ranging from 7.20 (SWSP02) to 7.58 (SWSP01).

Despite the short groundwater residence times in the saprolite aquifer, laboratory results suggest that some mineral dissolution is occurring.

Table 5.15 and Table 5.16 summarise the concentration range of total and dissolved metals, respectively, as reported in the spring water inferred to be discharging from the saprolite aquifer. Metal species with reported concentrations that were consistently below the laboratory limit of reporting (LOR) have been excluded from this summary table. Average concentrations have been calculated assuming that measurements below the LOR are 0 mg/L, outliers have been excluded, and results from SWSP06 have been excluded as this spring is not considered representative of baseline groundwater conditions.

Table 5.15 Range and average concentration of total metals in the saprolite aquifer

Analytes	NDWQ standards (mg/L)	Concentration range (mg/L)	Average concentration (mg/L)
Aluminium*	0.2	<0.01 - 0.19	0.041
Arsenic	0.05	<0.0005 - 0.0079	0.0011
Barium	0.7	<0.02 - **0.13**	0.039
Cadmium	0.003	<0.0001 - 0.001	0.0001
Copper	2.0	<0.001 - 0.013	0.0023
Iron*	1.0	<0.012 - 0.256	0.0713
Lead	0.01	<0.001 - **0.148**	**0.0258**
Manganese	0.4	<0.001 - 0.09	0.014
Strontium	NA	<0.001 - 0.03	0.008
Zinc*	3	<0.005 - 2.44	0.111

* Aesthetic (not of health significance) standards

Values in bold exceed the NDWQ standard

Table 5.16 Range and average concentration of dissolved metals in the saprolite aquifer

Analytes	ANZ DGV (mg/L)	Concentration range (mg/L)	Average concentration (mg/L)
Aluminium	0.055	<0.01 – **0.08**	0.012

Analytes	**ANZ DGV (mg/L)**	**Concentration range (mg/L)**	**Average concentration (mg/L)**
Arsenic	0.013	<0.0005 – 0.0026	0.00049
Barium	N/A	<0.01 – 0.08	0.033
Cadmium	0.0002	<0.0001 – **0.0003**	0.0001
Copper	0.0014	<0.001 – **0.004**	0.0013
Iron	N/A	<0.005 – 0.143	0.021
Lead	0.0034	<0.001 – **0.086**	**0.011**
Manganese	1.9	<0.001 – 0.371	0.016
Strontium	N/A	<0.001 – 0.023	0.007
Zinc	0.008	<0.005 – **0.16**	**0.039**

Values in bold exceed the ANZ DGV.

Recorded concentrations of total and dissolved lead (multiple locations), total iron (SWSP01), total manganese (SWSP01) and sulphate (SWSP04) exceed the adopted drinking water criteria.

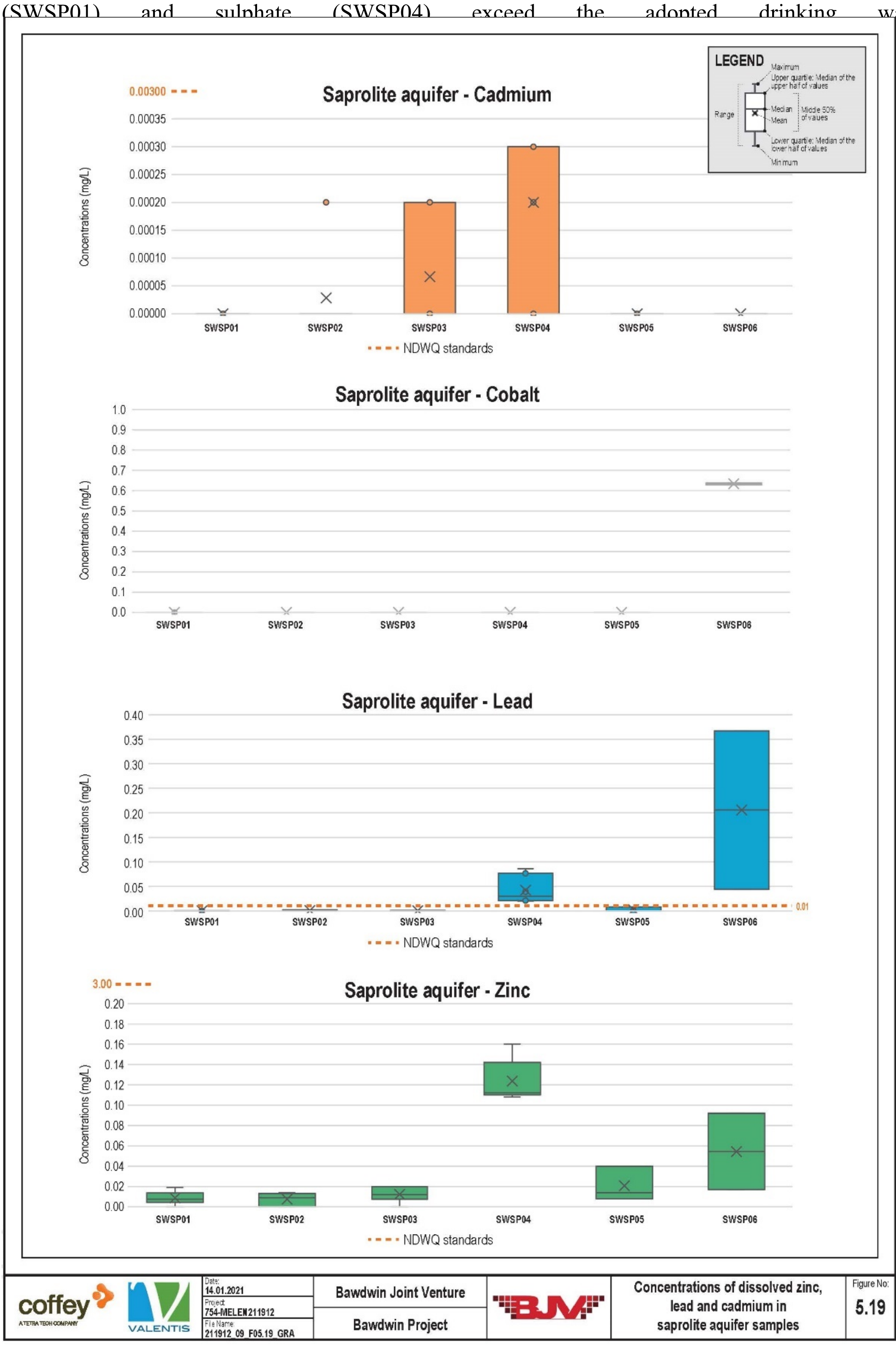
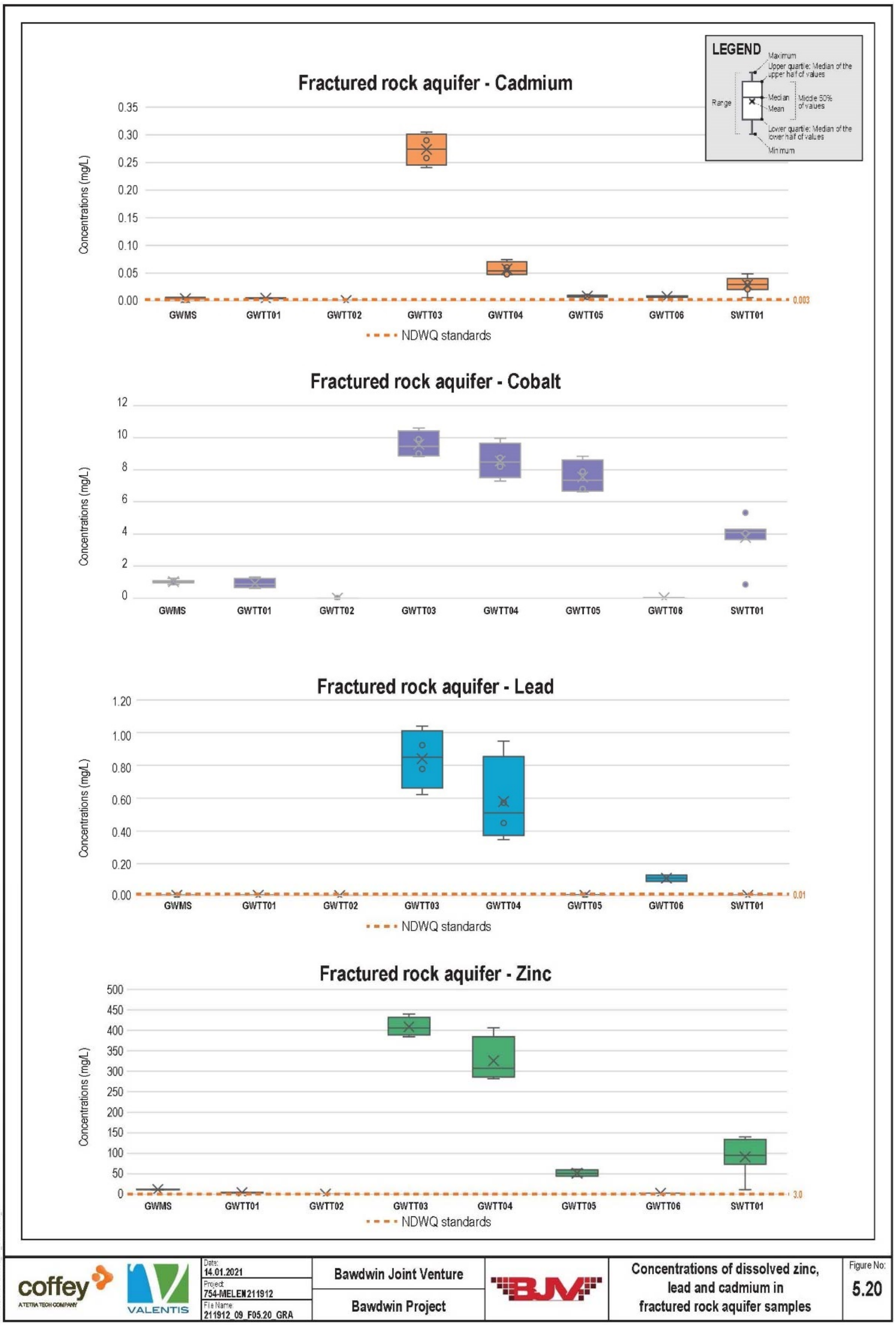


Figure 5.19 shows the recorded concentrations of dissolved cadmium, zinc and lead in the saprolite aquifer. Sites SWSP06 and SWSP04 exhibit the greatest concentrations of these metals.

Many of these metal species may be naturally occurring in the saprolite aquifer as a result of the interaction with the naturally mineralised parent rock. The up-gradient catchments for most springs have largely not been directly affected by historical mining activities other than land clearing, however some degree of dust deposition may have led to increased dissolved metals concentrations.

There are no discernible trends in total or dissolved metal concentrations over time, including in any correlation to the wet or dry season.

It was noted that the samples from spring SWSP06 (located north of the existing open pit) contained elevated concentrations of total and dissolved metals that in some cases significantly exceeded the range presented in Table 5.15 and Table 5.16. Groundwater from SWSP06 reported elevated concentrations of cobalt (0.63 mg/L), aluminium (1.7 mg/L), nickel (0.55 mg/L) and zinc (0.092 mg/L).



Concentrations of dissolved zinc, lead and cadmium in fractured rock aquifer samples

Figure 5.20 shows the elevated level of cobalt at SWSP06 compared to other sites. In addition, arsenic (0.0012 mg/L), barium (0.03 mg/L), and strontium (0.006 mg/L) were also present at detectable concentrations in one or more sampling rounds. The elevated concentrations at SWSP06 have been attributed to the placement of waste rock from historical mining activities within the catchment. Results from sample location SWSP06 are not considered representative of baseline groundwater conditions in the saprolite aquifer but do highlight the impact of previous mining activities on both groundwater and surface water quality at some locations.

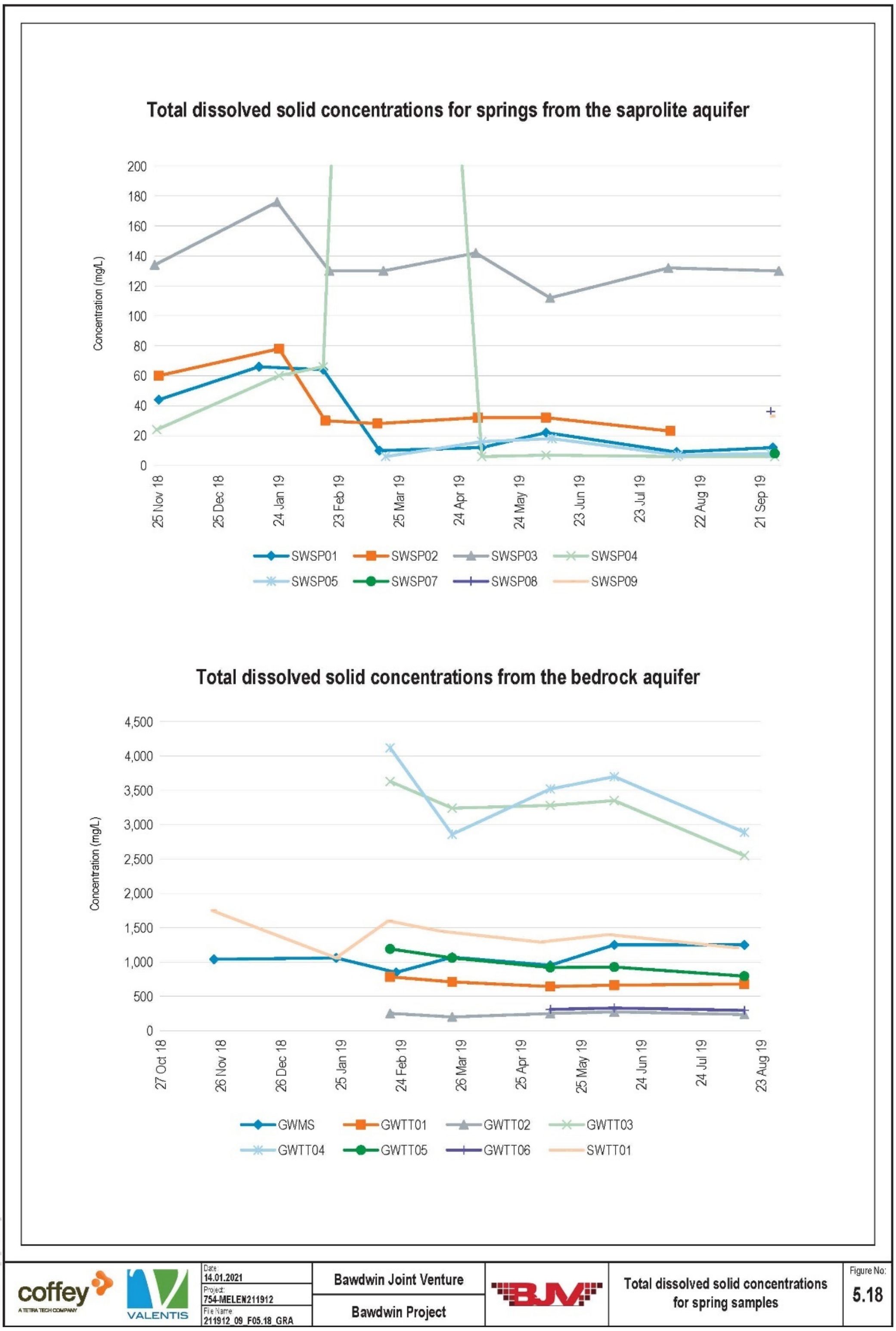


Figure 5.18 Total dissolved solid concentrations of groundwater springs

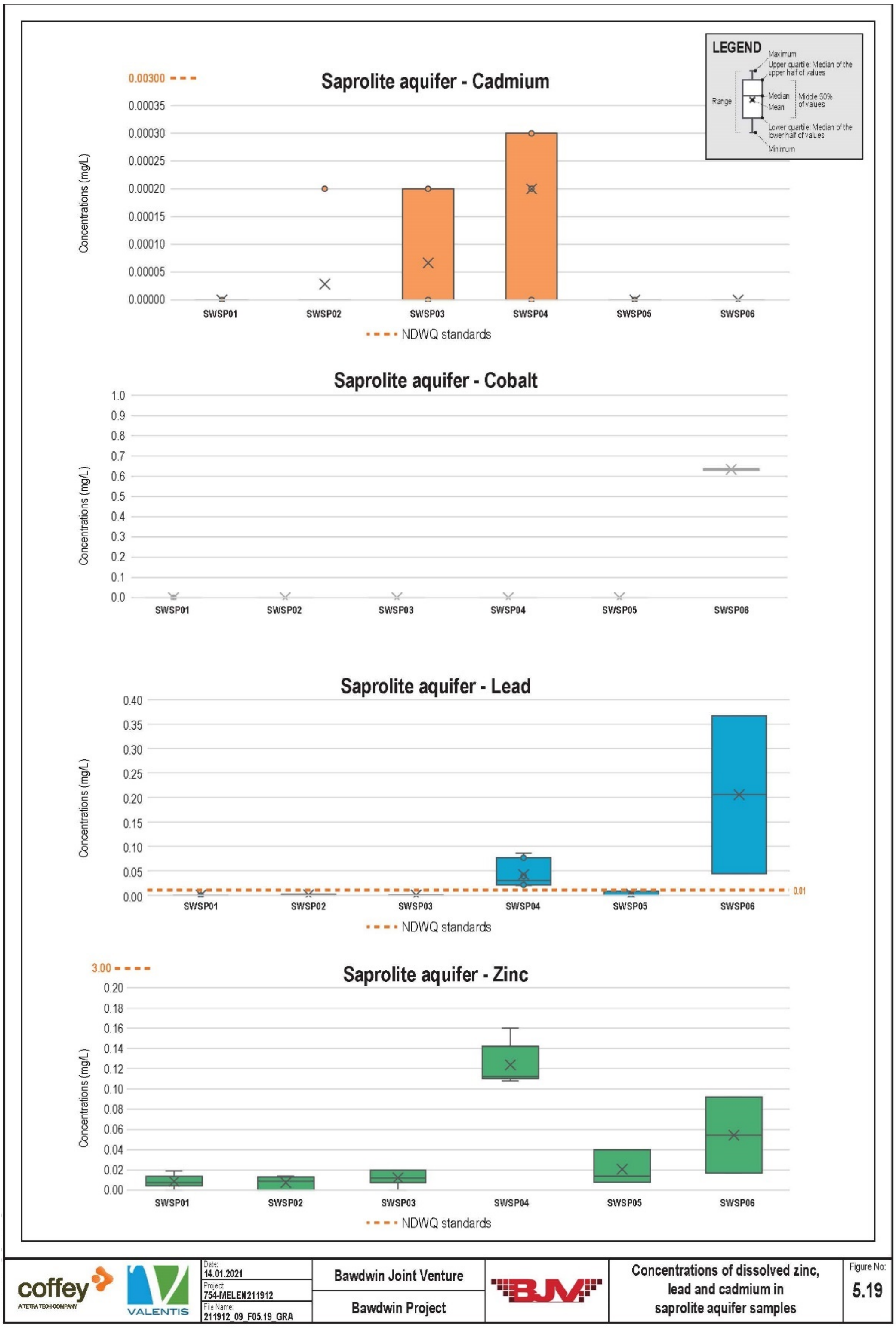


Figure 5.19 Concentrations of dissolved metals in saprolite aquifer

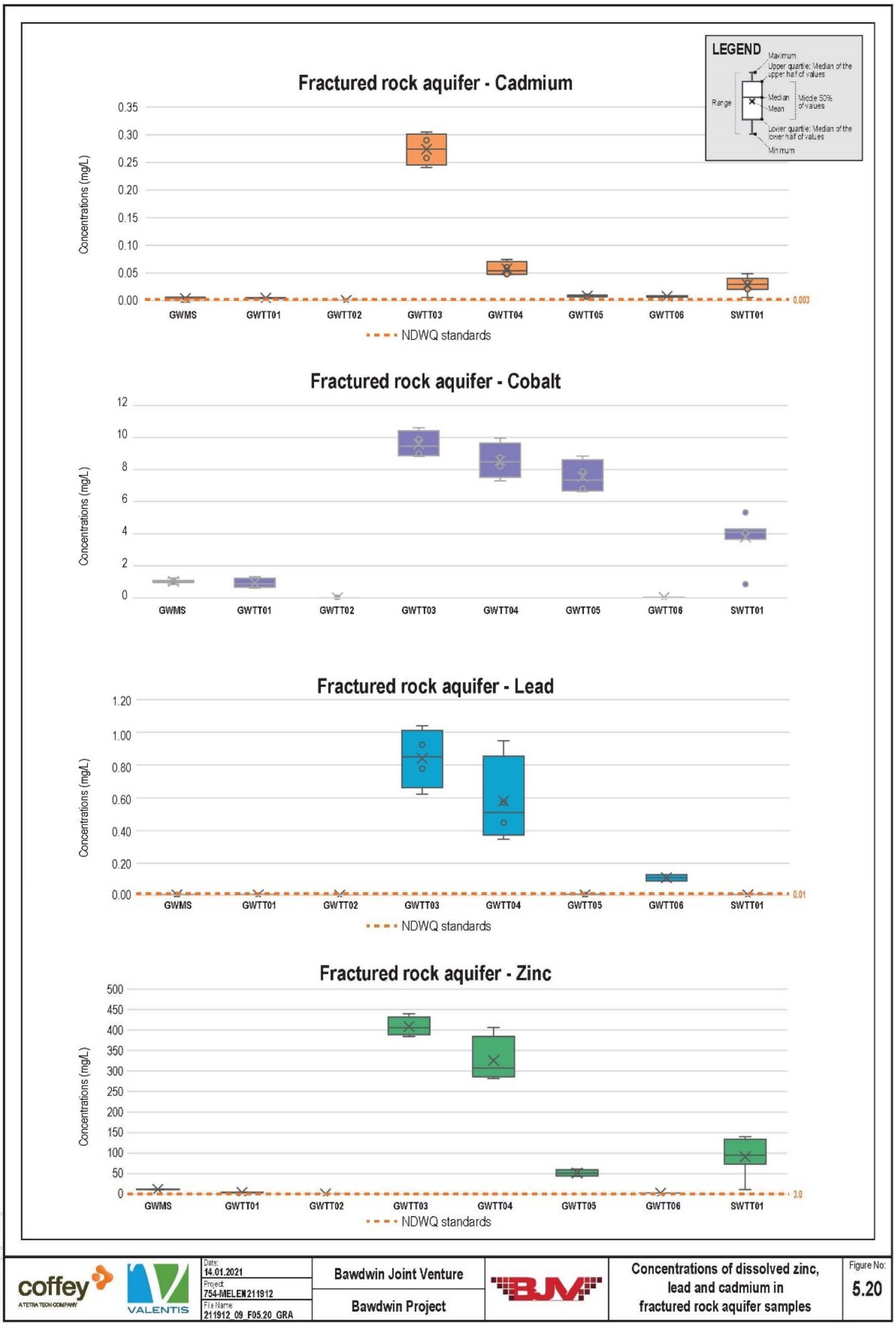


Figure 5.20 Concentrations of dissolved metals in fractured rock aquifer

Based on limited sampling and preliminary laboratory analysis completed in Myanmar, groundwater from the saprolite aquifer has been contaminated *by E. coli* and potentially other harmful pathogens. Nitrate was present at detectable concentrations at all springs with the exception of SWSP01 (headwaters of the Nam Pangyun). Reported concentrations of nitrate in the samples ranged from less than 0.005 to 0.7 mg/L, with an average of 0.12 mg/L. Phosphorus was present at all sampled locations in at least one round, ranging up to a maximum of 1.83 mg/L at SWSP05. These contaminants may be sourced from either agricultural practices and animal or human sewage waste disposal. Table 5.17 summarises the concentration of nutrients detected in the spring water draining from the saprolite aquifer. For all of these samples, nutrient concentrations were below the NDWQ standard.

Table 5.17 Range and average concentration of nutrients in the saprolite aquifer

Analyte	NDWQ standard (mg/L)	Concentration range (mg/L)	Average concentration (mg/L)
Nitrate (as NO_3)	50	<0.005 - 00702	0.12
Nitrite (as NO_2)	3	<0.001 – 0.003	0.002
Nitrogen (Total)	NA	0.06 – 2.29	0.49
Total Kjeldahl Nitrogen (as N)	NA	<0.02 – 1.59	0.37
Total phosphorous	NA	<0.005 – 1.83	0.26
Total phosphate	NA	0.054 – 0.33	0.16

Organic contaminants (TPH, PAHs, VOC, MAHs) were not detected at any locations during the initial monitoring round and analysis was discontinued during subsequent rounds.

All sampled water sources exceeded one or more of the drinking water quality standards (metals, dissolved metals) and would require further testing and treatment before being considered suitable for human consumption.

Fractured rock aquifer

Groundwater infiltrating to the upper levels of the underground mine is relatively fresh (average TDS of 234 mg/L at GWTT02) and TDS progressively increases with depth to approximately 1,000 mg/L at Level 6 (GWMS and GWTT05), 200 m below surface. The TDS concentration of groundwater infiltrating to the underground mine has been shown to be generally stable over the baseline monitoring period, which is consistent with the conceptual understanding that groundwater residence times in the fractured rock aquifer are likely to be longer and less susceptible to seasonal effects than the saprolite aquifer (

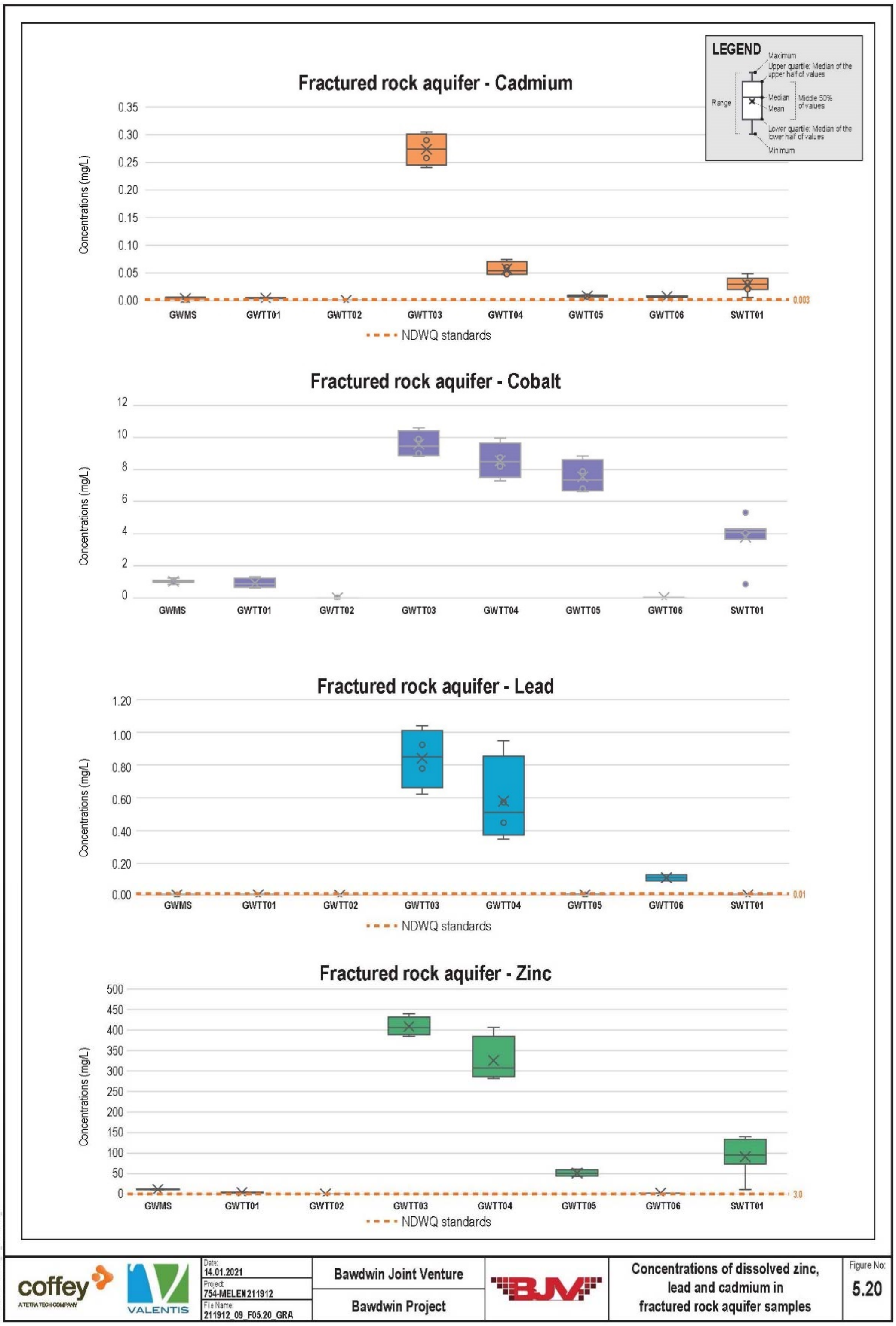
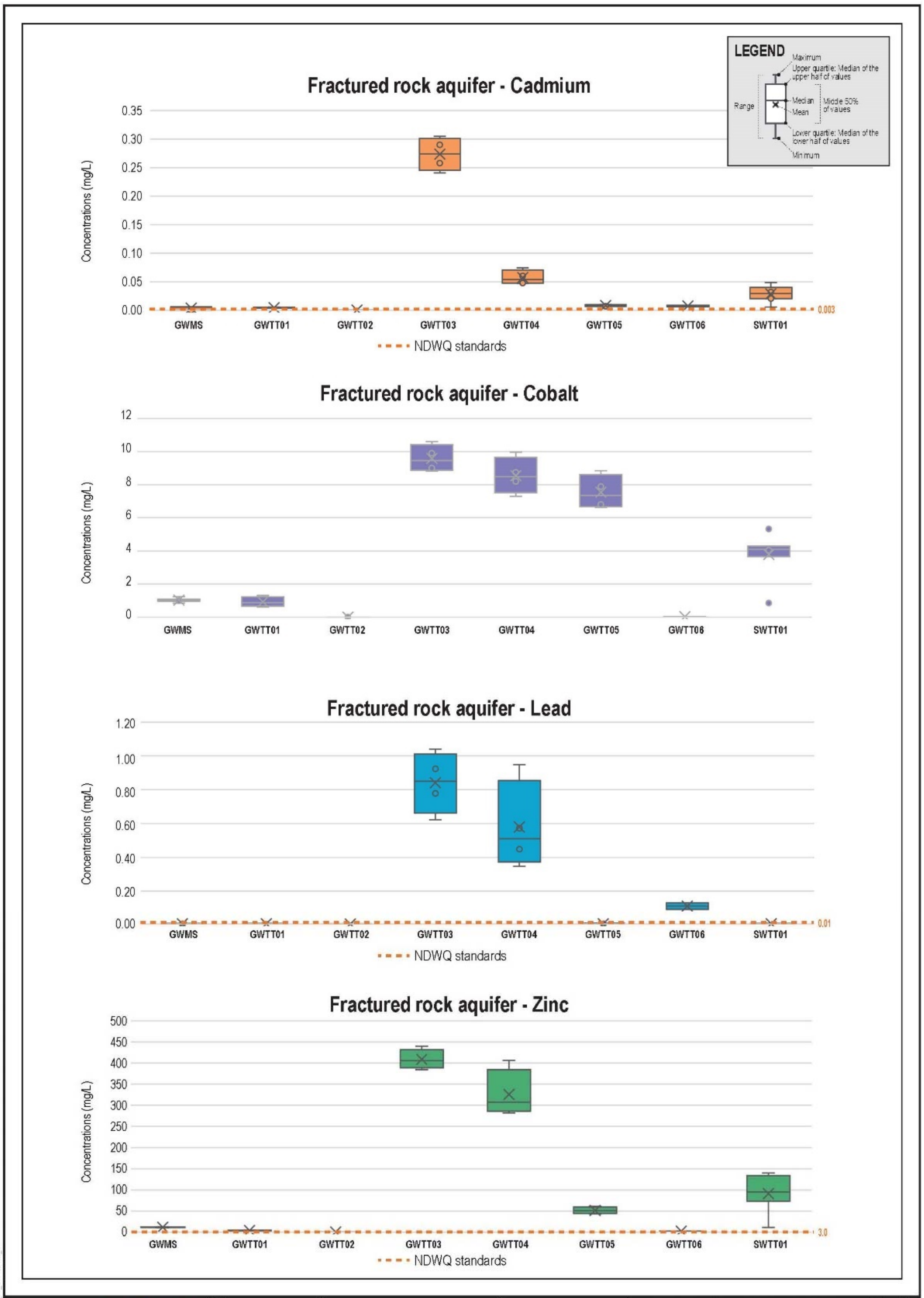


Figure 5.20).

Groundwater in the fractured rock aquifer was slightly acidic at all depths with pH ranging from 6.0 to 6.7. Temperature ranged from 23°C to 30°C.

Groundwater within the fractured rock aquifer has elevated concentrations of total aluminium, antimony, arsenic, cadmium, iron, lead, manganese, nickel and zinc, all of which exceed either aesthetic or health-based drinking water guidelines (Table 5.18). Average concentrations have been calculated assuming that measurements below the LOR are 0 mg/L, and outliers have been excluded.

Deeper groundwater within the fractured rock aquifer has been subject to increased mineral dissolution reflected in the dissolved metal concentrations of the groundwater samples (Table 5.18 and Table 5.19). Dissolved concentrations of aluminium, cadmium, copper, lead, manganese, nickel, and zinc also exceed ecosystem protection criteria (Table 5.19) and are therefore likely to be toxic to aquatic ecosystems of the Nam Pangyun. This is consistent with the limited aquatic ecosystem values identified in the Nam Pangyun.



Date: 14.01.2021 Project: 754-MELEN211912 File Name: 211912_09_F05.20_GRA	Bawdwin Joint Venture Bawdwin Project	Concentrations of dissolved zinc, lead and cadmium in fractured rock aquifer samples	Figure No: 5.20

Figure 5.20 shows the recorded concentrations of dissolved cadmium, zinc and lead in the bedrock aquifer. GWTT03 and GWTT04 exhibit the greatest concentrations of these metals.

Table 5.18 Range and average concentration of total metals in the fractured rock aquifer

Analyte	NDWQ standard (mg/L)	Concentration range (mg/L)	Average concentration (mg/L)
Aluminium*	0.2	<0.01 - **0.30**	0.047
Antimony	0.02	0.0028 **- 0.12**	**0.028**
Arsenic	0.05	0.0112 - **2.14**	**0.619**
Barium	0.7	<0.01 - 0.09	0.05
Cadmium	0.003	0.0005 - **0.075**	**0.0175**
Cobalt	NA	0.005 - 11.2	3.98
Copper	2.0	0.002 - 0.074	0.0151
Iron*	1.0	<20.6 - **50.2**	**16.62**
Lithium	NA	<0.001 - 0.029	0.0060
Lead	0.01	0.007 - **1.53**	**0.373**
Manganese	0.4	0.043 - **35.6**	**13.92**
Molybdenum	NA	<0.001 - 0.008	0.0017
Nickel	0.07	0.021 - **16.4**	**6.11**
Selenium	0.04	<0.0005 - 0.0085	0.00118
Strontium	NA	0.018 - 0.234	0.1011
Uranium	0.03	<0.005 – 0.021	0.0023
Zinc*	3	0.284 - **583**	**116**

* Aesthetic (not of health significance) standards
Values in bold exceed the NDWQ standard

Table 5.19 Range and average concentration of dissolved metals in the fractured rock aquifer

Analyte	ANZ DGV (mg/L)	Concentration range (mg/L)	Average concentration (mg/L)
Aluminium	0.055	<0.01 – **0.37**	0.047
Antimony	0.009	<0.0005 – **0.04**	**0.009**
Arsenic	0.013	0.0007 – **0.0579**	0.0077
Barium	N/A	<0.01 – 0.09	0.05
Cadmium	0.0002	**0.0004 – 0.305**	**0.046**
Cobalt	0.0014	<0.001 – **10.6**	**4**
Copper	0.0014	<0.001 – **0.17**	**0.023**
Iron	N/A	<0.005 – 0.807	0.086
Lithium	N/A	<0.001 – 0.029	0.006
Lead	0.0034	<0.001 – **1.04**	**0.17**
Manganese	1.9	<0.001 – **34.4**	**14**
Molybdenum	N/A	<0.001 – 0.006	0.0017
Nickel	0.011	0.021 – **16.3**	**6**
Selenium	N/A	<0.0005 – 0.0048	0.0011
Strontium	N/A	0.017 – 0.177	0.095
Uranium	N/A	<0.001 – 0.005	0.0012
Zinc	0.008	**0.236 - 440**	**114**

Values in bold exceed ANZ DGVs

Analysis of the major ion composition of groundwater from the fractured rock aquifer allows further assessment of the geochemical processes that are occurring. Piper plots (also known as trilinear diagrams) are a commonly used approach for visualising the relative abundance of common ions in multiple water samples. A trilinear Piper diagram is provided in Figure 5.21 and compares the relative ionic composition of groundwater samples collected at various depths in the fractured bedrock (GWTT01 to GWTT06) to a representative surface water sample from the Nam Pangyun (SWNP03).

Shallow groundwater in the fractured rock aquifer (GWTT02) displays a balance between bicarbonate and sulfate ions that is comparable to the composition of surface water in the Nam Pangyun (SWNP03 in Figure 5.21). This is consistent with shallow groundwater in the bedrock aquifer being recharged either by rainfall recharge or via infiltration from Nam Pangyun. The anionic balance evolves with depth, becomes increasingly dominated by sulfate ions (indicated by the arrow in Figure 5.21) and suggests that groundwater is dissolving sulfate from minerals such as galena (PbS), sphalerite ((Zn,Fe)S), pyrite (FeS_2) and chalcopyrite ($CuFeS_2$) present in the disseminated sulfide ore.

Detectable concentrations of nitrate were reported for all locations from the underground mine typically ranging from 0.01 to 0.20 mg/L with an average concentration of 0.05 mg/L, well below the 50 mg/L drinking water guideline value. This may potentially be related to explosives from previous mining. Table 5.20 summarises the concentration of nutrients in this deeper groundwater. Average concentrations have been calculated assuming that measurements below the LOR are 0 mg/L.

Table 5.20 Range and average concentration of nutrients in fractured rock aquifer

Analyte	NDWQ standard (mg/L)	Concentration range (mg/L)	Average concentration (mg/L)
Nitrate (as NO_3)	50	<0.005 – 0.202	0.049
Nitrite (as NO_2)	3	<0.001 – 0.034	0.005
Total nitrogen	NA	0.06 – 1.05	0.46
Total Kjeldahl Nitrogen (as N)	NA	<0.02 – 0.93	0.4
Total phosphorous	NA	0.08 – 4.01	0.82

Tiger Tunnel is the primary point of groundwater discharge from the underground mine and represents a mix of water contributed from various depths and within the mineralised zone. Samples collected between November 2017 and August 2019 demonstrate that groundwater discharging via the Tiger Tunnel to the Nam Pangyun contains concentrations of total and dissolved metals that significantly exceed health and aesthetic drinking water criteria, as well as Myanmar National Environmental Quality (Emission) Guidelines (NEQEG) (MOECAF, 2015) (Table 5.21).

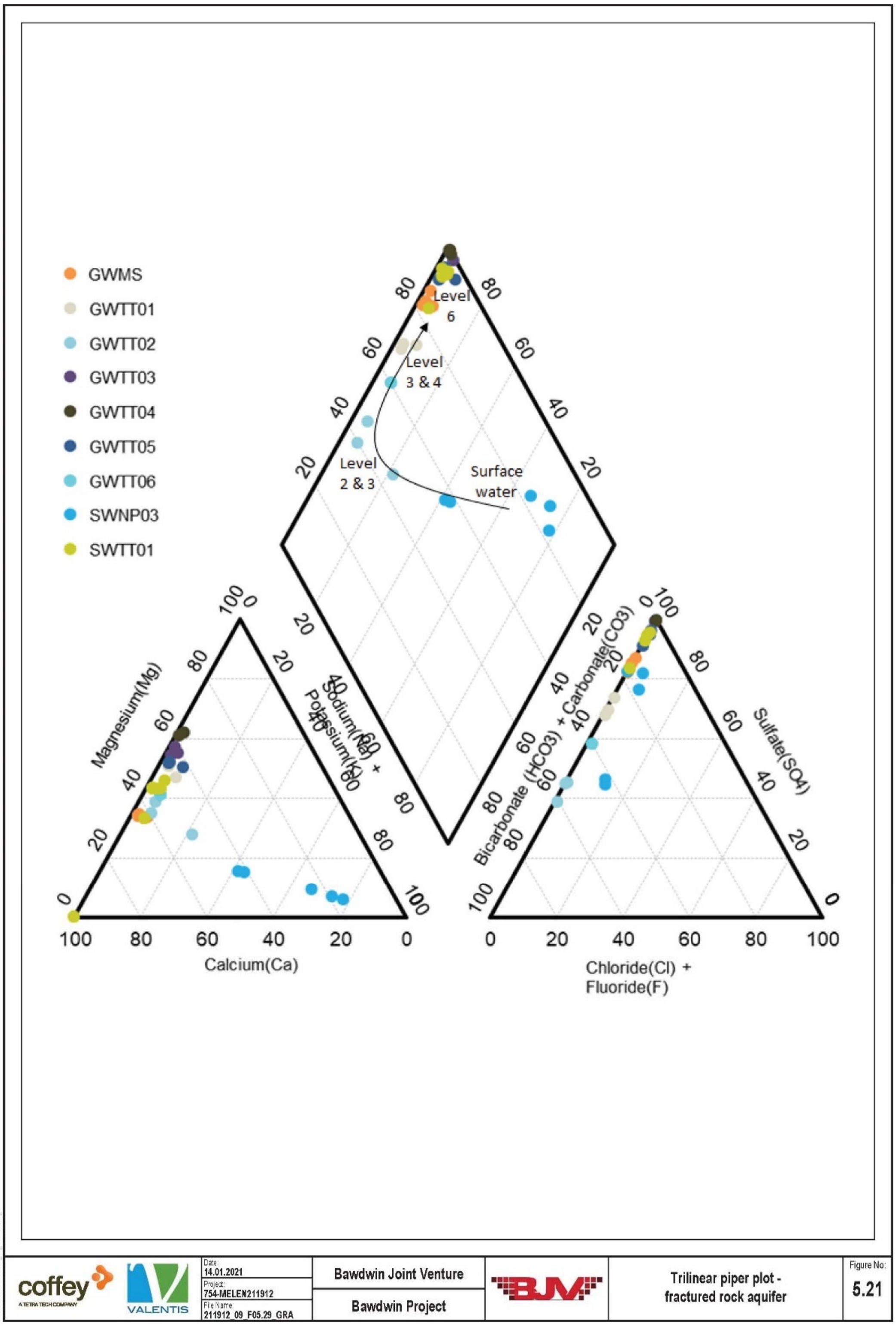


Figure 5.21 Trilinear piper plot - fractured rock aquifer

Table 5.21 Tiger Tunnel discharge water quality compared to draft Myanmar emissions guidelines

	Unit	NEQEG - Mining	SWTT01	SWTT01	SWTT01	SWTT01	SWTT01	SWTT01	SWTT01	SWTT01
Date of sampling			12-11-17	22-11-18	23-01-19	18-02-19	16-03-19	05-05-19	08-06-19	10-08-19
Aluminium	mg/L	-	0.17	0.3	0.02	<0.13	0.11	<0.09	0.08	0.09
Arsenic	mg/L	0.1	0.55	0.89	1.4	0.76	0.74	0.70	0.68	0.61
Cadmium	mg/L	0.05	0.041	0.055	0.0079	0.033	0.031	0.026	0.025	0.025
Iron	mg/L	2	13	26.4	19.2	24.3	23.4	<20.6	20	17.4
Lead	mg/L	0.2	0.32	0.51	0.37	0.39	0.38	0.29	0.32	0.26
Nickel	mg/L	0.5	7	8.68	1.75	6.49	6.64	6.15	5.7	5.61
Zinc	mg/L	0.5	140	152	12.2	99.4	96.3	91	81.5	84

Shading indicates exceedance of the relevant standard.

Groundwater use

There are numerous springs within the Bawdwin project area, many of which are used by the local community as water supplies for potable and domestic use, as well as agricultural production. The Bawdwin villages and the surrounding communities (including Tiger Camp) rely solely on groundwater supply from the saprolite-fed springs for commercial, domestic, and agricultural needs.

Part of the Namtu township is supplied with potable water from the Nam La Flume, a constructed water delivery system which sources water from the Nam La stream at an offtake point north of Namtu. In turn, surface water in the Nam La is sustained during dry periods by baseflow discharge from the fractured rock aquifer and spring discharge from the saprolite aquifer. The remainder of Namtu township's water supply is sourced from Kho Mo Reservoir, located on the southern flank of the Myitnge River, independent of the Nam La.

The uses of groundwater from the Nam Pangyun and Nam La catchments are outlined in Table 5.22.

Table 5.22 Environmental value of groundwater

Groundwater Catchment	Aquifer	Groundwater uses						
		Groundwater dependent ecosystems	Consumptive use (drinking water)	Other consumptive uses	Recreation	Agriculture & irrigation	Industrial	Cultural & spiritual
Nam Pangyun catchment	Saprolite	✓	✓	✓	-	✓	✓	P
	Fractured rock	✓	-	-	-	✓	✓	-
Nam La and surrounding catchments	Saprolite	✓	✓	✓	✓	✓	✓	P
	Fractured rock	✓	✓	P	P	P	P	-

Notes:

✓ Currently realised and/or supports this value in most areas.

✓ Currently realised in some areas or has the potential to support this value in some areas.

P Potential future use or unknown current use

\- Not expected to support this value

5.2.3 Summary

The two main hydrogeological units in the area are the saprolite aquifer and fractured rock aquifer.

- The saprolite aquifer discharges as springs in the Nam Pangyun and Nam La catchments. Springs on valley floors flow year-round and springs higher upslope flow seasonally due to seasonal fluctuations in groundwater levels of up to 5 m.
- The fractured rock aquifer is groundwater stored in fractures, joints, bedding, and cavities in the underlying basement rock. This aquifer has higher hydraulic conductivity in area surrounding mine due to increased faulting, fractures and historic mining activities and long residence times of months to years.
- The aquifers are recharged predominantly by rainfall in the wet season (May to October) with the highest recharge rates likely to occur on exposed ridgelines and hilltops. Infiltration from the saprolite aquifer may recharge fractured rock aquifer.

Monitoring of groundwater level and flow indicates:

- Groundwater levels range between less than 2 m below ground level to approximately 150 m below ground level. Groundwater levels and flow direction are influenced by historic mining and dewatering of the underground mine. Dewatering of the underground mine by continuous pumping is a major groundwater discharge for the fractured rock aquifer.
- The Nam La and Nam Pangyun streams receive groundwater baseflow, however baseflow to the Nam Pangyun is reduced near the mine due to mine dewatering.

Monitoring of groundwater quality during the monitoring period shows:

- Extensive historical mining has contributed to elevated concentrations of some metals due to exposure of mineralised rock and disposal of mineral concentration by-products.
- The saprolite aquifer had concentrations of total and dissolved lead, total iron, total manganese and sulphate exceeding the adopted drinking water criteria.
- Contaminants (*E. coli*, nitrate and/or phosphorous) from agricultural practices, animal or human sewage waste disposal, or prior explosives use were detected, albeit below applicable drinking water standards.
- Groundwater within the fractured rock aquifer has elevated concentrations of total aluminium, antimony, arsenic, cadmium, iron, lead, manganese, nickel, and zinc, all of which exceed either aesthetic or health-based drinking water guidelines.
- Groundwater discharging via the Tiger Tunnel to the Nam Pangyun contains concentrations of total and dissolved metals that significantly exceed health and aesthetic drinking water criteria and Myanmar's Draft National Environmental Quality (Emission) Guidelines (MOECAF, 2014).

5.2.4 Sensitivity of groundwater values

This section builds on the characterisation of groundwater above and describes the sensitivity of groundwater values in terms of the importance, vulnerability and resilience of the saprolite aquifer, fractured rock aquifer and springs. Springs are the expression of the saprolite aquifer at the surface and will consequently have similar sensitivities, however these are defined as separate values to allow a comprehensive impact assessment.

Sensitivity is defined as the susceptibility of groundwater systems to changes in quantity or quality, including the capacity of groundwater systems to adapt to, or accommodate, the kinds of changes that the Project may bring about. Sensitivity is based on the importance of the value, the vulnerability of the value to change, and the resilience of the value in terms of its ability to overcome changes and maintain its inherent value.

The importance of each aquifer and the springs were determined by considering the current and potential future uses of both groundwater from the aquifers/springs and the aquifers themselves, and their intrinsic value. Current uses have been based on observations made in the study area and from consultation with local communities. The potential future use considers the chemical suitability of water for a use, access limitations (such as spring flow rates, aquifer yield), and the availability of alternative supplies such as surface water. Intrinsic values have been established based on the dependence of other ecosystems and segments of the environment, such as aquatic ecosystems, surface water features and groundwater dependent vegetation. The vulnerability of each receptor is defined by considering its location with respect to the project, relationship to other receptors and current condition. The resilience of each receptor is defined by considering the ability of a receptor to respond to a change/disturbance by resisting damage and/or recovering quickly to its original value.

The groundwater-specific definitions for the varying levels of sensitivity relating to groundwater values that were adopted are provided in Table 5.23. Table 5.24 outlines the importance, vulnerability, and resilience for each value, based on a low, medium and high scale as outlined in Table 5.23.

Table 5.23 Importance, vulnerability and resilience definitions and ratings criteria

	Definition	Ratings Criteria		
		Low	Medium	High
Importance	The value that is associated with the groundwater system in its current form. This includes the ability of the system to support ecosystems and beneficial uses, as well as any inherent resource value.	Attributes of the groundwater system (quality, occurrence, volume, extraction potential) are not suitable for beneficial uses, and/or attributes of the groundwater system are common on a local and regional scale, and therefore have both local and regionally available alternatives.	Attributes of the groundwater system are of low to moderate ecological importance and are characterised as slightly to moderately disturbed. Intrinsic attributes support the use of the groundwater for construction and irrigation purpose, and/or attributes of the groundwater system are locally unique but have regionally available alternatives.	Attributes of the groundwater system are of high ecological importance and/or cultural or spiritual significance. Intrinsic attributes support the use of the groundwater for potable supply, agricultural use, and food production and/or attributes of the groundwater system are unique. There are limited available alternatives.
Vulnerability	The extent to which the value is susceptible to change. This includes the existing condition of the terrain unit in terms of its physical and chemical properties and how readily additional change may cause deterioration or loss of associated ecosystems or land use value.	Low susceptibility of groundwater level to external influences. Low level of vulnerability to contamination.	Medium susceptibility of groundwater level to external influences. Medium level of vulnerability to contamination.	High susceptibility of groundwater level to external influences. High level of vulnerability to contamination. Permanent quality or quantity changes may result.
Resilience	The extent to which the value can adapt or recover from change.	Intrinsic properties of the groundwater system are very susceptible to change. The overall function of the groundwater system would be permanently altered for example groundwater systems with very low recharge rates and very slow recovery periods. Recovery will be successfully achieved in all cases.	Intrinsic properties of the groundwater system are moderately susceptible to change. The overall function of the groundwater system could be moderately altered for example groundwater systems with moderate recharge rates and medium-term recovery periods. Recovery is likely to be slow or only partially successful.	Intrinsic properties of the groundwater system are resilient to change for example groundwater systems with very high recharge rates and very short recovery periods. Extremely limited recovery potential if impact on the value cannot be avoided.

Table 5.24 Summary of groundwater receptors and their sensitivity

Receptor	Primary aquifer	Importance	Vulnerability	Resilience	Sensitivity
Nam Pangyun catchment	Saprolite	**High** Currently groundwater from the saprolite aquifer has beneficial uses as a potable water supply and supports aquatic ecosystems and is of high importance.	**Low** Low groundwater residence times are likely to positively influence recovery provided the impact source is removed.	**Low** Intrinsic properties of the groundwater system are very susceptible to change (such as land clearing and excavation). The overall function of the groundwater system would be permanently altered.	**High**
	Fractured rock	**Low** Attributes of the groundwater system (quality, occurrence, volume, extraction potential) are not suitable for beneficial uses due to natural mineralisation and historical mineral processing activity. Locally, the groundwater system does not support ecosystems. Further downstream the groundwater system supports ecosystems of low ecological importance, and/or groundwater dependent surface water features which are characterised as highly altered from their natural state.	**Medium** Recovery is likely to be slow or only partially successful.	**Medium** Intrinsic properties of the groundwater system are moderately resistant to change. The overall function of the groundwater system could be moderately altered.	**Low to medium**
Nam La and surrounding catchments	Saprolite	**High** Intrinsic attributes support the use of the groundwater for potable supply (for Namtu township), agricultural use, and food production. Attributes of the groundwater system are of moderate to high ecological importance, supporting terrestrial and aquatic ecosystems that are characterised as largely undisturbed.	**Low** Low groundwater residence times are likely to positively influence recovery provided the impact source is removed.	**Low** Intrinsic properties of the groundwater system are very susceptible to change. The overall function of the groundwater system would be permanently altered.	**High**
	Fractured rock	**Medium**	**Medium**	**Medium**	**Medium**

Receptor	Primary aquifer	Importance	Vulnerability	Resilience	Sensitivity
		Attributes of the groundwater system (quality, occurrence, volume) are suitable for beneficial uses however the reduced extraction potential has resulted in this resource not being exploited for a consumptive beneficial use. The groundwater system supports aquatic and some terrestrial ecosystems of ecological importance. Catchments outside of developed urban centre of Namtu township are largely unaltered from their natural state and will have some dependence on groundwater discharge during dry months. Attributes of the groundwater system are common on a local and regional scale, and therefore have both local and regionally available alternatives.	Recovery is likely to be slow or only partially successful.	Intrinsic properties of the groundwater system are slightly resistant to change. However, the overall function of the groundwater system remains relatively unchanged.	
Springs	Saprolite	**High** Intrinsic attributes support the use of the groundwater for potable supply, agricultural use, and food production for current Bawdwin villages, Tiger Camp and Namtu. Currently the springs provide base flow to the Nam Pangyun as well as supporting the beneficial uses of groundwater and are of high importance.	**Medium** Low groundwater residence times are likely to positively influence recovery provided the impact source is removed, however as springs take a longer time to disperse contaminants than rivers, they are more vulnerable to change. Springs represent a limited number of surface expressions of the saprolite aquifer and are therefore more vulnerable to permanent change and significant degradation.	**Low** Intrinsic properties of the springs are very susceptible to change (such as land clearing and excavation), however will maintain high connectivity to the saprolite aquifer. The overall function of the springs would be permanently altered.	**High**

5.2.5 Uncertainties and limitations

The following uncertainties and limitations are noted in relation to the characterisation of the existing groundwater environment:

- Groundwater quality of the saprolite aquifer has been assessed based on samples collected immediately downstream of spring discharge points due to difficulty directly accessing the source. The reported quality may vary from the groundwater quality in situ and may be affected by contaminants within the catchment between the spring discharge and the sampling point.
- Groundwater quality of the bedrock aquifer has been assessed based on samples collected from various piped drainage points constructed to transfer groundwater ingress from various levels of the underground mine. Potential for contamination or mixing of water types exists and samples may not represent in situ aquifer conditions.
- The assessment of groundwater levels and flow directions at some locations has been based on measured groundwater levels in both cased and uncased exploration boreholes. The measured levels may be affected by a range of factors that could under or overestimate the inferred water table.
- Some groundwater quality parameters are subject to short holding times that could not be met due to the inherently long international sample transport time, limited domestic laboratory alternatives of suitable quality, and delays in export permissions. However, key parameters of interest (such as metals) are considered to have lower potential for impact by longer sample holding time, and this is unlikely to have materially affected the conclusions of the baseline groundwater assessment.

5.3 Surface water

This section describes the existing surface water environment of the project. A baseline water study for the project was conducted by Coffey and Valentis between 2017 and 2020 to characterise the surface water environment. The baseline report is presented in Appendix C. Additional investigations relating to surface water features were completed by CSA Global (2020) to inform the Definitive Feasibility Study (DFS) for BJV and presented in Appendix B. The information presented in this section is a consolidated summary of information presented in both reports to characterise the existing surface water conditions in relation to the project.

5.3.1 Context

The project is located within the Myitnge River basin, which is a tributary of the Ayeyarwady River. The Ayeyarwady River is the largest river in Myanmar and spans 2,210 km. It flows from the confluence of the N'mai and Mali rivers in Kachin State, south through Myanmar to the Ayeyarwady Delta in the Andaman Sea. The Myitnge River flows for 477 km from the headwaters in the Mount Loi Swang mountains to the Ayeyarwady River.

The primary watercourses in the study area are the Nam Pangyun and Nam La streams, which both flow in an approximately southeasterly direction and discharge into the Myitnge River near Namtu. In Shan language "Nam" (as in Nam Pangyun) refers to a creek or stream.

The Nam Pangyun catchment area covers approximately 47.8 km^2 and comprises three main sections: upper, mid and lower catchment (

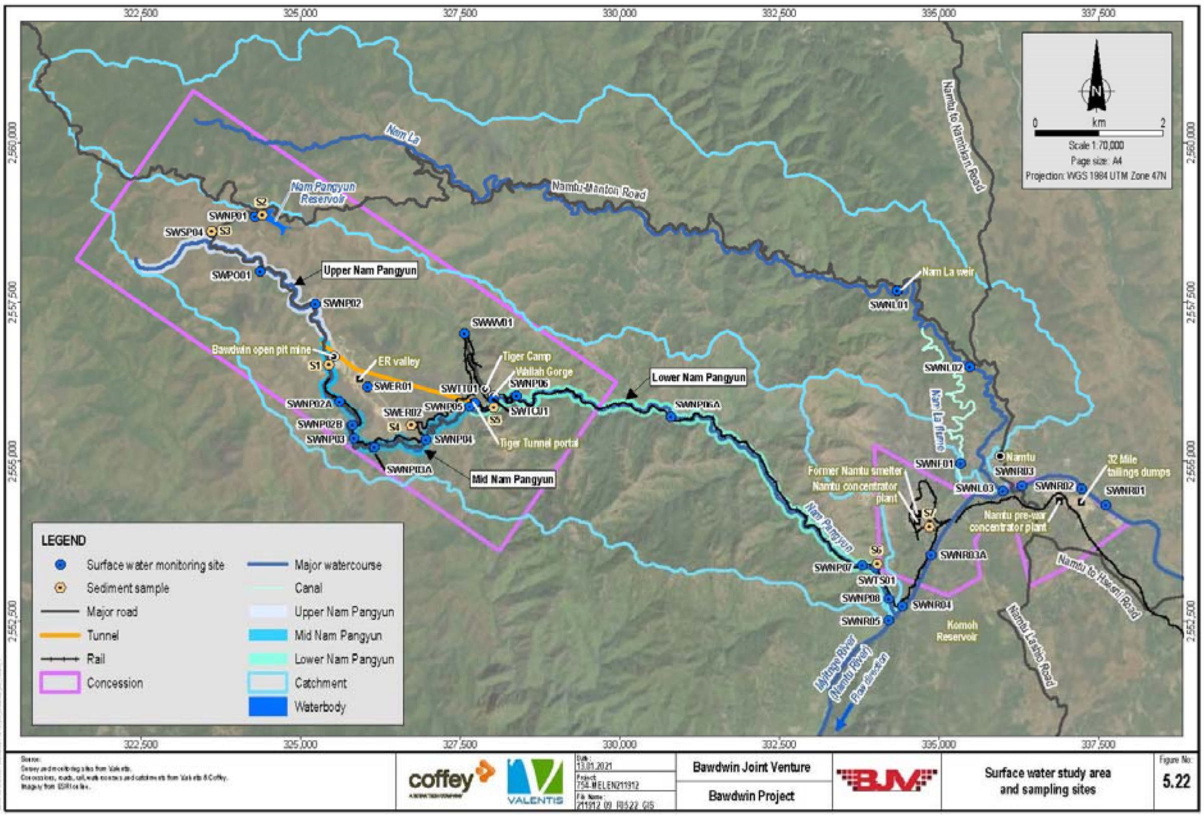


Figure 5.22). The catchment elevation ranges between 560 m above mean sea level (AMSL) and 1,400 m AMSL, with relatively steep topography. Most of the slopes in the catchment exceed 20 degrees, and the upper Nam Pangyun has created a steep-sided valley and gorges in several places. The stream passes through several wards of Bawdwin village in the upper catchment (Thiri Mingalar, Yadanar Myay, Aung Chan Thar), mid catchment (Pyi Taw Aye, Aung Tha Pyay, Mingalar Kwe, Aung Theikdhi) and lower catchment (Tiger Camp).

The Nam La catchment covers approximately 35.5 km^2. The stream has its headwaters approximately 7 km northwest of the Bawdwin open pit and flows through Namtu at its confluence with the Myitnge River. Pang Hai ward is located east of the Nam La, on the northern side of the Myitnge River. Wards 5, 6 and 7 of Namtu town are located on the northern side of the Myitnge River, downstream of the Nam La confluence. Wards 1 – 4 and Har Lin village are located on the southern side of the Myitnge River.

The water quality of the surface water features in the catchments reflect natural water quality, current human usage of surrounding land and legacy environmental issues related to historic mining activities over six centuries. High levels of heavy metals and sewage are present in the Nam Pangyun, and high levels of waste/sewage are also present in the Nam La, with the discharge from these watercourses reflected in water quality of the Myitnge River.

5.3.2 Method and study area

Study area

The surface water study area encompasses the catchments of the Nam Pangyun (separated into upper, mid, and lower catchment), Nam La, Myitnge River and minor tributaries of these (Figure 5.22). This study area includes the project area and additional reference locations to provide sufficient regional context to understand the values associated with the surface water features.

The extent of the surface water study area has been defined so as to capture the water quality in the Myitnge River, and the minimally impacted headwaters of the Nam Pangyun and Nam La, along with degradation downstream of areas of mining activities.

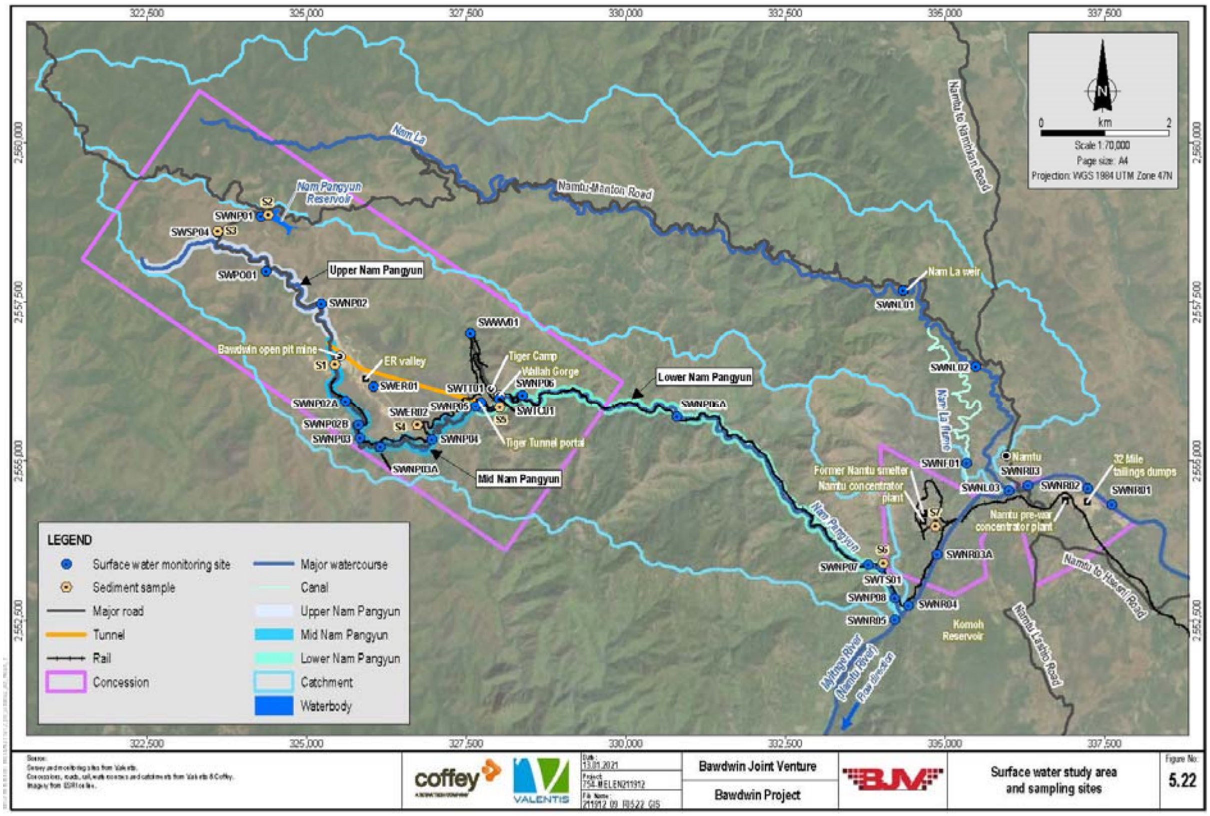


Figure 5.22 Surface water study area and sampling sites

Method

The baseline water quality was sampled at 36 monitoring sites in the Nam Pangyun, Nam La and Myitnge River between November 2018 and November 2019 (Appendix C). The monitoring program consisted of analysis of physical and chemical parameters of surface water samples to establish baseline conditions of surface waters.

Both in situ measurements and water quality samples were taken along with visual observations of the conditions. Water quality parameters (pH, electrical conductivity, temperature and turbidity) were measured in the field using a calibrated water quality meter, and Hach test strips were used to estimate hardness and alkalinity. Samples were transported under chain of custody to PT Intertek Utama Services, a KAN accredited laboratory in Jakarta, Indonesia, for analysis of the following physical and chemical parameters:

- Total dissolved solids (TDS), total suspended solids (TSS), pH, hardness.
- Fluoride, ammonia cyanide, cyanide (CN).
- Volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene, xylene and naphthalene (BTEXN). These contaminants were below the limit of detection at all sites in during the initial monitoring round and were not sampled in subsequent rounds.
- Pesticides (organochlorine and organophosphorus) and herbicides. These contaminants were below the limit of detection at all sites in during the initial monitoring round and were not sampled in subsequent rounds.
- Major cations: calcium (Ca), magnesium (Mg), sodium (Na), potassium (K).
- Major anions: sulfate (SO_4), chloride (CI), carbonate (CO_3), bicarbonate (HCO_3)
- Metals and metalloids – filtered and unfiltered: aluminium, antimony, arsenic, barium, bismuth, beryllium, boron, cadmium, chromium (VI), chromium (III+VI), cobalt, copper, iron, lithium, lead, manganese, mercury, molybdenum, nickel, silver, selenium, strontium, thallium, thorium, tin, titanium, uranium, vanadium and zinc. Metals that were not detected or didn't have any applicable standards are not discussed in this section.
- Nutrients: total nitrogen, total kjeldahl nitrogen (TKN), nitrate (NO_3), nitrite (NO_2), ammonia (NH_3), phosphate, total phosphorus.

In most waters, metal contaminants will be present in dissolved, complexed and particulate forms. The bioavailability of a contaminant is the proportion of substance that enters the circulation of organisms and is able to have an active effect. The bioavailability of each of these forms of contaminants differs considerably. Particulate and strongly complexed forms of metals are not bioavailable, i.e. they are not taken up by an organism or directly available to cause biological effects. Conversely, dissolved forms typically have higher bioavailability. In order to examine the concentration of both forms of metals, two water samples were obtained at each location during each sampling round. Of these two samples, one was filtered prior to analysis to remove particulate matter, thereby giving the concentration of dissolved metals, and the second was left unfiltered, thereby representing the concentrations of total recoverable metals, including particulate and complexed forms.

Table 5.25 provides a summary of the surface water quality sampling sites and the number of monitoring events during the study period.

Table 5.25 Surface water monitoring locations

Location ID	Location	Description	Easting	Northing	Monitoring Events
Nam Pangyun – Upper catchment					
SWNP01	Nam Pangyun	Immediately downstream of the Nam Pangyun Reservoir embankment	324290	2558844	9
SWSP04	Nam Pangyun	One of two spring sources at head of Nam Pangyun	323608	2558592	8
SWPO01	Nam Pangyun	Off-take channel from Nam Pangyun into the settling pond of the Bawdwin potable water supply system	324372	2557988	8
SWNP02	Nam Pangyun	1 km upstream of the open pit	325233	2557482	8
Nam Pangyun – Mid catchment					
SWNP02A	Nam Pangyun	Bawdwin, 0.75 km downstream of open pit	325609	2555943	7
SWNP02B	Nam Pangyun	Bawdwin, 1.25 km downstream of open pit	325809	2555570	7
SWNP03	Nam Pangyun	Bawdwin, 1.75 km downstream of open pit	325844	2555359	7
SWNP03A	Nam Pangyun	Bawdwin, 2.25 km downstream of open pit	326155	2555221	7
SWNP04	Nam Pangyun	0.1 km upstream of confluence with ER Valley creek	326968	2555336	7
SWNP05	Nam Pangyun	0.5 km upstream of Tiger Camp	327656	2555859	7
SWER01	ER Valley	ER valley creek at toe of historical waste rock dump	326054	2556179	8
SWER02	ER Valley	ER valley creek prior to confluence with Nam Pangyun	326753	2555570	7
Nam Pangyun – Lower catchment					
SWNP06	Nam Pangyun	1 km downstream of Tiger Camp	328388	2556032	7
SWNP06A	Nam Pangyun	Lopah Village, approximately 4 km downstream of Tiger Camp and 5.25 km upstream of the confluence with Myitnge River	330806	2555694	6
SWNP07	Nam Pangyun	1 km upstream of confluence with Myitnge River	333806	2553378	8
SWNP08	Nam Pangyun	Immediately upstream of confluence with Myitnge River	334217	2552859	8
SWWV01	Wallah Valley	Wallah valley creek upstream of Tiger Camp	327572	2557004	8
SWTC01	Tiger Camp	Wallah valley creek downstream of Tiger Camp	328023	2555974	7
SWTS01	Nam Pangyun tributary	Tributary stream draining valley behind Namtu smelter stack to Nam Pangyun, 0.2 km downstream of SWNP07.	334006	2553338	8
Nam La					
SWNL01	Nam La	Nam La upstream of the Nam La Flume	334346	2557683	8
SWNL02	Nam La	Nam La upstream of Namtu town, downstream of the Nam La Flume	335483	2556485	8
SWNL03	Nam La	Nam La downstream of Namtu town at the confluence with Myitnge River	336009	2554539	9
SWNF01	Nam La Flume	Nam La Flume approximately 0.6 km upstream of flume offtake structure	335341	2554963	8

Location ID	Location	Description	Easting	Northing	Monitoring Events
Myitnge River					
SWNR01	Myitnge River	0.25 – 0.5 km upstream of the 32 Mile tailings dump and 32 Mile pre-war concentrator plant	337611	2554320	8
SWNR02	Myitnge River	1 km upstream of the centre of Namtu, downstream of the 32 Mile tailings dump	337233	2554572	8
SWNR03	Myitnge River	Namtu, downstream of industrial area, 0.3 km upstream of confluence with Nam La	336300	2554624	8
SWNR03A	Myitnge River	0.3 km downstream of former Namtu smelter, 2 km downstream of Namtu	334875	2553531	7
SWNR04	Myitnge River	0.1 km upstream of confluence with Nam Pangyun	334428	2552733	8
SWNR05	Myitnge River	0.2 km downstream of confluence with Nam Pangyun	334218	2552512	8

Sediment samples were taken from seven sites in the study area in November 2017 for analysis to characterise stream sediments. The sites were located primarily in the Nam Pangyun downstream of the existing Bawdwin open pit, in ER Valley and downstream of historical processing infrastructure at Namtu. Table 5.26 summarises the sediment quality sampling sites from the November 2017 sediment sampling.

Table 5.26 Sediment sampling locations

Sediment Sample ID	Location	Description	Easting	Northing
Nam Pangyun – Upper catchment				
S2	Nam Pangyun	Upstream of concentrator. Located near the Nam Pangyun Reservoir embankment. Close to water sample site SWNP01.	0324399	2558864
S3	Nam Pangyun	Upstream of mine and villages at road crossing near the headwaters of the Nam Pangyun. Close to water sample site SWSP04.	0323612	2558609
Nam Pangyun – Mid catchment				
S1	Nam Pangyun	Downstream of concentrator, adjacent to mine pit.	0325443	2556515
S4	Nam Pangyun	ER Valley upstream of railway crossing	0326738	2555558
Nam Pangyun – Lower catchment				
S5	Nam Pangyun	Downstream of Tiger Camp, approximately 0.3 km downstream of Tiger Tunnel discharge point.	0328036	2555840
S6	Nam Pangyun	Small creek draining from the historic smelter stack to the Nam Pangyun. Close to water sample site SWTS01	0334036	2553392
Myitnge River				
S7	Un-named creek	Small creek draining from the former Namtu smelter to the Myitnge River. Downstream of former Namtu smelter and Namtu concentrator plant	0334860	2553977

CSA Global conducted analysis of surface water flow rates in the Nam Pangyun catchment in 2019 and 2020 (Appendix B). The monitoring program consisted of weekly measurements of the flow rate at specific locations along the Nam Pangyun (Table 5.27). The float method of measuring flow rates was utilised at PS01 beginning in February 2019 and at SWF02 and SWF03 beginning in August 2019. The float method involves multiplying the cross-section area of water by the velocity of the stream. The velocity is calculated by measuring the time taken for a small float to travel down a measured length of the stream. As of October 2019, an automatically integrating hand-held flow meter (a Valeport model BFM002) was used to measure flow rates in addition to the float method at these locations to enable comparison between the two methods. Water levels were also recorded by a Solinst 3250 LevelVent M5 automatic vented level logger at SWF09, installed in February 2020 to establish trends in water levels.

Table 5.27 Flow rate measurement locations

Location ID	Location	Parameter measured
PS01	Adjacent to mine pit	Flow rate
SWF02	Upper catchment, downstream of TSF	Flow rate
SWF03	Downstream of mine pit	Flow rate
SWF09	Downstream of current BJV operational areas at the Spiral Bridge on the Tiger Camp-Namtu railway line	Level logger

Water and sediment quality standards and guidelines

To characterise existing surface water conditions, water quality results were compared to the proposed Myanmar drinking water standards and international guidelines for aquatic ecosystem protection. The National drinking water quality standard was developed by technical Committee for Food Stuff – Standardization Technical Sub-committees and it was approved according to the (1/ 2018) by the National Standardization Council meeting held on 27th November 2018. , these standards provide criteria for microbiological quality, physical water quality, chemical water quality (including total metal concentrations) with aesthetic and health limits, and pesticides.

While not all streams are used for drinking water (e.g., the Nam Pangyun), water quality at all sites was compared to the drinking water standards to provide context on their suitability for such use and their existing level of contamination.

As Myanmar does not have water quality standards for aquatic ecosystem protection, water and stream sediment quality results are discussed with reference to Australian and New Zealand water and sediment quality guidelines (ANZG, 2018). The ANZG are discussed further with respect to groundwater quality assessment criteria in Section 5.2.1.

The ANZG (2018) sediment quality guidelines provide:

- Default guideline values (DGVs), which indicate the concentrations below which there is a low risk of biological effects occurring.
- Upper guideline values (GV-high), which provide an indication of concentrations at which toxicity related effects would be expected.

At concentrations between the DGV and GV-high, toxicity related effects may be expected, and the guidelines recommend further investigations should be undertaken to assess the risks of biological effects occurring. Comparison to these guidelines allows for understanding whether contaminants in sediments are elevated with respect to typical healthy aquatic ecosystems.

5.3.3 Surface water features

This section characterises the key surface water features in the study area based on their physical and chemical properties as determined during sampling. Several sampling sites are referred to in this section, from which hydrology, water quality and sediment quality information was collected at representative locations in the streams.

Nam Pangyun

The Nam Pangyun is the primary watercourse that drains the Bawdwin concession area, flowing in a southeasterly direction through the mine area to the confluence with Myitnge River. The Nam Pangyun is fed by two main perennial springs, initiating north of the Bawdwin open pit. These springs sustain flows during dry months. The elevation of the Nam Pangyun ranges from 1,400 m AMSL in the upper reaches of the catchment north of Bawdwin, to 560 m AMSL at the confluence with the Myitnge River downstream of Namtu.

Several first and second order streams drain the surrounding catchment and contribute flow to the Nam Pangyun. The Nam Pangyun Reservoir has been created at the headwaters of a tributary of the Nam Pangyun, north of the mine (

Plate 5.7). The reservoir and a pipeline to Bawdwin were established to provide water for historic mine activities. As the reservoir is positioned close to the catchment boundary with the Nam La and hence has a small catchment area, primarily receiving runoff during the wet season, water from the Nam La was historically pumped to the reservoir to maintain supply to the mining operation during the dry season. Seepage occurs from the reservoir, draining to the Nam Pangyun. This was observed at an approximate rate of 5 to 10 L/s during an inspection by KP in August 2018 (Knight Piésold, 2020).

Upper Catchment

Hydrology

The upper catchment of the Nam Pangyun stretches from the headwater springs to just upstream of the Bawdwin open pit. The headwaters are characterised by a clear, slow flowing stream fed by springs. The stream at site SWSP04 (Plate 5.8) had a flow rate of about 100 L/s when estimated in November 2018. SWNP01 is located within the Nam Pangyun reservoir. The upper catchment serves as one of the primary potable water supplies for the Bawdwin village with a water offtake point on the Nam Pangyun approximately halfway between SWNP01 and SWNP02, and a settling pond (SWPO01). The streambed in the upper Nam Pangyun is comprised primarily of boulders, cobbles and pebbles scattered with gravels and sands, resulting in cascading and turbulent flows. Two kilometres downstream at monitoring site SWNP02 (see Figure 5.22; Plate 5.9), the stream is incised in steep, rocky cliffs and has a variable depth, alternating between shallow flows and pool sections.

Water quality

Physico-chemical parameters and ions

Water quality monitoring between November 2018 and November 2019 showed that average turbidity in the upper catchment ranged between approximately 3.9 NTU at SWSP04 to approximately 55.2 NTU at SWNP02. Turbidity measurements at SWNP01 and SWNP02 exceeded the NDWQ aesthetic standards of 5 NTU at all monitoring events. Average concentrations of total suspended solids (TSS) increased from 2 mg/L at SWSP04 to 123 mg/L at SWNP02. TSS ranged from 3 to 12 mg/L at SWNP01 and from 3 to 620 mg/L at SWNP02. While variable, TSS results indicate that surface water in the upper Nam Pangyun catchment has low suspended solids, which reflects the limited urban development in the area and a general absence of historical mining activities in the upper catchment. The ranges of turbidity and TSS increased notably between sites SWSP04 and SWNP01 and the site closer to the open pit, SWNP02. This indicates that sediment runoff into the catchment increases from the headwaters to just upstream of the open pit and is likely associated with increased adjacent land disturbance, urban development, and increased traffic along the unsealed road that follows the path of the stream. Overall TSS and turbidity records were variable across the sampling period with no clear correlation with rainfall. The high intensity rainfall events experienced in the region and the steep topography, means that the catchment responds rapidly to rainfall, this is expected to result in a short time lag between rainfall and elevated TSS and turbidity due to sediment runoff.

The average pH measurements across the monitoring period at sites SWSP04 (pH 7.2), SWNP01 (pH 7.6) and SWNP02 (pH 6.5) were within the NDWQ aesthetic standard range of pH 6.5 to 8.5. The pH was outside the drinking water aesthetic standard range at SWSP04 in May (pH 5.9) and September 2019 (pH 6.1) and SWNP02 in January (pH 5.2), May (pH 5.8) and September 2019 (pH 6.5). There was a notable decrease in pH range between site SWNP01 (pH 6.5 to 8.4) and further downstream closer to the open pit at site SWNP02 (pH 5.2 to 7.2). Each month during the monitoring period, individual pH measurements were lower at SWNP02 than SWNP01 to a varying degree, with differences ranging from 0.05 to 2.7. This may indicate that impacts associated with historical mining activities (such as old Chinese workings and British exploration adits) or exposures of sulphide mineralogy could be generating acidic runoff that is influencing Nam Pangyun water pH some 700 m upstream of the open pit. Based on the data collected, there does not appear to be any strong correlation between the acidity and rainfall.

During the monitoring period, water hardness was below 18.5 mg/L in the upper catchment, below the 500 mg/L NDWQ standard. Electrical conductivity was typically low, with the maximum value of 85 µS/cm measured at site SWNP02. This is considerably lower than the NDWQ standard of 1,500 µS/cm. Average total dissolved solids (TDS) concentration ranged from 25 mg/L at SWNP01 to 148 mg/L at SWSP04, and the ranges increased between site SWNP01 (8 to 56 mg/L) and SWNP02 (40 to 72 mg/L). Total dissolved solids were below the 1,000 mg/L in the NDWQ standards, except for site SWSP04, which recorded a maximum TDS of 1,010 mg/L in March 2019. The increase in electrical conductivity and TDS between SWNP01 and SWNP02 correlates with an increase in ions and dissolved metals concentrations moving downstream, likely associated with historic mining at the open pit and mining waste rock and slag disposal in the area (see below).

Results for physico-chemical parameters are presented in Table 5.28. Values in bold indicate exceedance of the NDWQ standard.

Table 5.28 Physico-chemical parameters in the upper Nam Pangyun catchment

Parameter	NDWQ standard	SWSP04 Range (mean)	SWNP01 Range (mean)	SWNP02 Range (mean)
Turbidity (NTU)	5	1.2 – **8.1** (3.9)	**7.0 – 24 (11.0)**	**7.9 – 159.0 (55.2)**
pH	6.5 – 8.5	**5.9** – 8.0 (7.2)	6.5 – 8.4 (7.6)	**5.2** – 7.2 (6.5)
Total suspended solids (mg/L)	-	<1 – 4 (2*)	3 – 12 (8)	3 – 620 (123)
Hardness (mg/L)	500	1.0 – 2.2 (1.5)	2.9 – 4.3 (3.8)	7.6 – 18.5 (13.5)
Total dissolved solids (mg/L)	1,000	6 – **1,010** (148)	8 – 56 (25)	40 – 72 (54)
Electrical conductivity (µS/cm)	1,500	4 – 13 (7)	7 – 21 (11)	3 – 85 (59)

Values in bold indicate exceedance of the NDWQ standard.

*average has been calculated assuming <1 is a result of 0.

The ionic composition of surface water samples indicates that sodium and sulfate were the dominant ions in the upper catchment, reflecting the underlying mineralogy. Sodium concentrations range between less than 0.5L and 13.1 mg/L at SWNP01 and between 2.4 and 12.3 mg/L at SWNP02. Sulfate ranges from less than 2 to 33 mg/L at SWNP01, and from 6 to 38 mg/L at SWNP02. This composition is consistent with that of SWSP04, where sodium concentration ranges beween less than 0.5 and 17.2 mg/L and sulfate ranges between less than 2 and 442 mg/L. The upper catchment water composition is distinct from waters of the Nam La and Myitnge River catchments which have lower sulfate and higher bicarbonate concentrations (see Sections 5.2.2 and 5.2.3 for discussion of water quality for Nam La and Myitnge River, respectively).

Plate 5.7 Nam Pangyun Reservoir at site SWNP01

Plate 5.8 Headwaters of the upper Nam Pangyun at site SWSP04

Plate 5.9 Upper Nam Pangyun at site SWNP02

Nutrients and organics

Nitrate and nitrite concentrations were detected at levels below NDWQ health standards of 50 mg/L and 3 mg/L respectively. Nitrate ranged between less than 0.01 and 0.22 mg/L at SWSP04, less than 0.01 and 0.14 mg/L at SWNP01, and 0.20 and 0.44 mg/L at SWNP02. Nitrite ranged between less than 0.001 and 0.002 mg/L at SWSP04, less than 0.001 and 0.003 mg/L at SWNP01, and less than 0.001 and 0.012 mg/L at SWNP02.

No ammonia was detected during the monitoring period at any of the sites in the upper catchment, with the exception of 0.5 mg/L reported at SWNP02 in August 2019. This is lower than the 1.5 mg/L drinking water aesthetic standard.

Concentrations of organic contaminants (total petroleum hydrocarbons (TPHs), polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), monocyclic aromatic hydrocarbons (MAHs)), fungicides, herbicides and pesticides were below the limit of reporting at all sampling locations in the first round of monitoring in November 2018 and analysis for these contaminants were not continued in following rounds.

Metals and metalloids

The Bawdwin area has naturally high metal concentrations associated with regional minerology and also elevated concentrations of metals due to centuries of mining, ore processing and disposal of mine waste material. Given the potential for metals concentrations in the environment to be at levels of concern and for their potential to bioaccumulate, this section establishes the existing concentration ranges and averages of key potential metal toxicants.

As discussed in Section 5.2.3, Myanmar National Drinking Water Quality Standards and Australian and New Zealand water and sediment quality guidelines (ANZG, 2018) have been adopted. Comparison to these guidelines allows for understanding whether metals are elevated with respect to typical healthy aquatic ecosystems. The following discussion is focussed on parameters where there are exceedances to these guidelines.

At SWSP04, a spring feeding a tributary of the Nam Pangyun, total (unfiltered) concentrations of lead were consistently at least three times greater than the NDWQ health standard of 0.01 mg/L, ranging between 0.03 mg/L and 0.15 mg/L. Comparison between total and dissolved lead concentrations suggests that the source of lead is unlikely to be related to suspended particulate matter (such as from recent dust disposition), and may either reflect the natural quality of discharging spring water or may indicate the presence of unknown historical mining waste in the tributary catchment. At SWNP01, in the Nam Pangyun immediately downstream of the Nam Pangyun Reservoir, the total concentration of lead ranged between less than 0.006 mg/L and 0.028 mg/L. These concentrations were the lowest reported in the Nam Pang yun catchment and reflect the reduced impact of historical mining activities in the upper catchment, as well as the likely effects of periodically transferring water from the unimpacted Nam La to the reservoir. However, both the maximum lead concentration and the average concentration of 0.012 mg/L exceed the NDWQ health standards.

Maximum recorded total concentrations of manganese exceeded the drinking water health standard of 0.4 mg/L at SWNP01 (0.514 mg/L) and SWNP02 (1.050 mg/L). At SWNP02, the average concentration of manganese (0.448 mg/L) and all recorded concentrations of lead (ranging between 0.248 mg/L and 4.790 mg/L) exceeded drinking water standards for health.

At SWNP02, average total concentrations of aluminium (1.3 mg/L) and iron (2.3 mg/L) exceed the NDWQ aesthetic standards of 0.2 mg/L and 1.0 mg/L respectively. Table 5.29 presents the NDWQ standards and metal concentrations. Concentrations in bold indicate exceedance of the standard.

Table 5.29 Total metal concentrations (unfiltered) in upper Nam Pangyun catchment surface water, compared to NDWQ standards

	NDWQ standards	SWSP04 Range (mean)	SWNP01 Range (mean)	SWNP02 (Range (mean)
NDWQ Health Standards				
Antimony (mg/L)	0.02	<0.0050 - 0.0028 (0.0018)	<0.005	0.0023 - **0.0353** (0.0133)

	NDWQ standards	SWSP04 Range (mean)	SWNP01 Range (mean)	SWNP02 (Range (mean)
Arsenic (mg/L)	0.05	<0.0005 - 0.0017 (0.0004)	0.0011 - 0.0031 (0.0020)	<0.041 - 0.0498 (0.0154)
Barium (mg/L)	0.7	<0.02 - 0.02 (0.013)	<0.01 - 0.02 (0.01)	0.09 - 0.27 (0.16)
Cadmium (mg/L)	0.003	<0.0001 - 0.0010 (0.0004)	<0.0001 - 0.0005 (0.0001)	0.0017 - **0.0035** (0.0024)
Chromium (III+VI) (mg/L)	0.05	<0.001	<0.002	<0.001 - 0.009 (0.001)
Copper (mg/L)	2	<0.001 - 0.005 (0.0031)	0.002 - 0.020 (0.006)	0.248 - 0.979 (0.606)
Lead (mg/L)	0.01	**0.030 - 0.150 (0.072)**	<0.006 - **0.028 (0.012)**	**0.248 - 4.790 (1.800)**
Manganese (mg/L)	0.4	0.005 - 0.040 (0.017)	<0.095 - **0.514** (0.201)	0.097 - **1.050 (0.450)**
Mercury (mg/L)	0.001	<0.0001	<0.00005 - 0.00008 (0.00001)	<0.00005 - 0.00028 (0.00005)
Nickel (mg/L)	0.07	<0.001 - 0.002 (0.001)	<0.001	0.017 - 0.049 (0.033)
NDWQ Aesthetic Standards				
Aluminium (mg/L)	0.2	<0.02 - 0.10 (0.04)	<0.02 - 0.19 (0.06)	**<2.58 - 7.30 (1.30)**
Calcium (mg/L)	200	<0.5 - 0.7 (0.3)	0.6 – 1 (0.9)	2.2 - 5.4 (3.8)
Iron (mg/L)	1	<0.02 - 0.227 (0.056)	0.294 - **2.310** (0.794)	0.286 - **9.270 (2.339)**
Magnesium (mg/L)	150	<0.5 - 0.13 (0.09)	<0.5 - 0.40 (0.32)	0.48 - 1.20 (0.80)
Sodium (mg/L)	200	<0.5 - 17.2 (4.6)	<0.5 - 13.1 (4.7)	2.4 - 12.3 (6.3)
Zinc (mg/L)	3	0.11 - 0.27 (0.16)	<0.005 - 0.03 (0.02)	0.34 - 0.91 (0.56)

Values in bold indicate exceedance of the NDWQ standard. Measurements below detection limits were assumed to be zero for the purpose of calculating average concentrations

Throughout the monitoring period, average dissolved concentrations of cadmium, lead and zinc at SWSP04 exceeded ANZ guidelines. Samples from the Nam Pangyun reservoir (SWNP01) did not have any average dissolved concentrations exceeding ANZ guidelines, although the maximum concentrations of copper (0.002 mg/L) and zinc (0.015 mg/L) exceeded their respective ANZ guideline values of 0.0014 mg/L and 0.008 mg/L. No cadmium, cobalt, or nickel were detected, and lead was only detected in June 2019, at 0.003 mg/L, close to the DGV of 0.003 mg/L. Downstream at site SWNP02, all measurement events recorded concentrations of cadmium, cobalt, copper, lead, nickel, and zinc that exceeded ANZ guidelines. Cadmium concentrations ranged between 0.0014 mg/L and 0.0031 mg/L, which is above the ANZ guideline of 0.0002 mg/L.

Between sites SWNP01 and SWNP02, concentrations of dissolved metals generally increased, for example, dissolved lead concentrations at SWNP01 ranged from less than 0.001 to 0.003 mg/L, and SWNP02 from 0.053 to 0.402 mg/L. The measurements at SWNP02 are significantly greater than the ANZ guideline value of 0.0034 mg/L. Table 5.30 presents the ANZ DGVs and metal concentrations. Concentrations in bold indicate exceedance of the standard.

The increase in total and dissolved metal concentrations in waters between SWNP01 and SWNP02 could be due to the influence of historic mine workings and associated mobilisation of metals.

Table 5.30 Dissolved metal concentrations in upper Nam Pangyun catchment surface water, compared to ANZ DGVs

	ANZ DGV	SWSP04 Range (mean)	SWNP01 Range (mean)	SWNP02 Range (mean)
Aluminium (mg/L)	0.055*	<0.01 - **0.08** (0.011)	<0.05	<0.01 - 0.04 (0.013)
Antimony (mg/L)	0.009	<0.005 - 0.0027 (0.0015)	<0.005	0.0020 - 0.0052 (0.0040)

	ANZ DGV	SWSP04 Range (mean)	SWNP01 Range (mean)	SWNP02 Range (mean)
Arsenic (mg/L)	0.013**	<0.0005 - 0.0014 (0.0002)	<0.0005 - 0.0015 (0.0007)	<0.0005 - 0.0047 (0.0012)
Cadmium (mg/L)	0.0002	<0.0001 - **0.0003** (**0.0002**)	<0.0002	**0.0014 - 0.0031 (0.0021)**
Cobalt (mg/L)	0.0014	<0.001	<0.001	**0.022 - 0.048 (0.036)**
Copper (mg/L)	0.0014	<0.001 - **0.003** (0.0013)	<0.001 - **0.002** (0.0013)	**0.141 - 0.407 (0.2282)**
Lead (mg/L)	0.0034	**0.020 - 0.086 (0.042)**	<0.001 - 0.003 (0.0004)	**0.053 - 0.402 (0.1825)**
Manganese (mg/L)	1.9	0.003 - 0.021 (0.008)	<0.001 - 0.134 (0.022)	0.086 - 0.934 (0.315)
Nickel (mg/L)	0.011	<0.001 - 0.002 (<0.001)	<0.001	**0.019 - 0.037 (0.028)**
Zinc (mg/L)	0.008	**0.108 - 0.160 (0.124)**	<0.005 - **0.015** (0.007)	**0.270 - 0.547 (0.408)**

<LOD = below the limit of detection

Values in bold indicate exceedance of the ANZ DGV standard. Measurements below detection limits were assumed to be zero for the purpose of calculating average concentrations

*Guideline is 0.055 mg/L where pH is >6.5, 0.0008 where pH is <6.5. However, as the sites had average pHs of >6.5 over the monitoring period, the 0.055 mg/L guideline value was adopted.

** Guideline is 0.013 mg/L for As(V) and 0.024 mg/L for As(III). In the absence of knowledge of arsenic speciation in the waters, the more conservative guideline value for As(V) has been adopted.

Sediment quality

Stream sediment sample sites S2 and S3 are located upstream of the Bawdwin open pit in the headwaters of the Nam Pangyun (see Figure 5.22). Site S2 comprised fine to coarse dark brown sand with minor silt; while site S3 comprised fine dark brown silty sand. The stream sediment samples from the upper catchment had lower concentrations of metals than samples from the mid and lower catchments. Site S3 is the only site to not have any total recoverable hydrocarbons (TRH) reported. Concentrations of lead at S3 and concentrations of lead, silver and zinc at S2 were above the ANZ sediment quality GV-high (Table 5.31). This indicates that metal concentrations are elevated in these sediments and are likely to have associated toxicity to benthic biota. Antimony, arsenic, copper, mercury and nickel exceeded the DGV at site S2 and antimony exceeded the DGV at site S3, indicating these metals may have some toxic effects to benthic biota.

Table 5.31 Toxicant concentrations of stream sediment in the upper Nam Pangyun catchment

Metal	ANZ DGV	ANZ GV-High	Site S2	Site S3
Antimony (mg/kg)	2.0	25	**19.4**	**4.3**
Arsenic (mg/kg)	20	70	**58**	9
Cadmium (mg/kg)	1.5	10	0.43	0.28
Chromium (mg/kg)	80	370	23	15
Copper (mg/kg)	65	270	**107**	45
Lead (mg/kg)	50	220	**3,770**	**827**
Mercury (mg/kg)	0.15	1.5	**0.28**	0.04
Nickel (mg/kg)	21	52	**23**	6
Silver (mg/kg)	1.0	4.0	**6.16**	0.63
Zinc (mg/kg)	200	410	**1,380**	185
PAHs (mg/kg)	10	50	<0.01	<0.01
Total hydrocarbons* (mg/kg)	280	550	<10	20

Bold indicates concentration exceeding DGV. Shading indicates concentration exceeding GV-high.

* Results are for total recoverable hydrocarbons and the ANZ guideline is for total petroleum hydrocarbons, however the comparison is made for indicative purposes

Mid catchment

Hydrology

The mid catchment of the Nam Pangyun stretches from the Bawdwin open pit to just upstream of where the discharge from the Tiger Tunnel enters the stream (see Figure 5.22). Within this section of the catchment the Nam Pangyun flows through the highly disturbed and developed lower Bawdwin villages where the stream banks are, in places, bound by engineered embankments, waste rock fill, and other highly altered landforms. The Nam Pangyun is was observed as the central waste disposal site for residents of the Bawdwin village and included communal drop toilets positioned over the stream, and commonly observed disposal of buckets of domestic waste, soil and inert waste tipped into the stream. Extensive domestic waste and rubbish was observed throughout the mid-catchment, including at site SWNP03 (

Plate 5.10).

The streambed is characteristic of a highly disturbed system, as well as a high-energy system, with a variable mix of substrate, from boulders to silt. The random sorting of substrate is reflective of the long running disposal of waste rock material and erosion in the catchment. The catchment morphology changes south of the football field (SWNP03a) and is generally characterised by a steep-walled 'slot canyon'. Site SWNP04, three kilometres downstream of the Bawdwin open pit is in a highly meandering section of the stream in a narrow, steep valley (

Plate 5.11). The stream had a flow rate of about 400 L/s at site SWNP04 and 700 L/s at site SWNP06 when estimated in November 2018. Flow velocity is expected to be much higher during wet months and during high rainfall events, when large rock boulders falling from the cliff face are commonly reported to be transported downstream. SWER01 and SWER02 are located in ER valley, a tributary valley that has historically received waste rock from previous open cut mining activities. ER valley stream joins the Nam Pangyun in the mid catchment. The ER valley stream had a flow rate about 7 L/s at SWER02 when estimated in November 2018 and is also expected to experience much higher flows during rainfall events, evidenced by the former railway bridge that spanned the lower ER valley which was washed out.

Estimates by CSA Global of flow rate calculated using the float method ranged from 30L/s to 280 L/s at PS01 located on the Nam Pangyun, adjacent to the mine pit (Appendix B). There was a high correlation between the float method and automatic stream gauge. High flow rates generally occur as a response to heavy rainfall events (

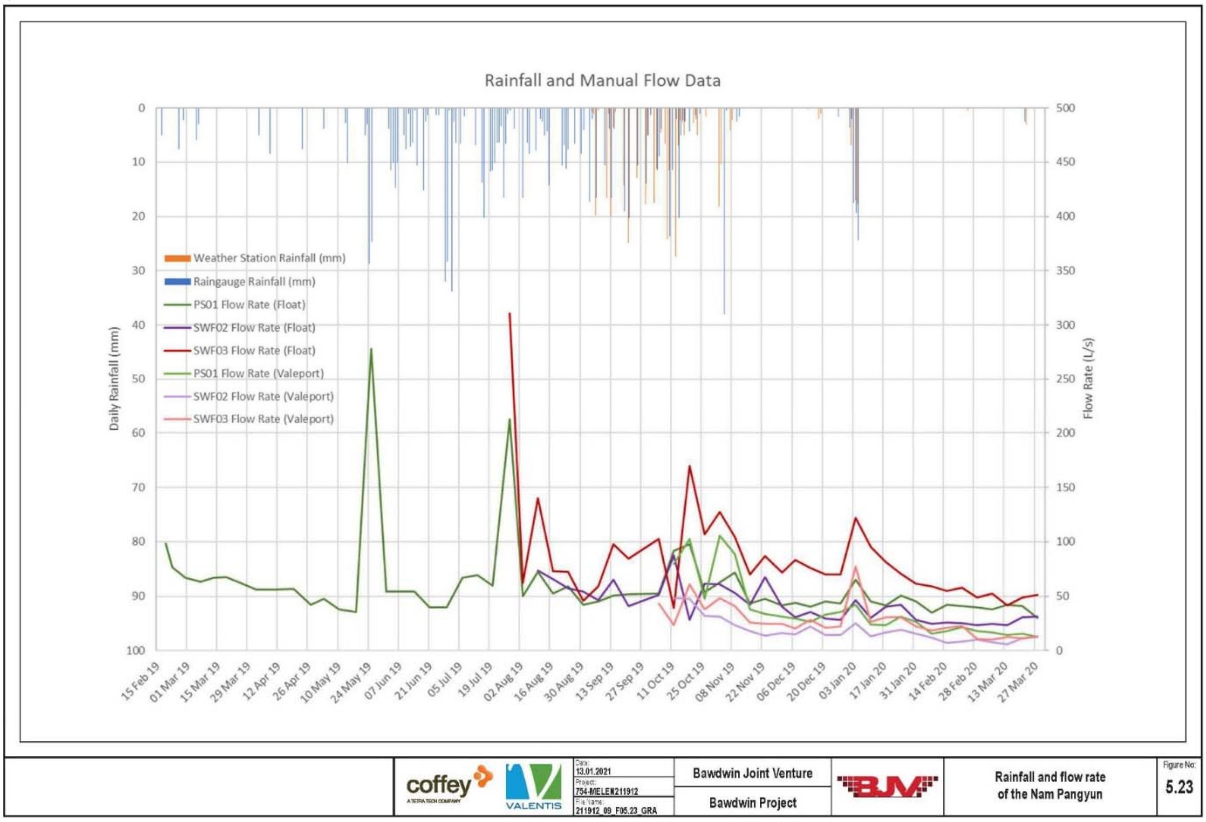


Figure 5.23). High flow rates following periods of rainfall are to be expected given the steepness of terrain and the limited vegetation the Nam Pangyun catchment resulting in limited infiltration.

Water quality

Physico-chemical parameters and ions

Average turbidity ranged from 14.2 NTU at site SWNP02A, to 20.9 NTU at SWNP03A, increasing downstream to 187.9 NTU at SWNP05. Average turbidity values at all sites in the mid catchment (SWNP02A – SWNP05) exceed NDWQ aesthetic standard of 5 NTU, however there were notable fluctuations in turbidity at each site. Table 5.32 indicates turbidity ranged between 6.0 NTU and 24.3 NTU at site SWNP02A and between 1.2 NTU and 266.0 NTU at SWNP04.

Average concentrations of total suspended solids increased downstream, ranging from 11 mg/L at SWNP02A to 261 mg/L at SWNP05. The ranges of TSS concentrations increases further downstream. At SWNP02A TSS ranged from 2 to 36 mg/L, whereas downstream at SWNP05 TSS ranged between 2 and 1,740 mg/L. The exception to the increasing trend in TSS is site SWNP03, which recorded concentrations ranging between 8 and 360 mg/L, averaging 86 mg/L. Between the upper catchment at site SWNP02 (upstream of mine pit) and the mid catchment at site SWNP02A (downstream of mine pit), average TSS concentrations decreased from 123 to 11 mg/L, possibly indicating dilution or sediment settling.

All sites in the Nam Pangyun mid catchment recorded an average pH between 6.5 and 7.3, within the NDWQ aesthetic standard range of 6.5 to 8.5, with the exception of SWNP03, which averaged a pH of 6.4. Several sites recorded pH levels below the NDWQ aesthetic standard, SWNP03 had below standard readings in January (pH 5.5), April (pH 6.2), May (pH 6.1) and September (pH 6.1); SWNP04 had a below standard reading in May (pH 6.3); and SWNP02A (pH 6.3 to 6.4), SWNP02B (pH 6.1 to 6.2) and SWNP03A (pH 5.9 to 6.3) had below standard readings in April, May and September. Overall, the pH remained fairly constant through the mid catchment and was slightly more acidic than the pH of the upper catchment (average pH ranging between 6.6 and 7.6).

Water hardness was below the NDWQ standard of 500 mg/L at all monitoring events in the mid catchment. Average hardness ranged from 13.2 mg/L at SWNP02A to 18.1 mg/L at SWNP04, with a slight increasing trend downstream. Electrical conductivity was below the NDWQ standard of 1,500 µS/cm at all monitoring events. This followed a similar increasing trend, with average EC of 60 µS/cm at SWNP02A increasing to 99 µS/cm at SWNP04. Both average hardness and EC lowered slightly between SWNP04 and SWNP05. The highest recorded measurements of hardness (27.4 mg/L) and EC (216 µS/cm) in the mid catchment were recorded at SWNP04. Total dissolved solids (TDS) were below 110 mg/L, below the 1,000 mg/L NDWQ standard. Average TDS ranged between 59 mg/L at SWNP01 and 67 mg/L at SWNP03 and SWNP05.

In ER Valley, turbidity ranged between 0 NTU to over 1,100 NTU at SWER01 and between 0 NTU and 151 NTU at SWER02. Average turbidity at SWER01 and SWER02 (163.3 NTU and 32.3 NTU, respectively) were above the 5 NTU NDWQ standard. Total suspended solids ranged between less than 1 and 4,410 mg/L at SWER01 and less than 1 and 102 mg/L at SWER02. Both turbidity and TSS at SWER01 were greater at SWER01 than the majority of sites in the section of Nam Pangyun in the mid catchment. This is expected to be due to the influence of the waste rock that has been historically dumped in ER Valley. The pH of samples from SWER02 were more acidic than those in the rest of the mid catchment, with the lowest measurement of 4.9 and average of 6.2 both below the NDWQ limit. This is also consistent with extensive waste rock disposal to the head of the ER valley. Hardness, EC and TDS were all below the NDWQ standards at both sites in ER Valley.

Results for physico-chemical parameters are displayed in Table 5.32.

Table 5.32 Physico-chemical parameters in the mid Nam Pangyun catchment

	NDWQ standard	**SWNP02A Range (mean)**	**SWNP02B Range (mean)**	**SWNP03 Range (mean)**	**SWNP03A Range (mean)**	**SWNP04 Range (mean)**	**SWNP05 Range (mean)**	**SWER01 Range (mean)**	**SWER02 Range (mean)**
Turbidity (NTU)	5	**6.0 – 24.3 (14.2)**	**7.9 – 30.1 (13.4)**	**7.4 – 29.3 (14.4)**	1.7 – **69.8 (20.9)**	1.2 – **266.0 (65.8)**	3.1 – **>1,100 (187.9**)**	0 – **>1,100 (163.3**)**	0 – **151.0 (32.3)**
pH	6.5 – 8.5	**6.3** – 7.7 (6.9)	**6.1** – 7.5 (6.8)	**5.5** – 7.1 (**6.4**)	**5.9** – 7.7 (6.7)	**6.3** – 7.9 (7.3)	6.7 – 7.5 (7.2)	**6.3** – 7.6 (6.9)	**4.9** – 7.2 (**6.2**)
TSS (mg/L)		2 – 36 (11)	7 – 70 (27)	8 – 360 (86)	2 – 93 (33)	5 - 230 (43)	2 – 1,740 (261)	<1 – 4,410 (560*)	<1 – 102 (22*)
Hardness (mg/L)	500	10.6 – 16.2 (13.2)	11.6 – 17.2 (14.4)	9.7 – 18.2 (13.8)	12.9 – 19.9 (16.4)	12.6 – 27.4 (18.1)	12.5 – 20.9 (17.5)	4.1 – 7.3 (6.0)	5.3 – 14.5 (9.3)
TDS (mg/L)	1,000	42 – 110 (59)	34 – 88 (65)	40 – 106 (60)	50 – 100 (67)	48 – 92 (66)	48 – 94 (67)	18 – 86 (44)	30 – 75 (48)
EC (µS/cm)	1,500	46 – 76 (60)	46 – 88 (69)	45 – 90 (71)	61 – 97 (79)	50 – 216 (99)	50 – 158 (86)	28 – 49 (40)	37 – 103 (68)

Values in bold indicate exceedance of the NDWQ standard.

*average has been calculated assuming <1 is a result of 0.

** average has been calculated assuming >1,100 is a result of 1,100.

The ionic composition of surface water samples in the mid catchment is consistent with the upper catchment, dominant in sodium and sulfate ions. Average sulfate concentration ranges between 20 mg/L at SWNP02A and 28 mg/L at SWNP05. Average sodium concentrations in the section of the Nam Pangyun in the mid catchment range between 6.6 and 8.2 mg/L. The concentrations of ions were consistent between the ER Valley and the mid Nam Pangyun catchment, with the exception of average sodium concentrations at SWER02 (1.5 mg/L).

Nutrients and organics

Nitrogen species (nitrate, nitrite and ammonia) and sulfate were detected at concentrations below their respective NDWQ standards of 50 mg/L, 3 mg/L, 1.5 mg/L and 250 mg/L. The highest concentrations of nitrates in the Nam Pangyun catchment were recorded in the mid catchment, downstream of Bawdwin at SWNP03 (0.5 mg/L), SWNP03A (0.5 mg/L) and SWNP05 (0.7 mg/L). This is likely result of untreated sewage from nearby villages in the catchment entering the watercourse.

Concentrations of organic contaminants (total petroleum hydrocarbons (TPHs), polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), monocyclic aromatic hydrocarbons (MAHs)), fungicides, herbicides and pesticides were below the limit of reporting at all sampling locations in the first round of monitoring in November 2018 and were not continued in following rounds.

Metals and metalloids

All recorded measurements of total cadmium and lead concentrations between sites SWNP02A and SWNP05 (

Plate 5.12) exceeded the NDWQ health standards of 0.003 mg/L and 0.01 mg/L respectively. The lowest recorded total concentration of lead in the mid catchment was 0.487 mg/L at SWNP02B, an order of magnitude greater than the standard, whereas the greatest value was 10.500 mg/L at SWNP05, three orders of magnitude greater than the standard. Other metals with average total concentrations exceeding NDWQ health standards were arsenic (0.0718 mg/L at SWNP05) and manganese (0.405 mg/L at SWNP02B, 0.412 mg/L at SWNP03, 0.420 mg/L at SWNP03A, 0.442 mg/L at SWNP04 and 0.464 mg/L at SWNP05). Average total concentrations of aluminium and iron exceeded their respective NDWQ aesthetic standards of 0.2 mg/L and 1 mg/L at all sites between SWNP02B and SWNP05.

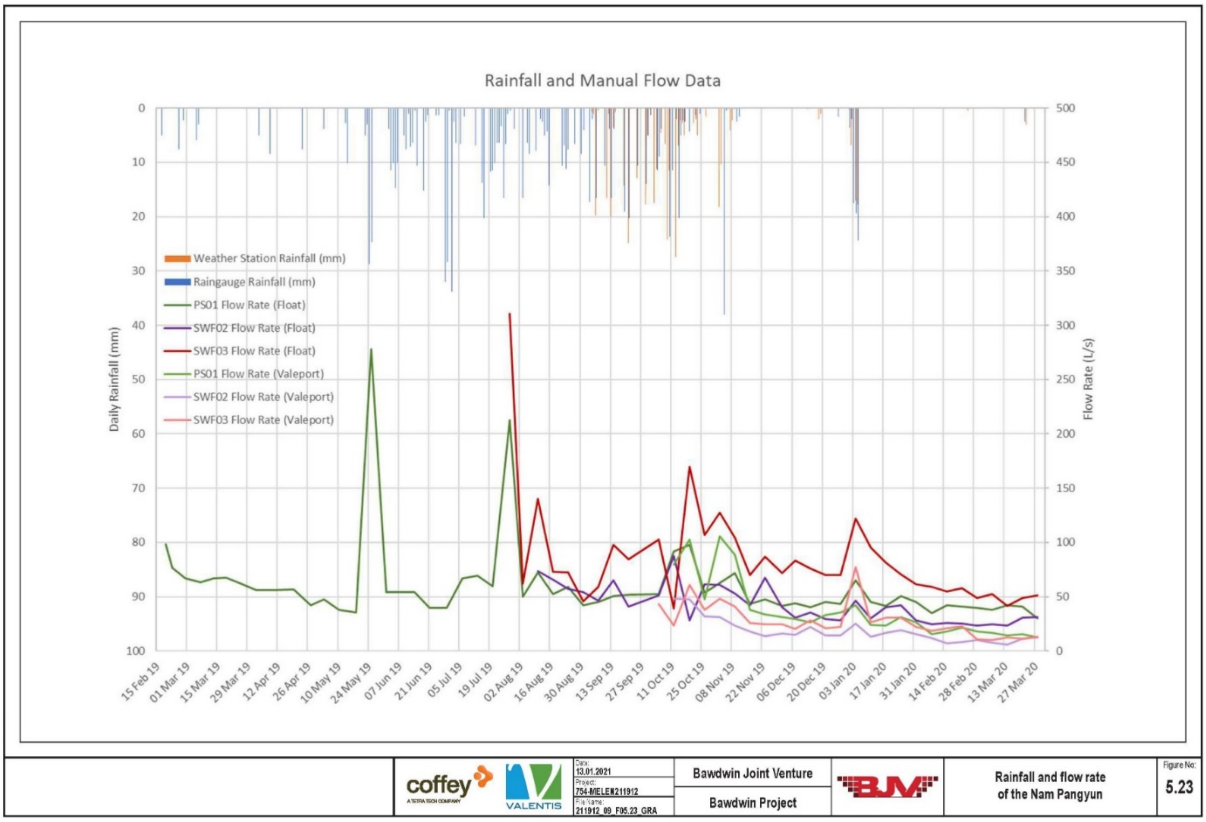


Figure 5.23 Bawdwin rainfall and Nam Pangyun flow rate

Plate 5.10 **SWNP03 in the mid Nam Pangyun with the spoil dump visible in the left of image and rubbish visible in the river**

Plate 5.11 **Site SWNP04 in the mid Nam Pangyun. Note the poorly sorted matrix of material deposited on the right-hand side of the image**

Plate 5.12 **Lower Nam Pangyun catchment at site SWNP05**

Maximum total concentrations of antimony slightly exceeded NDWQ standards of 0.02 mg/L at SWNP03 (0.0237 mg/L), SWNP04 (0.0201 mg/L) and SWNP05 (0.0334 mg/L). Average total concentrations of antimony at these sites were well below the NDWQ standards, at 0.0091 mg/L, 0.0080 mg/L and 0.0090 mg/L respectively.

The total concentration of barium exceeded the NDWQ standard of 0.7 mg/L on one occasion in the mid catchment, with a measurement of 1.18 mg/L recorded at SWNP05 in August 2019. Similarly, the total concentration of nickel and zinc both exceeded their respective NDWQ standards of 0.07 mg/L and 3.0 mg/L on one occasion, with nickel reaching 0.10 mg/L and zinc reaching 3.63 mg/L at SWNP04 in August 2019.

Table 5.33 presents the NDWQ standards and total metal concentrations. Concentrations in bold indicate exceedance of the standard.

Average dissolved metal concentrations of aluminium, antimony, arsenic and manganese were below ANZ guidelines in the mid catchment. All recorded measurements of dissolved cadmium, cobalt, copper, lead, nickel and zinc exceeded ANZ guidelines with the exception of nickel in February 2019 at SWNP02A measured at 0.009 mg/L. Average concentrations of dissolved copper were an order of magnitude greater than the ANZ guideline value of 0.0014 mg/L, ranging from 0.0496 to 0.0740 mg/L.

Average dissolved cadmium concentrations were an order of magnitude greater than the ANZ guideline of 0.0002 mg/L, increasing downstream from 0.0033 mg/L at SWNP02 to 0.0096 mg/L at SWNP05. Average dissolved cobalt concentrations showed a similar trend, exceeding the ANZ guideline of 0.0014 mg/L by an order of magnitude, increasing from 0.018 mg/L at SWNP02 to 0.038 mg/L at SWNP05.

All recorded concentrations of dissolved lead were at least an order of magnitude greater than the ANZ standard of 0.0034 mg/L, with the lowest recorded value of 0.035 mg/L at SWNP02B. Average concentrations of lead were two orders of magnitude greater than the DGV, ranging between 0.102 mg/L and 0.597 mg/L. Similarly, all recorded concentrations of zinc were at least two orders of magnitude greater than the ANZ guideline value of 0.008 mg/L, with average concentrations up to three orders of magnitude greater, ranging between 0.578 and 1.567 mg/L.

Table 5.45 presents the ANZ guidelines and dissolved metal concentrations. Concentrations in bold indicate exceedance of the DGV.

The elevated metal concentrations in the mid catchment indicate a highly impacted section of the stream. Total concentrations of metals generally increased downstream within the mid catchment and between the upper and mid catchments. For example, total cadmium concentrations increased from 0.0043 mg/L at SWNP02A to 0.0110 mg/L at SWNP05. In comparison, the average concentration of cadmium in the upper catchment ranged between 0.0004 and 0.0024 mg/L.

Waste rock from historical mining of the Bawdwin pit was disposed in ER Valley, causing surface water in this area to have elevated concentrations of metals. Average concentrations of aluminium, arsenic, cadmium, iron, and lead exceeded NDWQ standards at SWER01, and cadmium and lead at SWER02. All dissolved concentrations of cadmium, cobalt, copper, lead, and zinc exceeded ANZ standards at SWER01 and SWER02. Average concentrations of nickel exceeded the ANZ standards at SWER01 and SWER02.

Table 5.33 Total (unfiltered) metal concentrations in mid Nam Pangyun catchment surface water, compared to NDWQ standards.

	NDWQ standard	SWNP02A Range (mean)	SWNP02B Range (mean)	SWNP03 Range (mean)	SWNP03A Range (mean)	SWNP04 Range (mean)	SWNP05 Range (mean)	SWER01 Range (mean)	SWER02 Range (mean)
NDWQ Health Standards									
Antimony (mg/L)	0.02	0.0034 - 0.0074 (0.0053)	0.0032 - 0.0160 (0.0073)	0.0028 - **0.0237** (0.0091)	0.0025 - 0.0138 (0.0083)	0.0024 - **0.0201** (0.0080)	0.0022 - **0.0334** (0.0090)	<0.0005 - **0.0570** (0.0080)	<0.0005 - 0.0151 (0.0039)
Arsenic (mg/L)	0.05	0.0055 - 0.0175 (0.0096)	0.0055 - **0.0520** (0.0207)	0.0064 - **0.0770** (0.0257)	0.0038 - 0.0415 (0.0209)	0.0029 - **0.1090** (0.0244)	0.0022 - **0.4450 (0.0718)**	0.0022 - **0.9080 (0.1180)**	<0.0005 - **0.0641** (0.0180)
Barium (mg/L)	0.7	0.10 - 0.17 (0.13)	0.09 - 0.30 (0.17)	0.11 - 0.47 (0.20)	0.10 - 0.27 (0.18)	0.09 - 0.64 (0.21)	0.11 - **1.18** (0.30)	0.08 - **2.76** (0.45)	0.07 - 0.24 (0.13)
Cadmium (mg/L)	0.003	**0.0032 - 0.0059 (0.0043)**	**0.0045 - 0.0178 (0.0074)**	**0.0050 - 0.0098 (0.0065)**	**0.0058 - 0.0107 (0.0079)**	**0.0052 - 0.0224 (0.0100)**	**0.0073 - 0.0135 (0.0106)**	0.0014 - **0.0279 (0.0137)**	0.0029 - **0.0357 (0.0179)**
Chromium (III+VI) (mg/L)	0.05	<0.003	<0.001 - 0.002 (<0.001)	<0.001 - 0.008 (0.001)	<0.001	<0.001	<0.001	<0.001 - 0.011 (0.002)	<0.001 - 0.002 (<0.001)
Copper (mg/L)	2	0.060 - 0.186 (0.132)	0.092 - 0.184 (0.139)	0.073 - 0.484 (0.228)	0.107 - 0.172 (0.136)	0.074 - 0.347 (0.149)	0.079 - 0.570 (0.162)	0.047 - 1.300 (0.255)	0.005 - 0.295 (0.146)
Lead (mg/L)	0.01	**0.515 - 1.070 (0.761)**	**0.487 - 2.530 (1.117)**	**0.595 - 4.430 (1.558)**	**0.654 - 2.340 (1.440)**	**0.503 - 2.880 (1.178)**	**0.731 - 10.5 (2.495)**	**0.255 - 24.4 (3.995)**	**0.052 – 11.0 (4.071)**
Manganese (mg/L)	0.4	0.148 - **0.827** (0.330)	0.199 - **0.984 (0.405)**	0.176 - **0.980 (0.412)**	0.196 - **0.911 (0.420)**	0.202 - **0.928 (0.442)**	0.190 - **1.01 (0.464)**	0.028 - **1.790** (0.279)	0.010 - 0.233 (0.081)
Mercury (mg/L)	0.001	<0.00005 - 0.00007 (0.00001)	<0.00005 - 0.00008 (0.00001)	<0.00005 - 0.00022 (0.00006)	<0.00005 - 0.00009 (0.00004)	<0.00005 - 0.00026 (0.00004)	<0.00005 - **0.00121** (0.00017)	<0.00005	<0.00005 - 0.00060 (0.00009)
Nickel (mg/L)	0.07	0.019 - 0.023 (0.021)	0.025 - 0.033 (0.030)	0.027 - 0.041 (0.035)	0.034 - 0.042 (0.038)	0.031 - **0.101** (0.048)	0.038 - 0.058 (0.046)	0.032 - **0.103** (0.055)	0.033 - **0.107** (0.065)
NDWQ Aesthetic Standards									
Aluminium (mg/L)	0.2	<0.13 - **0.25** (0.11)	<0.14 - **0.64 (0.20)**	<0.07 - **5.69 (1.06)**	<0.05 - **0.57 (0.21)**	<0.04 - **1.55 (0.29)**	<0.04 - **9.32 (1.41)**	<0.01 - **20.90 (2.69)**	<0.01 - **0.97** (0.17)
Calcium (mg/L)	200	3.1 - 4.5 (3.8)	3.4 - 4.9 (4.1)	2.8 – 5.0 (3.8)	3.7 - 5.4 (4.6)	3.5 - 5.5 (4.6)	3.5 - 5.7 (4.7)	1.1 - 1.9 (1.7)	1.4 - 3.3 (2.1)
Iron	1	0.388 - **1.410** (0.662)	0.423 - **2.620 (1.041)**	<0.598 - **6.590 (1.910)**	0.298 - **2.170** (0.980)	0.214 - **2.630** (0.849)	0.162 - **10.7 (1.908)**	0.058 - **26.1 (3.391)**	0.022 - **1.390** (0.290)

	NDWQ standard	SWNP02A Range (mean)	SWNP02B Range (mean)	SWNP03 Range (mean)	SWNP03A Range (mean)	SWNP04 Range (mean)	SWNP05 Range (mean)	SWER01 Range (mean)	SWER02 Range (mean)
(mg/L)									
Magnesium (mg/L)	150	0.69 - 0.97 (0.81)	0.78 - 1.11 (0.91)	0.62 - 1.09 (0.85)	0.89 - 1.29 (1.08)	0.92 - 1.43 (1.22)	0.93 - 1.60 (1.30)	0.36 - 0.61 (0.51)	0.42 - 1.10 (0.69)
Sodium (mg/L)	200	1.9 - 26.5 (8.2)	2.2 - 14.9 (7.9)	2.5 - 18.2 (7.4)	2.4 - 18.7 (7.6)	2.2 – 13.0 (6.6)	2.1 - 14.3 (7.2)	0.2 - 15.8 (5.7)	<0.5 - 6.7 (1.5)
Zinc (mg/L)	3	0.56 - 0.89 (0.72)	0.94 - 1.67 (1.16)	1.03 - 1.58 (1.27)	1.18 - 1.94 (1.55)	0.97 - **3.63** (1.76)	1.12 - 2.50 (1.80)	0.13 - 2.72 (1.52)	0.30 - **5.53** (2.49)

Values in bold indicate exceedance of the NDWQ standard. Measurements below detection limits were assumed to be zero for the purpose of calculating average concentrations.

<xx = below limit of detection

Table 5.34 Dissolved metal concentrations in mid Nam Pangyun catchment surface water, compared to ANZ DGVs

	ANZ DGV	SWNP02A Range (mean)	SWNP02B Range (mean)	SWNP03 Range (mean)	SWNP03A Range (mean)	SWNP04 Range (mean)	SWNP05 Range (mean)	SWER01 Range (mean)	SWER02 Range (mean)
Aluminium (mg/L)	0.055*	<0.01	<0.01	<0.01 - 0.04 (0.007)	<0.01	<0.01	<0.01	<0.01 - **0.10** (0.017)	<0.01 - 0.04 (0.008)
Antimony (mg/L)	0.009	0.0022 - 0.0043 (0.0037)	0.0023 - 0.0062 (0.0042)	0.0015 - 0.0079 (0.0045)	0.0021 - 0.0069 (0.0044)	0.0017 - 0.0054 (0.0037)	0.0018 - 0.0045 (0.0033)	<0.0005 - 0.0010 (0.0005)	<0.0005 - 0.0027 (0.0009)
Arsenic (mg/L)	0.013**	<0.0005 - 0.0026 (0.0016)	0.001 - 0.0041 (0.0023)	0.0007 - 0.0036 (0.0019)	0.0007 - 0.0040 (0.0017)	<0.0005 - 0.0038 (0.0012)	<0.0005 - 0.0025 (0.0009)	<0.0005 - 0.0040 (0.0009)	<0.001 - 0.0085 (0.0032)
Cadmium (mg/L)	0.0002	**0.0023 - 0.0040 (0.0033)**	**0.0041 - 0.0065 (0.0052)**	**0.0049 - 0.0079 (0.0058)**	**0.0056 - 0.0084 (0.0069)**	**0.0052 - 0.0107 (0.0076)**	**0.0070 - 0.0126 (0.0096)**	**0.0013 - 0.0162 (0.0123)**	**0.0028 - 0.0210 (0.0112)**
Cobalt (mg/L)	0.0014	**0.010 - 0.025 (0.018)**	**0.024 - 0.031 (0.027)**	**0.024 - 0.035 (0.030)**	**0.028 - 0.038 (0.033)**	**0.025 - 0.039 (0.034)**	**0.032 - 0.046 (0.038)**	**0.031 - 0.041 (0.037)**	**0.026 - 0.051 (0.036)**
Copper (mg/L)	0.0014	**0.027 - 0.111 (0.0596)**	**0.032 - 0.079 (0.0496)**	**0.037 - 0.211 (0.0740)**	**0.031 - 0.077 (0.0596)**	**0.022 - 0.130 (0.0593)**	**0.018 - 0.120 (0.0595)**	**0.035 - 0.141 (0.0918)**	**0.003 - 0.140 (0.0666)**
Lead (mg/L)	0.0034	**0.092 - 0.246 (0.148)**	**0.035 - 0.249 (0.102)**	**0.060 - 0.402 (0.163)**	**0.221 - 0.464 (0.349)**	**0.174 - 0.404 (0.294)**	**0.365 - 0.775 (0.596)**	**0.146 - 1.570 (0.918)**	**0.030 - 2.790 (1.1488)**
Manganese (mg/L)	1.9	0.093 - 0.800 (0.284)	0.160 - 0.761 (0.315)	0.097 - 0.711 (0.284)	0.166 - 0.835 (0.350)	0.172 - 0.883 (0.344)	0.169 - 0.892 (0.336)	0.027 - 0.140 (0.072)	0.047 - 0.178 (0.094)
Nickel (mg/L)	0.011	0.009 - **0.023 (0.018)**	**0.026 - 0.029 (0.028)**	**0.026 - 0.037 (0.031)**	**0.033 - 0.043 (0.037)**	**0.029 - 0.043 (0.037)**	**0.037 - 0.050 (0.042)**	<0.001 - **0.055 (0.047)**	**0.031 - 0.071 (0.046)**
Zinc (mg/L)	0.008	**0.409 - 0.728 (0.578)**	**0.913 - 1.130 (0.975)**	**1.020 - 1.200 (1.088)**	**1.120 - 1.610 (1.342)**	**0.950 - 1.800 (1.380)**	**1.100 - 2.090 (1.567)**	**0.116 - 1.930 (1.409)**	**0.249 - 2.900 (1.335)**

Values in bold indicate exceedance of the standard. Measurements below detection limits were assumed to be zero for the purpose of calculating average concentrations
< = below limit of detection

* Guideline is 0.055 mg/L where pH is >6.5, 0.0008 where pH is <6.5. However, as the sites had average pHs of >6.5 over the monitoring period, the 0.055 mg/L guideline value was adopted.

** Guideline is 0.013 mg/L for As(V) and 0.024 mg/L for As(III). In the absence of knowledge of arsenic speciation in the waters, the more conservative guideline value for As(V) has been adopted.

Sediment quality

Site S1, located downstream of the concentrator, comprised fine to medium light brown sand. Site S1 had the highest concentrations of, antimony, arsenic, cadmium, copper, lead and silver measured in the Nam Pangyun catchment (S1 – S6). Concentrations of antimony, arsenic, copper, lead, mercury, silver and zinc exceed their respective ANZ GV-high. Concentrations of cadmium and nickel exceed the ANZ DGV. S1 is the only stream sediment sample in the Nam Pangyun catchment with PAHs detected, with 0.19 mg/kg recorded, well below the ANZ DGV of 10 mg/kg.

Site S4 is located in ER Valley, a tributary in the mid Nam Pangyun catchment where waste rock disposal occurred in the past. This sample comprised coarse yellowish light brown sand with minor silt and gravel. Concentrations of arsenic, antimony, lead, mercury and silver in stream sediments at S1 and S4 exceed GV-high for sediment quality. Concentrations of copper exceeded the ANZ DGV of 65 mg/kg at both sites.

Metal concentrations and adopted guideline values are outlined in Table 5.35. In the table, bold indicates concentration exceeding the DGV and shading indicates concentrations exceeding GV-high.

Table 5.35 Metal and hydrocarbon concentrations of stream sediment in the mid Nam Pangyun catchment

Metal	ANZ DGV	ANZ GV-High	S1	S4
Antimony (mg/kg)	2.0	25	**34.1**	**26.7**
Arsenic (mg/kg)	20	70	**416**	**297**
Cadmium (mg/kg)	1.5	10	**2.3**	0.6
Chromium (mg/kg)	80	370	19	11
Copper (mg/kg)	65	270	**721**	**207**
Lead (mg/kg)	50	220	**>5,000**	**3,140**
Mercury (mg/kg)	0.15	1.0	**1.9**	**2.5**
Nickel (mg/kg)	21	52	**31**	17
Silver (mg/kg)	1.0	4.0	**21.1**	**14.0**
Zinc (mg/kg)	200	410	**1,200**	193
PAHs (mg/kg)	10	50	0.19	<0.01
Total hydrocarbons* (mg/kg)	280	550	47	<10

Bold indicates concentration exceeding DGV. Shading indicates concentration exceeding GV-high.

* Results are for total recoverable hydrocarbons and the ANZ guideline is for total petroleum hydrocarbons, however the comparison is made for indicative purposes.

Lower catchment

Hydrology

The lower catchment stretches from the Tiger Tunnel discharge point to the confluence with the Myitnge River and is a disturbed system, with mixed substrates and evidence of waste rock and spoil input. Sites SWNP06 to SWNP08 along the Nam Pangyun are within the lower catchment. The stream at site SWNP08 had a flow rate of about 2,000 L/s when estimated in November 2018.

The lower catchment receives water from the many first and second order tributary streams that drain the surrounding hills. The catchment morphology is typically wider, and more open than parts of the mid-catchment where the Nam Pangyun passes through steep gorges. However, many of the smaller tributary streams are incised into steep valleys. Wallah Valley is one of the first major tributary streams that discharges to the lower catchment of the Nam Pangyun at Tiger Camp. The lower catchment is largely undeveloped and includes only the hamlet of Lopah, some rural houses on the riverbanks and temporary settlements of artisanal miners.

The river valley downstream of Tiger Camp has been extensively impacted by waste rock and slag from the historical Bawdwin mining operation. The slag waste is mined extensively by artisanal miners generally south of Lopah station on the Namtu-Bawdwin railway line, through to the confluence with Myitnge River. This is a practice that continues today.

The underground mine is dewatered to a depth of approximately 200 metres below the ground surface level at Marmion Shaft, equivalent to a reduced level (RL) of 794 m ASL. Dewatering is achieved by a combination of continuous pumping from the Marmion Shaft and discharge via the Tiger Tunnel to keep the mine dry at Level 6, and by groundwater seepage from the levels above which drain to the Tiger Tunnel. The combined discharge flows through the Tiger Tunnel and exits at Tiger Tunnel portal, approximately 300 m west of Tiger Camp (surface elevation of 818 m above sea level (m ASL)) where it discharges to the Nam Pangyun at an average rate of approximately 6 ML/day.

This discharge point is between SWNP05 (mid catchment) and SWNP06 (lower catchment). A tributary creek in Wallah Valley (sites SWWV01 and TWTC01) discharges into the Nam Pangyun downstream of Tiger Tunnel, prior to site SWNP06.

Water quality

Physico-chemical parameters and ions

In the lower catchment, average turbidity exceeded the NDWQ standard of 5 NTU, with an average of 102.4 NTU downstream of Tiger Camp at SWNP06, increasing downstream to an average of 456.1 NTU at SWNP07 towards the confluence with Myitnge River. The highest concentrations of total suspended solids were at SWNP06A, ranging between 88 and 902 mg/L, with an average concentration of 280 mg/L. The turbidity and TSS of the lower catchment were greater than that of the upper and mid catchments, where average turbidity was up to 55.2 NTU and 187.9 NTU respectively. Artisanal mining activities contribute to the elevated TSS concentration observed in the lower catchment.

The average pH of the lower catchment ranged between 6.9 and 7.1, within the NDWQ standard range of 6.5 to 8.5. Within the monitoring period, the pH dropped below this standard range at SWNP06 (pH 6.2), SWNP06A (pH 6.2) and SWNP08 (pH 6.3) in May 2019, and SWNP07 (pH 5.3) in August 2019.

Hardness and TDS increased downstream of Tiger Camp. Site SWNP05, upstream of Tiger Camp, recorded an average hardness of 17.5 mg/L and an average TDS concentration of 67 mg/L. This increased to an average hardness of 201 mg/L and an average TDS concentration of 384 mg/L at site SWNP06. In the lower catchment, average hardness and average TDS decreased slightly downstream, reaching 178 mg/L and 294 mg/L, respectively at SWNP08. Despite the slight decrease in average measurements, the range of recorded values remained fairly consistent from sites SWNP06A (hardness of 150 to 209 mg/L and TDS of 222 to 352 mg/L) to SWNP08 (hardness of 135 to 205 mg/L and TDS of 242 to 332 mg/L).

Electrical conductivity of the surface water increased to an average of 539 µS/cm between SWNP05 and SWNP06, near the Tiger Tunnel discharge point. After SWNP06, EC decreased slightly but the average EC remained between 428 and 462 µS/cm throughout the lower catchment towards the confluence with the Myitnge River. It is notable that all recorded values of hardness, TDS and EC in the lower Nam Pangyun catchment during the monitoring period were below their respective NDWQ standards of 500 mg/L, 1,000 mg/L and 1,500 mg/L, despite the influence of the Tiger Tunnel discharge on the water quality.

Groundwater discharge from Tiger Tunnel has an EC of 1,500 µS/cm, turbidity of up to 136 NTU, and TDS concentration of 1,000 to 1,750 mg/L. The addition of this discharge to the stream, along with runoff from surrounding infrastructure and mining activities area probably contributes to the disparity in these parameters between the upper/mid catchments and the lower catchment, as well the presence of orange/brown discolouration (likely a result of metal precipitation) in the lower catchment (

Plate 5.13,

Plate 5.14 and

Plate 5.15). The quality of this discharge is discussed further in Section 5.2 Groundwater.

The discharge from Wallah Valley (sites SWTC01 and SWWV01) probably does not contribute to the degradation of the Nam Pangyun. Turbidity at SWTC01 and SWWV01 is low compared to the Nam Pangyun, ranging between 0.1 NTU and 22.9 NTU at SWWV01 and between 0.3 NTU and 10.1 NTU at SWTC01. The average turbidity of 5.8 NTU at SWWV01 slightly exceeds the NDWQ standard of 5 NTU, however downstream this decreases to an average of 3.9 NTU at SWTC01. The concentration of TSS is lower than the TSS in the lower Nam Pangyun, with a maximum recorded concentration of 15 mg/L. The hardness, TDS and EC of samples in Wallah Valley are comparable to samples from the less disturbed upper catchment.

SWTS01 is in a small tributary draining a valley behind the Namtu smelter stack discharging to the Nam Pangyun between SWNP07 and SWNP08. This catchment has historically been affected by vegetation dieback as a result of sulfur contamination from the smelter stack and likely waste disposal in the upper catchment. The turbidity (average of 56.8 NTU) and TSS (average of 28 mg/L) were considerably lower than other samples in the Nam Pangyun, however turbidity (ranging between 1.8 and 198.0 NTU) still exceeded the NDWQ standard of 5 NTU. The average hardness (159.6 mg/L), TDS (225 mg/L) and EC (329 µS/cm) of SWTS01 were similar to SWNP08, which had an average hardness of 178.3 mg/L, TDS of 294 mg/L and EC of 428 µS/cm.

Results for physico-chemical parameters are displayed in Table 5.36.

Table 5.36 Physico-chemical parameters in the lower Nam Pangyun catchment

	NDWQ standard	SWNP06 Range (mean)	SWNP06A Range (mean)	SWNP07 Range (mean)	SWNP08 Range (mean)	SWWV01 Range (mean)	SWTC01 Range (mean)	SWTS01 Range (mean)
Turbidity (NTU)	5	**12.6 – 261.0 (102.4)**	**23.6 – 1,100.0 (289.8)**	1.8 – **2,687.0 (456.1)**	2.3 – **276.0 (139.4)**	0.1 – **22.9 (5.8)**	0.3 – **10.1** (3.9)	1.8 – **198.0 (56.8)**
pH	6.5 – 8.5	**6.2** – 7.2 (6.9)	**6.2** – 7.5 (7.1)	**5.3** – 7.8 (6.9)	**6.3** – 7.8 (7.1)	6.9 – 7.7 (7.5)	6.6 – 7.8 (7.4)	**6.1** – 8.5 (7.6)
TSS (mg/L)		20 – 248 (68)	88 – 902 (280)	50 – 244 (140)	86 – 318 (153)	<1 – 7 (3*)	<1 – 15 (4*)	2 – 116 (28)
Hardness (mg/L)	500	154.0 – 256.0 (201.0)	150.0 – 209.0 (184.0)	136.0 – 210.0 (180.6)	135.0 – 205.0 (178.3)	6.6 – 16.7 (10.9)	12.2 – 20.3 (16.0)	140.0 – 204.0 (159.6)
TDS (mg/L)	1,000	260 – 456 (384)	222 – 352 (323)	256 – 348 (302)	242 – 332 (294)	20 – 66 (34)	30 – 74 (45)	188 – 318 (225)
EC (µS/cm)	1,500	413 – 645 (539)	370 – 527 (462)	264 – 495 (412)	358 – 485 (428)	27 – 48 (35)	39 – 71 (55)	253 – 489 (329)

Values in bold indicate exceedance of the NDWQ standard.

*average has been calculated assuming <1 is a result of 0.

Mixing of the sodium and sulfate rich Nam Pangyun water with the groundwater discharge from Tiger tunnel is evident in the ionic composition of the lower catchment surface waters. Samples downstream of Tiger Camp exhibited higher concentrations of sulfate. Sulfate concentrations at SWNP06 ranging between 154 mg/L and 333 mg/L, with the average concentration of 260 mg/L exceeding the NDWQ standard of 250 mg/L. SWNP06 was the only site in the lower catchment to exhibit sulfate concentrations exceeding the standard. These concentrations were diluted by additional freshwater further downstream, with concentrations of sulfate decreasing downstream to a range of 117 to 184 mg/L at SWNP08.

Nutrients and organics

The highest concentrations of nitrate and ammonia recorded in the main Nam Pangyun watercourse in the lower catchment were at SWNP06A, at 0.3 mg/L and 0.1 mg/L, respectively. SWNP06A is located in the vicinity of Lopah village and these elevated nutrient concentrations are attributed to sewage disposal from the village to the Nam Pangyun. Reported concentrations of nitrate and ammonia are below their respective NDWQ standards of 50 mg/L and 1.5 mg/L. The highest recorded concentration of nitrite was 0.011 mg/L at SWNP06, considerably lower than the 3 mg/L NDWQ standard.

Concentrations of organic contaminants (total petroleum hydrocarbons (TPHs), polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), monocyclic aromatic hydrocarbons (MAHs), fungicides, herbicides and pesticides were below the limit of reporting at all sampling locations in the first round of monitoring in November 2018 and were not continued in following rounds.

Metals and metalloids

High metal concentrations in the Nam Pangyun persist downstream as far as the Myitnge River. All recorded measurements of total cadmium, lead, and nickel in the Nam Pangyun throughout the monitoring period exceeded the NDWQ health standards of 0.003 mg/L, 0.01 mg/L and 0.07 mg/L, respectively. Total concentrations of antimony and arsenic frequently exceeded their respective NDWQ health standards of 0.02 mg/L and 0.05 mg/L.

Whilst not all total concentrations of aluminium and iron exceeded the NDWQ aesthetic standards of 0.2 mg/L (aluminium) and 1 mg/L (iron), average aluminium concentrations ranged between 0.33 mg/L and 1.17 mg/L and average iron concentration ranged between 3.35 mg/L and 6.22 mg/L, exceeding the standards. All measurements of zinc exceeded the NDWQ standard of 3 mg/L at all sites in the lower catchment, with average zinc concentrations ranging between 13.35 mg/L and 26.66 mg/L.

Table 5.37 presents the NDWQ standards and total metal concentrations. Concentrations in bold indicate exceedance of the standard.

All measured concentrations of dissolved cadmium, cobalt, copper, lead, nickel and zinc between SWNP06 and SWNP08 throughout the monitoring period exceeded ANZ guidelines. Dissolved concentrations of zinc were very high, reaching a maximum of 28.90 mg/L at SWNP06, immediately downstream of the Tiger Camp industrial area. Average values at SWNP06 (25.82 mg/L), SWNP06A (16.14 mg/L), and SWNP07 (11.31 mg/L) throughout the monitoring period were also four orders of magnitude higher than the ANZ guideline value of 0.008 mg/L.

The concentration of metals increased significantly in the lower catchment following the addition of discharge from the Tiger Tunnel, which was characterised by elevated dissolved metal concentrations. Throughout the monitoring period the average copper concentrations were slightly higher than the ANZ DGV, with manganese one order of magnitude higher, cadmium and nickel two orders of magnitude higher, cobalt three orders of magnitude higher and zinc four orders of magnitude higher. The Tiger Tunnel discharge is discussed further in Section 5.2 Groundwater.

Table 5.38 compares dissolved metal concentrations in the lower catchment with the ANZ water quality guidelines. Concentrations in bold indicate exceedance of the standard. Figure 5.24 shows the increase in dissolved cadmium and zinc metal concentrations in the Nam Pangyun following the Tiger Tunnel discharge. Lead concentrations appeared to decrease following the addition of the discharge, although they remained elevated.

At SWNP06, dissolved concentrations of cobalt and zinc increased dramatically from concentrations measured at SWNP05, immediately upstream of Tiger Tunnel in the mid catchment. Between SWNP05 and SWNP06, average concentrations of cobalt throughout the monitoring period increased from 0.038 to 1.078 mg/L and zinc increased from 1.567 to 25.817 mg/L.

In the mid catchment, average total lead concentrations reached 2.495 mg/L in the Nam Pangyun. In contrast, the average total lead concentration in the lower catchment reached 4.663 mg/L, which is comparable to the average total lead value of up to 4.071 mg/L in the ER Valley, which contains waste rock from historical open pit mining.

Metal concentrations in surface water samples from Wallah Valley generally had lower metal concentrations than other samples in the lower catchment. Lead was the only metal which had total concentrations exceeding NDWQ standards this may be due to historic railway transport of ore, with an average of 0.045 mg/L at SWTC01 and 0.079 mg/L at SWWV01. At SWWV01 average dissolved concentrations of cadmium (0.0003 mg/L) slightly exceeded the ANZ DGV of 0.0002 mg/L, and lead (0.0277 mg/L) and zinc (0.077 mg/L) exceeded their respective ANZ DGVs of 0.0034 mg/L and 0.008 mg/L by an order of magnitude. At SWTC01, average concentrations of dissolved cadmium (0.0008 mg/L) and copper (0.0020 mg/L) slightly exceeded the ANZ guideline values of 0.0002 mg/L and 0.0014 mg/L respectively. Average dissolved zinc (0.144 mg/L) exceeded the ANZ DGV of 0.008 mg/L more significantly than at SWWV01, while lead concentrations at SWTC01 (0.0033 mg/L) sat around the ANZ DGV of 0.0034 mg/L.

Wallah Valley and Tiger Camp have been the site of former ore stockpiling, crushing and loading onto trains for transport to Namtu. Waste rock and very high concentrations of metals are present in soils across Tiger Camp, which are transported in dust and vehicle movement through Wallah Valley. The observed concentrations of metals in surface water in the Wallah Valley (SWWV01) and where the tributary stream flows through Tiger Camp (SWTC01) are likely to be sourced from rainfall runoff and leaching of soils that have been impacted by a range of historical mining activities particularly in the vicinity of Tiger Camp.

The tributary stream monitored in the lower catchment (SWTS01) had metal concentrations consistent with the lower Nam Pangyun measurements. Average total concentrations of cadmium, lead and nickel exceeded NDWQ health standards, and average aluminium concentrations exceeded aesthetic standards. Average concentrations of dissolved cadmium, cobalt, lead, nickel and zinc exceed ANZ guidelines at this site. Elevated concentrations of metals at SWTS01 are likely to be attributed to the aerial deposition of metal contamination from the Namtu smelter stack which is located on the eastern edge of the catchment divide. Smelter waste may also have been disposed to this catchment given its close proximity.

Plate 5.13 Groundwater discharge from Tiger Tunnel, which enters the lower Nam Pangyun

Plate 5.14 Orange staining along the Nam Pangyun in the lower catchment (site SWNP06)

Plate 5.15 Turbid waters of the lower Nam Pangyun flowing through layers of deposited sediments and waste slag from years of upstream mining disturbance (site SWNP08)

Figure 5.24 Dissolved concentrations of cadmium, lead and zinc in the Nam Pangyun stream

Table 5.37 Total (unfiltered) metal concentrations in lower Nam Pangyun catchment surface water, compared to NDWQ standards

	NDWQ Standard	SWNP06 Range (mean)	SWNP06A Range (mean)	SWNP07 Range (mean)	SWNP08 Range (mean)	SWWV01 Range (mean)	SWTC01 Range (mean)	SWTS01 Range (mean)
NDWQ Health Standards								
Antimony (mg/L)	0.02	0.0077 - **0.0232** (0.0140)	**0.0240 - 0.0625 (0.0409)**	0.0119 - **0.0465 (0.0293)**	0.0132 - **0.0512 (0.0335)**	<0.0005 - 0.0048 (0.0029)	0.0019 - 0.0042 (0.0029)	<0.0005 - **0.0257** (0.0053)
Arsenic (mg/L)	0.05	**0.1430 - 0.2450 (0.1931)**	**0.1590 - 0.4630 (0.2682)**	**0.0728 - 0.2080 (0.1281)**	<0.119 - **0.2070 (0.1228)**	0.0010 - 0.0043 (0.0024)	0.0015 - 0.0056 (0.0027)	0.0006 - **0.0970** (0.0237)
Barium (mg/L)	0.7	0.10 - 0.38 (0.16)	0.21 - **0.73** (0.36)	0.15 - 0.44 (0.22)	0.16 - 0.38 (0.24)	0.04 - 0.09 (0.05)	0.07 - 0.09 (0.08)	0.05 - 0.20 (0.09)
Cadmium (mg/L)	0.003	**0.0131 - 0.0153 (0.0145)**	**0.0172 - 0.0480 (0.0345)**	**0.0289 - 0.0809 (0.0533)**	**0.0287 - 0.0782 (0.0525)**	<0.0001 - 0.0004 (0.0003)	0.0006 - 0.0023 (0.0009)	<0.0001 - **0.0526 (0.0106)**
Chromium (III+VI) (mg/L)	0.05	<0.001	<0.001 - 0.004 (0.001)	<0.001 - 0.003 (0.001)	<0.001 - 0.004 (0.001)	<0.001	<0.001	<0.001 - 0.002 (0.000)
Copper (mg/L)	2	0.037 - 0.185 (0.072)	0.099 - 0.424 (0.232)	0.041 - 0.249 (0.149)	0.048 - 0.278 (0.170)	<0.001 - 0.004 (0.002)	0.002 - 0.006 (0.003)	<0.001 - 0.123 (0.024)
Lead (mg/L)	0.01	**0.544 - 2.650 (0.962)**	**2.610 - 7.010 (4.663)**	**0.970 - 4.550 (2.646)**	**1.060 - 4.990 (3.090)**	<0.001 - **0.1730 (0.079)**	**0.029 - 0.055 (0.045)**	**0.014 - 2.370 (0.479)**
Manganese (mg/L)	0.4	**2.770 - 5.550 (4.350)**	**1.750 - 3.350 (2.545)**	**0.894 - 2.020 (1.453)**	**0.814 - 1.760 (1.338)**	<0.005 - 0.231 (0.036)	<0.017 - 0.213 (0.044)	<0.017 - **1.82 (0.423)**
Mercury (mg/L)	0.001	<0.00005 - 0.00023 (0.00003)	<0.00005 - 0.00036 (0.00015)	<0.00005 - 0.00017 (0.00005)	<0.00005 - 0.00036 (0.00009)	<0.0001	<0.00005	<0.00005 - 0.00013 (0.00003)
Nickel (mg/L)	0.07	**1.060 - 2.130 (1.683)**	**0.640 - 1.290 (1.088)**	**0.695 - 0.913 (0.808)**	**0.676 - 0.878 (0.759)**	<0.001 - 0.010 (0.002)	<0.001 - 0.007 (0.002)	<0.001 - **0.735 (0.176)**
NDWQ Aesthetic Standards								
Aluminium (mg/L)	0.2	<0.06 - **1.64 (0.33)**	<1 **- 3.88 (1.17)**	<0.93 - **1.59 (0.70)**	<0.98 - **1.99 (0.86)**	<0.04 - 0.17 (0.05)	<0.03 - 0.09 (0.04)	<0.01 - **1.09 (0.24)**
Calcium (mg/L)	200	33.4 - 58.1 (46.5)	39.5 - 48.6 (43.7)	33.9 - 51.7 (43.8)	33.2 - 50.1 (42.9)	1.8 - 3.2 (2.6)	3.3 - 5.4 (4.2)	29.4 - 49.8 (33.5)
Iron (mg/L)	1	<6.61 - **6.480 (4.949)**	<7.55 - **10.900 (6.220)**	<4.42 - **5.960 (3.346)**	<3.55 - **6.520 (3.765)**	<0.036 - 0.147 (0.070)	<0.085 - 0.251 (0.099)	<0.056 - **3.290 (0.758)**

	NDWQ Standard	**SWNP06 Range (mean)**	**SWNP06A Range (mean)**	**SWNP07 Range (mean)**	**SWNP08 Range (mean)**	**SWWV01 Range (mean)**	**SWTC01 Range (mean)**	**SWTS01 Range (mean)**
Magnesium (mg/L)	150	17.40 - 26.90 (22.47)	17.70 - 21.20 (19.78)	12.40 - 19.80 (16.66)	12.60 - 19.40 (16.73)	0.54 - 1.03 (0.78)	0.97 - 1.67 (1.27)	16.30 - 19.50 (17.40)
Sodium (mg/L)	200	1.60 - 16.60 (6.87)	1.29 - 14.30 (6.27)	1.17 - 13.60 (5.76)	1.17 - 13.50 (3.78)	<0.5 – 13.00 (2.74)	0.93 - 12.60 (4.45)	0.24 - 9.53 (2.86)
Zinc (mg/L)	3	**17.80 - 31.40 (26.66)**	**12.20 - 21.90 (18.97)**	**10.50 - 15.70 (14.14)**	**10.40 - 15.40 (13.35)**	0.02 - 0.22 (0.09)	0.10 - 0.36 (0.15)	0.013 - **11.30** (2.84)

<xx = indicates below limit of detection

Values in bold indicate exceedance of the NDWQ standard. Measurements below detection limits were assumed to be zero for the purpose of calculating average concentrations

Table 5.38 Dissolved metal concentrations in lower Nam Pangyun catchment surface water, compared to ANZ DGVs

	ANZ DGV	SWNP06 Range (mean)	SWNP06A Range (mean)	SWNP07 Range (mean)	SWNP08 Range (mean)	SWWV01 Range (mean)	SWTC01 Range (mean)	SWTS01 Range (mean)
Aluminium (mg/L)	0.055*	<0.01	<0.01	<0.01	<0.01 - 0.03 (0.005)	<0.01 - 0.05 (0.007)	<0.01	<0.01 - 0.03 (0.005)
Antimony (mg/L)	0.009	0.0026 - 0.0053 (0.0042)	0.0039 - 0.0053 (0.0047)	0.0036 - 0.0066 (0.0049)	0.0043 - 0.0067 (0.0055)	<0.005 - 0.0045 (0.0029)	0.0019 - 0.0032 (0.0026)	<0.0005 - 0.005 (0.0008)
Arsenic (mg/L)	0.013**	0.0008 - 0.0026 (0.0014)	<0.0005 - 0.0008 (0.0006)	0.0006 - 0.0009 (0.0008)	<0.0005 - 0.0040 (0.0011)	0.0010 - 0.0028 (0.0015)	0.0014 - 0.0045 (0.0022)	<0.0005 - 0.0011 (0.0008)
Cadmium (mg/L)	0.0002	**0.0133 - 0.0141 (0.0136)**	**0.0218 - 0.0443 (0.0352)**	**0.0331 - 0.0764 (0.0569)**	**0.0351 - 0.0703 (0.0576)**	**0.0003 - 0.0004 (0.0003)**	**0.0006 - 0.0016 (0.0008)**	<0.0001 - **0.0447 (0.0075)**
Cobalt (mg/L)	0.0014	**0.920 - 1.300 (1.078)**	**0.578 - 0.707 (0.639)**	**0.307 - 0.426 (0.378)**	**0.278 - 0.398 (0.351)**	<0.001	<0.001	<0.001 - **0.405 (0.068)**
Copper (mg/L)	0.0014	**0.004 - 0.014 (0.0073)**	**0.007 - 0.009 (0.0080)**	**0.006 - 0.011 (0.0088)**	**0.007 - 0.013 (0.0097)**	<0.001 - **0.002** (0.0006)	<0.001 - **0.005 (0.0020)**	<0.001 - **0.006** (0.0010)
Lead (mg/L)	0.0034	**0.006 - 0.014 (0.0083)**	**0.075 - 0.151 (0.0968)**	**0.081 - 0.260 (0.1543)**	**0.114 - 0.274 (0.1817)**	**0.006 - 0.046 (0.0277)**	<0.001 - **0.007** (0.0033)	<0.001 - **0.156 (0.0302)**
Manganese (mg/L)	1.9	**3.280 - 4.830 (4.222)**	1.600 - **3.150 (2.160)**	0.664 - 1.780 (1.144)	0.583 - 1.640 (1.026)	<0.005 - 0.145 (0.023)	<0.001 - 0.024 (0.005)	<0.001 - 1.690 (0.285)
Nickel (mg/L)	0.011	**1.380 - 2.010 (1.660)**	**0.937 - 1.200 (1.085)**	**0.616 - 0.843 (0.723)**	**0.556 - 0.773 (0.675)**	<0.001 - 0.002 (0.001)	<0.001 - 0.006 (0.002)	<0.001 - **0.650 (0.110)**
Zinc (mg/L)	0.008	**21.800 - 28.900 (25.817)**	**13.200 - 19.200 (16.140)**	**7.860 - 13.300 (11.310)**	**6.080 - 11.300 (9.615)**	**0.060 - 0.100 (0.077)**	**0.108 - 0.295 (0.144)**	**0.008 - 6.230 (1.071)**

<xx = below limit of detection

Values in bold indicate exceedance of the DGV. Measurements below detection limits were assumed to be zero for the purpose of calculating average concentrations

*Guideline is 0.055 mg/L where pH is >6.5, 0.0008 where pH is <6.5. However, as the sites had average pHs of >6.5 over the monitoring period, the 0.055 mg/L guideline value was adopted.

** Guideline is 0.013 mg/L for As(V) and 0.024 mg/L for As(III). In the absence of knowledge of arsenic speciation in the waters, the more conservative guideline value for As(V) has been adopted.

Sediment quality

Site S5 is located in the lower catchment immediately downstream of the Tiger Camp which was the site of former ore stockpiling and train loading activities associated with the historical Bawdwin mine (see Figure 5.22). The stream sediment sampled here was fine to medium brown sand and had concentrations of arsenic, antimony, lead, silver and zinc exceeding the GV-high, and copper and nickel exceeding the DGV (Table 5.39). Stream sediment is considered to be affected by the historical mining activities that have occurred at Tiger Camp and in the upstream catchment.

Site S6 is located downstream of smelter stack and comprised fine light brown sand with minor gravel. Stream sediment sampled here had low concentrations of metal compared to other sites in the Nam Pangyun catchment, with only nickel concentrations exceeding the GV-high and antimony, arsenic and lead concentrations exceeding the DGV (Table 5.39). Despite lower reported concentrations of most metals at sample location S6 the streambed sediments in the lower catchment were observed to be extensively impacted by mine waste including waste rock and slag from historical smelting operations that took place at Bawdwin.

Table 5.39 Toxicant concentrations of stream sediment in the lower Nam Pangyun catchment

Metal	ANZ DGV	ANZ GV-High	S5	S6
Antimony (mg/kg)	2.0	25	**26.9**	**2.1**
Arsenic (mg/kg)	20	70	**310**	**30**
Cadmium (mg/kg)	1.5	10	0.68	0.26
Chromium (mg/kg)	80	370	9	17
Copper (mg/kg)	65	270	**200**	57
Lead (mg/kg)	50	220	**2,250**	**114**
Mercury (mg/kg)	0.15	1.5	**2.30**	**0.55**
Nickel (mg/kg)	21	52	**33**	**67**
Silver (mg/kg)	1.0	4.0	**12.60**	0.60
Zinc (mg/kg)	200	410	**1,350**	58
PAHs (mg/kg)	10	50	<0.01	<0.01
Total hydrocarbons* (mg/kg)	280	550	11	<10

Bold indicates concentration exceeding DGV. Shading indicates concentration exceeding GV-high.

* Results are for total recoverable hydrocarbons and the ANZ guideline is for total petroleum hydrocarbons, however the comparison is made for indicative purposes

Nam La

Nam La is a second or third order stream with a catchment covering approximately 35.5 km^2. The stream is 3.2 km north of the Bawdwin open pit at its closest, running parallel to Nam Pangyun, flowing in a south-easterly direction to the Myitnge River.

Whilst historical Bawdwin mining activities were largely limited to the Nam Pangyun catchment, the sole road access to Bawdwin is via the Namtu to Manton road, which follows the Nam La. This access is likely to have facilitated historical logging activities in the Nam La catchment to support construction and operation of the mine. There are no major villages or settlements within the Nam La catchment north of Namtu and, with the exception of a small artisanal mining operation on the Nam La north of Bawdwin and small-scale agricultural activities throughout particularly the lower catchment, the Nam La catchment is comparatively undisturbed.

Small tributary streams from connecting valleys maintain flow year-round and either drain directly to the Nam La or flow across the Manton-Namtu Road. The Nam La is largely unregulated with the exception of one weir constructed 5.3 km upstream of its confluence with Myitnge River (Plate 5.16 and 5.17). The weir is associated with the intake for the Nam La Flume, an important part of the water supply infrastructure for the northern districts of Namtu.

A flume is a human-made gravity-fed channel for water, which has raised walls above the surrounding terrain. The flume was originally constructed to supply potable water to the smelter complex in Namtu (see Figure 5.22). It is comprised of both dug channels and elevated wooden chutes where it crosses valleys and provides a source of water that is isolated from most urban contamination sources and allows for gravity-fed supply to holding tanks, settling ponds and other storages around Namtu.

The Nam La flows through Namtu and is expected to become impacted by urban runoff, untreated waste discharge, and may receive impacted baseflow and stormwater runoff from urban and industrial land within Namtu. The confluence of the Nam La with the Myitnge River is upstream of the Namtu smelter complex at Namtu.

Hydrology

SWNL01 and SWNL02 are both located north of Namtu and are characterised by shallow, clear water. The streambed in the SWNL01 area comprises sands, gravels and cobbles with pools present in this section of the river. There is a large bar of variably sorted sediment lining one side of the stream at SWNL02 (Plate 5.18). Further downstream at SWNL03, at the confluence with the Myitnge River, the stream morphology is braided and incised in layers of deposited sediments. Sample location SWNF01 is located in the Nam La Flume, west of Namtu township.

Water Quality

Physico-chemical parameters and ions

The Nam La is an important source of water for drinking and irrigation in Namtu. Water for this purpose is delivered by the Nam La flume which has been sampled at monitoring sites SWNL01 upstream of the weir and SWNF01 at a holding pond supplied by the Nam La flume. Physico-chemical parameters at these two sites were fairly consistent (see Table 5.40).

The turbidity at SWNF01 ranged between 8.4 and 20.1 NTU, slightly above the NDWQ aesthetic standard of 5 NTU. Total suspended solids ranged between 5 and 13 mg/L. In the main Nam La watercourse, average turbidity increased from 9.3 NTU at SWNL01 to 100.6 NTU at SWNL02 and decreased to 11.2 NTU at SWNL03, indicating there is no apparent overall trend between upstream and downstream sites. Average turbidity exceeded NDWQ aesthetic standards, however the ranges of measurements are broad, with some measurements not exceeding the standard. Average TSS at SWNF01 (8 mg/L) and SWNL01 (3 mg/L) were lower than measurements at SWNL02 (37 mg/L) and SWNL03 (39 mg/L).

All pH measurements in the Nam La catchment fell within the acceptable drinking water pH range of 6.5 – 8.5 with the average pH ranging between 7.9 and 8.1. The pH of SWNF01 was more variable than the main Nam La watercourse, ranging between pH 6.5 and 8.4. There appears to be a slight increase in pH further downstream, with the range shifting from between pH 6.5 and 8.4 at SWNL01 to pH 7.8 and 8.3 at SWNL03.

Average water hardness ranged from 44.6 mg/L at SWNL01 to 109.9 mg/L at SWNL03, indicating minimal mineral dissolution within the catchment. Average electrical conductivity ranged between 107 µS/cm at SWNL01 and 240 µS/cm at SWNL03. Hardness, TDS and EC appeared to increase downstream between SWNL01 and SWNL03, though remained below the NDWQ standards of 500 mg/L, 1,000 mg/L and 1,500 µS/cm, respectively. At SWNF01, hardness, TDS and EC were also below NDWQ standards, and had average measurements similar to SWNL01.

Unlike Nam Pangyun, the ionic composition of Nam La is calcium-bicarbonate rich. The average concentration of bicarbonate and magnesium ions increases downstream, with bicarbonate increasing from 51 mg/L at SWNL01 to 112 mg/L at SWNL03, and magnesium increasing from 3 mg/L at SWNL01 to 11 mg/L at SWNL03. As the average concentration of total dissolved solids also increases (from 77 mg/L at SWNL01 to 156 mg/L at SWNL03), this may indicate stream baseflow or spring discharge entering the stream.

Plate 5.16 Nam La flume at site SWNL01

Plate 5.17 Confluence of the Nam La (bottom of image) and Myitnge (top of image) rivers

Plate 5.18 Site SWNL02 in the Nam La with sediment bar visible on left

Table 5.40 Physico-chemical parameters in the Nam La catchment

	NDWQ standard	SWNF01 Range (mean)	SWNL01 Range (mean)	SWNL02 Range (mean)	SWNL03 Range (mean)
Turbidity (NTU)	5	**8.4 – 20.1 (16.0)**	0 – **34.0 (9.3)**	0.8 **– 624.0 (100.6)**	**3.7 – 19.2 (11.2)**
pH	6.5 – 8.5	6.5 – 8.4 (7.9)	7.7 – 8.1 (8.0)	7.5 – 8.2 (8.0)	7.8 – 8.3 (8.1)
TSS (mg/L)		5 – 13 (8)	<1 – 8 (3*)	1 – 252 (37)	9 – 160 (39)
Hardness (mg/L)	500	33.4 – 51.4 (44.6)	37.0 – 53.0 (47.4)	49.0 -73.2 (65.0)	71.7 – 154.0 (109.9)
TDS (mg/L)	1,000	54 – 110 (74)	68 – 88 (77)	84 – 136 (105)	84 – 210 (156)
EC (µS/cm)	1,500	79 – 125 (99)	80 – 142 (107)	115 – 165 (140)	191 – 334 (240)

Values in bold indicate exceedance of the NDWQ standard.

*average has been calculated assuming <1 is a result of 0.

Nutrients and organics

Concentrations of nitrate, nitrite and phosphorus in Nam La increase between SWNL01 (upstream) and SWNL03 (downstream) though remain below NDWQ standards. Despite being below standards, these nutrients are likely to indicate the use of agricultural fertilisers (either commercially manufactured or manure) and/or disposal of untreated animal waste in agricultural areas, or discharge of untreated sewage in the Namtu area. This suggests there may be bacteria such as E. coli and faecal coliforms present in untreated water from the catchment that may represent health risk.

Concentrations of organic contaminants (total petroleum hydrocarbons (TPHs), polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), monocyclic aromatic hydrocarbons (MAHs)), fungicides, herbicides and pesticides were below the limit of reporting at all sampling locations in the first round of monitoring in November 2018 and were not continued in following rounds.

Metals and metalloids

Concentrations of total metals in water from the Nam La Flume (SWNF01) during the monitoring period were broadly comparable to those in the rest of the Nam La (SWNL01 to SWNL03). Total lead concentrations measured during the monitoring period at SWNF01 ranged between 0.021 mg/L and 0.060 mg/L, at minimum twice the NDWQ health standard of 0.01 mg/L. Average total lead concentrations exceeded NDWQ health standards at SWNL01 (0.031 mg/L), SWNL02 (0.053 mg/L) and SWNL03 (0.049 mg/L).

The concentration of total iron at SWNL02 and SWNL03 exceeded the NDWQ aesthetic standard of 1 mg/L during June and October 2019. The reported concentrations of total aluminium at SWNL02 were below the NDWQ aesthetic standard of 0.2 mg/L except for one anomalously high total aluminium concentration of 4.51 mg/L at SWNL02 in June 2019. Aluminium is likely to be associated with suspended sediments sourced either from stormwater runoff or from within the stream bed in the Namtu area.

Table 5.41 outlines the total metal concentrations against the NDWQ standards.

Upstream of Namtu at site SWNL01, dissolved concentrations of cadmium and copper only slightly exceeded the ANZ guidelines. Lead exceeded the guidelines by up to one order of magnitude and zinc by up to two orders of magnitude.

There were no consistent increasing or decreasing trends observed in total or dissolved metal concentrations along the stream length between SWNL01 and SWNL03 during the monitoring period. Figure 5.25 shows the lack of trends in dissolved cadmium, lead and zinc concentrations in the Nam La.

Table 5.42 outlines the total dissolved metal concentrations against the ANZ guidelines for ecological health.

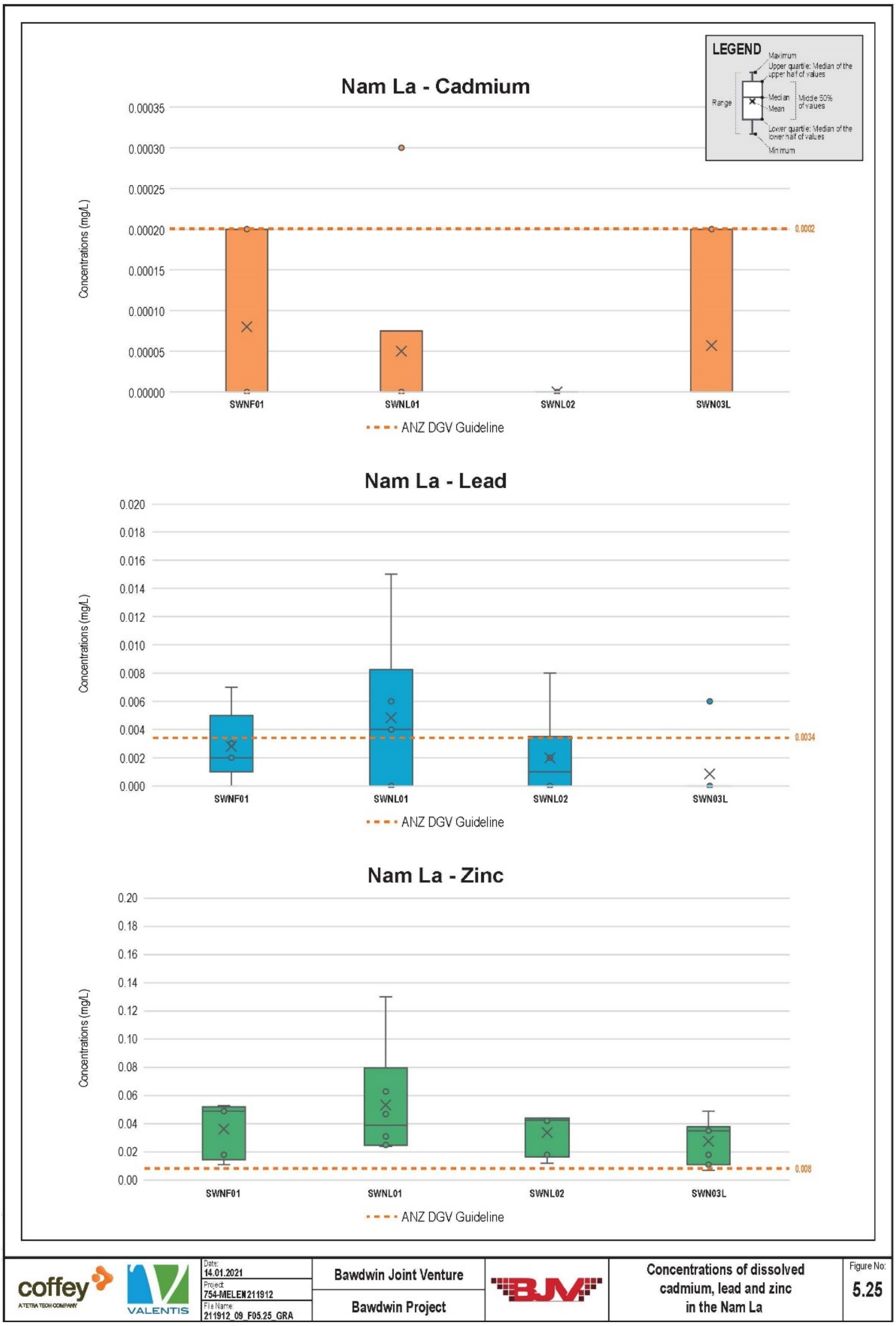


Figure 5.25 Concentrations of dissolved cadmium, lead and zinc concentrations in the Nam La stream

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Table 5.41 Total (unfiltered) metal concentrations in Nam La catchment surface water, compared to NDWQ standards

	NDWQ Standard	SWNF01 Range (mean)	SWNL01 Range (mean)	SWNL02 Range (mean)	SWNL03 Range (mean)
NDWQ Health Standards					
Antimony (mg/L)	0.02	0.0022 - 0.0038 (0.0029)	<0.005 - 0.0037 (0.0023)	0.0019 - 0.0036 (0.0026)	<0.005 - 0.0042 (0.0025)
Arsenic (mg/L)	0.05	0.0011 - 0.0029 (0.0019)	<0.0009 - 0.0024 (0.0012)	0.0011 - 0.0095 (0.0023)	0.0016 - 0.0036 (0.0023)
Barium (mg/L)	0.7	0.08 - 0.11 (0.09)	0.06 - 0.11 (0.10)	0.07 - 0.10 (0.09)	0.08 - 0.11 (0.09)
Cadmium (mg/L)	0.003	<0.0001 - 0.0002 (0.0001)	<0.0001 - 0.0003 (0.0001)	<0.0001 - 0.0009 (0.0002)	<0.0001 - 0.0003 (0.0001)
Chromium (III+VI) (mg/L)	0.05	<0.001 - 0.002 (<0.001)	<0.001	<0.001 - 0.005 (0.001)	<0.001
Copper (mg/L)	2	0.003 - 0.005 (0.004)	<0.001 - 0.007 (0.003)	<0.001 - 0.014 (0.004)	<0.001 - 0.009 (0.004)
Lead (mg/L)	0.01	**0.021 - 0.060 (0.038)**	<0.005 - **0.088 (0.031)**	<0.011 - **0.210 (0.053)**	<0.019 - **0.182 (0.049)**
Manganese (mg/L)	0.4	<0.021 - 0.047 (0.022)	<0.028 - 0.126 (0.053)	<0.019 - 0.326 (0.064)	<0.045 - 0.138 (0.053)
Mercury (mg/L)	0.001	<0.00005	<0.0001	<0.00005	<0.0001
Nickel (mg/L)	0.07	<0.001	<0.001 - 0.001 (<0.001)	<0.001 - 0.004 (0.001)	<0.001 - 0.002 (<0.001)
NDWQ Aesthetic Standards					
Aluminium (mg/L)	0.2	<0.05 - **0.40** (0.18)	<0.02 - 0.09 (0.04)	<0.03 - **4.51 (0.61)**	<0.12 - **1.15 (0.25)**
Calcium (mg/L)	200	8.8 - 13.7 (11.7)	1.6 - 14.4 (10.8)	12.1 - 17.5 (15.4)	16.8 - 34.4 (24.6)
Iron (mg/L)	1	0.152 - 0.428 (0.250)	<0.05 - 0.212 (0.111)	<0.07 - **4.010** (0.606)	<0.191 - **1.140** (0.372)
Magnesium (mg/L)	150	2.77 - 4.16 (3.57)	<0.5 - 4.66 (3.35)	4.55 - 7.27 (6.19)	7.22 - 16.50 (11.38)
Sodium (mg/L)	200	0.4 - 13.5 (2.6)	<0.5 - 8.4 (1.5)	0.4 - 13.4 (4.6)	1.5 - 9.7 (4.2)
Zinc (mg/L)	3	0.036 - 0.076 (0.06)	0.032 - 0.130 (0.06)	0.019 - 0.087 (0.05)	0.019 - 0.085 (0.05)

<xx = below limit of detection

Values in bold indicate exceedance of the NDWQ standard. Measurements below detection limits were assumed to be zero for the purpose of calculating average concentrations

Table 5.42 Dissolved metal concentrations in Nam La catchment surface water, compared to ANZ DGVs

	ANZ DGV	SWNF01 Range (mean)	SWNL01 Range (mean)	SWNL02 Range (mean)	SWNL03 Range (mean)
Aluminium (mg/L)	0.055*	<0.01 - **0.10** (0.032)	<0.01 - 0.02 (0.003)	<0.01 - **0.15** (0.025)	<0.05
Antimony (mg/L)	0.009	0.0016 - 0.0036 (0.0026)	<0.005 - 0.0036 (0.0020)	0.0015 - 0.0027 (0.0022)	<0.005 - 0.0026 (0.0019)
Arsenic (mg/L)	0.013**	0.0008 - 0.0019 (0.0013)	<0.0005 - 0.0021 (0.0007)	0.0007 - 0.0031 (0.0013)	0.0010 - 0.0028 (0.0016)
Cadmium (mg/L)	0.0002	<0.0001 - **0.0002** (0.0001)	<0.0001 **- 0.0003** (0.0001)	<0.0001	<0.0001 - **0.0002** (0.0001)
Cobalt (mg/L)	0.0014	<0.001	<0.001	<0.001	<0.001
Copper (mg/L)	0.0014	<0.001 - **0.002 (0.0016)**	<0.001 - **0.002** (0.0013)	<0.001 - **0.003** (0.0012)	<0.001 - **0.002** (0.0009)
Lead (mg/L)	0.0034	<0.001 - **0.007** (0.0028)	<0.001 - **0.015 (0.0048)**	<0.001 - **0.008** (0.0020)	<0.001 - **0.006** (0.0009)
Manganese (mg/L)	1.9	<0.001 - 0.007 (0.002)	<0.001 - 0.011 (0.003)	<0.001 - 0.002 (<0.001)	<0.001 - 0.007 (0.002)
Nickel (mg/L)	0.011	<0.001	<0.001 – 0.001 (0.000)	<0.001	<0.001
Zinc (mg/L)	0.008	**0.011 - 0.053 (0.036)**	**0.024 - 0.130 (0.053)**	**0.012 - 0.044 (0.034)**	0.007 **- 0.049 (0.028)**

<LOD = below limit of detection.

Values in bold indicate exceedance of the DGV. Measurements below detection limits were assumed to be zero for the purpose of calculating average concentrations

*Guideline is 0.055 mg/L where pH is >6.5, 0.0008 where pH is <6.5. However, as the sites had average pHs of >6.5 over the monitoring period, the 0.055 mg/L guideline value was adopted.

** Guideline is 0.013 mg/L for As(V) and 0.024 mg/L for As(III). In the absence of knowledge of arsenic speciation in the waters, the more conservative guideline value for As(V) has been adopted.

Sediment Quality

No stream sediment samples were taken from the Nam La.

Myitnge River

Hydrology

The Myitnge River is a major tributary of the Ayeyarwady River, in the northwest of Shan State, with a total catchment area covering 30,682 km^2. The river flows through Namtu where its width was estimated to range in the order of 50 to 70 m and its depth is reported by locals to be approximately 10 to 12 m deep. Rainfall in the wet season can cause frequent flooding events in the lower Myitnge River catchment and influence flow rates. The Ayeyarwady State of the Basin Assessment (SOBA) report (NWRC, 2017) indicating flows ranging from 38,052 L/s to over 1,712,327 L/s.

The Myitnge River flows through Namtu where it is expected that historical ore processing activities, including smelting on the northern bank of the Myitnge River, and ore concentration and tailings disposal on the southern bank (referred to as the 32 Mile site), have also contributed contaminated surface runoff and groundwater discharge to the Myitnge River. Plate 5.19 shows the Myitnge River as it passes Namtu.

The Myitnge River is fed by tributaries such as Nam Pangyun and Nam La. Discharge from these tributaries, along with contaminated runoff and groundwater from Namtu, are expected to contribute to poor water quality in the Myitnge River.

Water Quality

Physico-chemical parameters and ions

Turbidity of the Myitnge River was low as it passed Namtu (SWNR01 to SWNR04), with the exception of measurements made in August 2019. Between sites SWNR01 and SWNR04 in August, maximum turbidity ranged between 186.0 and 279.0 NTU. In other months, the average turbidity ranged between 3.4 and 4.8 NTU at these sites, below the NDWQ standard of 5 NTU. SWNR05, downstream of the confluence with Nam Pangyun (Plate 5.20), the turbidity reached a maximum of 164.0 NTU in August, with other months ranging between 3.4 and 42.3 NTU, averaging 14.1 NTU. The only months that had turbidity below the NDWQ standard at SWNR05 were May and September 2019.

Total suspended solids in the river followed a similar trend, with measurements in August 2019 considerably higher than other months, ranging between 127 and 214 mg/L. In other months, the average TSS ranged between 6 and 8 mg/L between sites SWNR01 and SWNR04. At site SWNR05, the average TSS increased to 32 mg/L.

The increase in turbidity and TSS between sites upstream of the confluence (SWNR01 to SWNR04) and downstream (SWNR05) is probably due to the inflow of the Nam Pangyun, as the Nam Pangyun catchment is influenced by high turbidity discharge from the Tiger Tunnel and by disturbance by artisanal mining activities. For reference, the average turbidity and TSS of SWNP08 in the Nam Pangyun catchment (immediately upstream of the confluence with the Myitnge River) is 139.4 NTU and 153 mg/L, respectively.

The average pH in the Myitnge River ranged between 7.6 and 8.0, with an absolute range across all monitoring sites of pH 7.2 to 8.2. These pH values are all within the NDWQ standard range of pH 6.5 to 8.5. Between SWNR04 and SWNR05, the range of pH in the river remained relatively similar, ranging from 7.0 to 8.0 at SWNR04 to 6.9 to 8.0 at SWNR05. There did not appear to be a decrease in pH between the two sites as a result of the slightly more acidic inflow from the Nam Pangyun, where pH ranged between 6.3 and 7.7 at SWNP08.

Hardness in the Myitnge River during the monitoring period was high relative to the Nam Pangyun and Nam La streams. Average hardness ranged between 195 and 199 mg/L and remained relatively consistent at all monitoring sites. The lowest hardness measurements in the catchment ranged between 160 and 167 mg/L, while the highest measurements ranged between 213 and 219 mg/L. All measurements were below the NDWQ standard of 500 mg/L. The high hardness relative to the Nam Pangyun and Nam La catchments is likely to reflect the underlying lithology of the catchment upstream, as the Upper Permian-Mesozoic carbonates of the Shan Plateau are likely to contribute to increased water hardness.

The electrical conductivity and total dissolved solid concentrations both had narrow absolute ranges, 332 to 438 µS/cm, and 220 to 304 mg/L, respectively. There did not appear to be an increasing or decreasing trend from upstream to downstream. Both EC and TDS concentrations were below the NDWQ standards of 1,500 µS/cm and 1,000 mg/L, respectively.

The ionic composition of the Myitnge River in the study area is calcium-bicarbonate rich, similar to that of the Nam La catchment. Between SWNR01 and SWNR04, the average bicarbonate concentration ranges between 190 mg/L at SWNR03 and 193 mg/L at SWNR04. This decreases downstream of the confluence with Nam Pangyun to 176 mg/L at SWNR05, likely due to the contribution of the comparatively low bicarbonate discharge from the Nam Pangyun (average of 61 mg/L at SWNP08). At SWNR05, the composition also becomes slightly more sulfate-rich due to the sulfate enriched discharge from Nam Pangyun (average of 155 mg/L at SWNP08). Upstream at SWNR01 the sulfate concentration was an average of 11 mg/L, increasing to 38 mg/L at SWNR05 after the confluence.

Results for physico-chemical parameters are presented in Table 5.43. Values in bold indicate exceedance of the NDWQ standard.

Table 5.43 Physico-chemical parameters in the Myitnge River catchment

	NDWQ standard	SWNR01 Range (mean)	SWNR02 Range (mean)	SWNR03 Range (mean)	SWNR03A Range (mean)	SWNR04 Range (mean)	SWNR05 Range (mean)
Turbidity (NTU)	5	0.7 – **230.0 (35.9)**	0.8 – **214.0 (34.0)**	1.6 – **190.0 (31.3)**	0.4 – **279.0 (42.8)**	2.5 – **186.0 (30.4)**	3.4 – **164.0 (35.5)**
pH	6.5 – 8.5	7.5 – 8.1 (7.9)	7.3 – 8.2 (8.0)	7.2 – 8.2 (7.9)	7.5 – 8.2 (7.9)	7.0 – 8.0 (7.6)	6.9 – 8.0 (7.7)
TSS (mg/L)		<1 – 171 (29*)	1 – 166 (26)	<1 – 145 (24*)	<1 – 214 (36*)	<1 – 147 (21*)	5 – 127 (44)
Hardness (mg/L)	500	163.0 – 219.0 (199.3)	166.0 – 214.0 (197.3)	167.0 – 213.0 (196.9)	164.0 – 213.0 (195.0)	160.0 – 214.0 (197.0)	166.0 – 218.0 (197.9)
TDS (mg/L)	1,000	224 – 282 (254)	220 – 290 (256)	226 – 292 (258)	220 – 298 (267)	224 – 290 (258)	232 – 304 (264)
EC (µS/cm)	1,500	343 – 418 (365)	334 – 412 (359)	332 – 422 (362)	344 – 418 (369)	351 – 417 (369)	345 – 438 (380)

Values in bold indicate exceedance of the NDWQ standard
*average has been calculated assuming <1 is a result of 0.

Nutrients and organics

The presence of nitrates and nitrates in Myitnge River samples during the monitoring period indicates potential contamination with bacteria such as E. coli and faecal coliforms in untreated surface water, although concentrations were considerably lower than NDWQ standards. Average nitrate concentrations ranged between 0.10 mg/L and 0.13 mg/L, with the highest measurement of 0.42 mg/L at SWNR03A, which is two orders of magnitude lower than the NDWQ standard of 50 mg/L. Similarly, nitrite concentrations averaged between 0.002 mg/L and 0.003 mg/L, well below the NDWQ standard of 3 mg/L. Ammonia concentrations were below detection limits at all monitoring events.

Concentrations of organic contaminants (total petroleum hydrocarbons (TPHs), polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), monocyclic aromatic hydrocarbons (MAHs)), fungicides, herbicides and pesticides were below the limit of reporting at all sampling locations in the first round of monitoring in November 2018 and were not continued in following rounds.

Metals and metalloids

Former ore processing at Namtu were divided into two main areas; the 32 Mile concentrator and tailings disposal areas on the southern bank (between SWNR01 and SWNR03), and the smelter on the northern bank (between SWNR03 and SWNR04). Discharge from Nam Pangyun occurs between SWNR04 and SWNR05.

Both the concentrator and tailings area, and the smelter are likely to be contributing to the observed increase in metal concentrations in the Myitnge River as it passes through Namtu.

Average total concentrations of aluminium, arsenic, iron, lead, manganese, nickel, copper and zinc increases as the Myitnge River received discharge from the Nam La and as it passes the former Namtu Smelter. Reported concentrations show a similar increasing trend as the river passes the former Namtu concentrator and tailings disposal area (32 Mile) on the southern bank of the Myitnge River (see Plate 5.19 and Plate 5.20).

In the Myitnge River upstream of the Namtu smelter at sites SWNR01 to SWNR03, average total lead concentrations ranged between 0.005 and 0.007 mg/L, with maximum measurements of 0.017 mg/L at all three sites exceeding the NDWQ health standard of 0.01 mg/L. Average total lead concentrations at sites downstream of the Namtu smelter (SWNR03A to SWNR05) exceeded the standard, ranging between 0.017 and 0.390 mg/L, representing an order of magnitude increase. Downstream of the smelter at SWNR03A the maximum concentration of manganese (0.437 mg/L) also exceeded the NDWQ health standard of 0.4 mg/L. This was measured in August 2019 and was the only occasion the concentration exceeded the standard at this site.

The geometric mean reported concentrations of zinc in the Myitnge River showed an increasing trend as it passed from upstream (SWNR01) to downstream (SWNR04) of the Namtu concentrator and smelter sites. This increase is observed with other metals to varying degree and is attributed to:

- The impacts of ongoing leaching from tailings and waste storages associated with the Namtu concentrators and Namtu smelter and mobilisation via groundwater, and
- Direct interaction with tailings waste that is thought to have been released to the Myitnge River during historical ore processing activities.

At SWNR05, downstream of the confluence with the Nam Pangyun, average total concentrations of cadmium (0.0066 mg/L), lead (0.390 mg/L), nickel (0.116 mg/L) exceeded the NDWQ health standards of 0.003 mg/L, 0.01 mg/L and 0.07 mg/L, respectively. SWNR05 also exhibited maximum concentrations of arsenic (0.0654 mg/L) and manganese (1.090 mg/L), which exceeded the NDWQ standards of 0.05 mg/L and 0.4 mg/L, respectively. Both measurements were taken in August 2019 and were the only exceedances at this site.

Average total aluminium concentrations at all sites exceeded the NDWQ aesthetic standard of 0.2 mg/L during the monitoring period, ranging between 0.30 mg/L and 0.58 mg/L. The maximum recorded concentrations at all sites were measured in August 2019, indicating a potential correlation with turbidity and TSS concentrations. If results from August are excluded, the average concentrations range between 0.09 mg/L and 0.21 mg/L, with the latter the only site (SWNR05) with an average that exceeds the NDWQ standard. Average iron concentrations do not exceed the NDWQ standard of 1 mg/L at any site, however there is a similar trend to that of aluminium, where the maximum values (2.24 mg/L to 4.91 mg/L) are recorded in August 2019. The measurements from August at all sites, and one measurement in January 2019 at SWNR05 (1.7 mg/L) are the only occasions iron concentrations exceeded the standard. Zinc concentrations exceed the NDWQ aesthetic standard of 3 mg/L at SWNR05 in January 2019 (3.14 mg/L) and August 2019 (8.40 mg/L). These are the only occasions the standard was exceeded, with 0.14 mg/L the highest concentration recorded at any of the other sites.

Plate 5.19 The Myitnge River adjacent to Namtu town at site SWNR03

Plate 5.20 The Myitnge River just downstream of the confluence with the Nam Pangyun

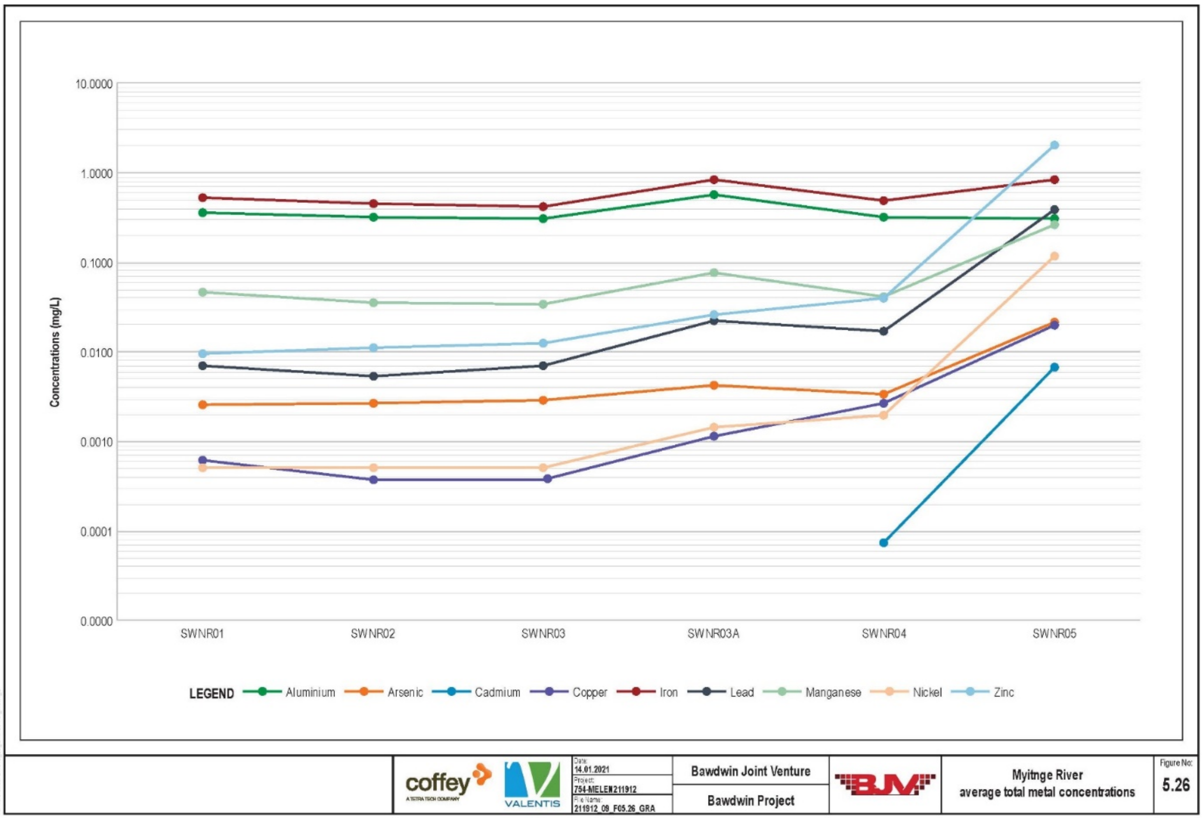

Figure 5.26 Myitnge River average total metals concentrations

Table 5.44 presents the NDWQ standards and total metal concentrations. Concentrations in bold indicate exceedance of the standard.

Dissolved metal concentrations in the Myitnge River catchment are relatively low in comparison to Nam Pangyun and Nam La surface waters. At all sites between SWNR01 and SWNR04, concentrations of dissolved antimony, cadmium, cobalt, copper and nickel were below detection limits at every monitoring event. This is in contrast to results from the Nam Pangyun and Nam La catchments which commonly measured concentrations of these metals exceeding ANZ guidelines. Concentrations of aluminium and manganese at all sites (SWNR01 to SWNR05) were below the ANZ guideline values of 0.055 mg/L and 1.9 mg/L, with all sites recording a maximum aluminium concentration of 0.020 mg/L, and a range of maximum concentrations of manganese between 0.002 mg/L and 0.254 mg/L.

Concentrations of lead exceeded ANZ guideline values of 0.0034 mg/L at all SWNR01, SWNR02, SWNR03 and SWNR05, however the only site with an average concentration to exceed to guideline is SWNR05 (0.0482 mg/L), where all measurements (ranging between 0.007 mg/L and 0.130 mg/L) exceeded the guideline. Maximum concentrations of zinc exceeded the ANZ guideline of 0.008 mg/L by an order of magnitude at all sites, however the only average concentrations of zinc to exceed the guideline were at SWNR03A (0.011 mg/L) and SWNR05 (0.660 mg/L).

Dissolved metal concentrations increased between SWNR04 and SWNR05, downstream of the confluence with the Nam Pangyun. Metals that were previously undetected (antimony, cadmium, cobalt, copper and nickel) were detected at SWNR05, with average concentrations of all these metals except antimony exceeding ANZ DGVs. Maximum concentrations of manganese increased between SWNR04 (0.002 mg/L) and SWNR05 (0.254 mg/L), although they remained below the DGV. Average cadmium concentrations at SWNR05 exceeded the DGV of 0.0002 mg/L by an order of magnitude, at 0.0034 mg/L. At SWNR05, zinc concentrations were up to three orders of magnitude greater than the guideline, with a maximum of 1.780 mg/L measured in November 2018. Average concentrations of zinc increased by two orders of magnitude between SWNR04 (0.007 mg/L) and SWNR05 (0.660 mg/L).

Table 5.45 presents the ANZ DGVs and dissolved metal concentrations. Concentrations in bold indicate exceedance of the standard.

Immediately downstream of the confluence with Nam Pangyun (SWNR05), total and dissolved metal concentrations generally increased due to the discharge of the metal-rich Nam Pangyun waters. This is exemplified in Figure 5.27, showing dissolved cadmium, lead and zinc concentrations in the Myitnge River. Reported metal concentrations during the monitoring period were mostly lower at site SWNR05 in the Myitnge River, downstream of the confluence with the Nam Pangyun, than at SWNP08 in the Nam Pangyun upstream of the confluence with the Myitnge River. For example, average concentrations of lead were an order of magnitude greater at SWNP08 (3.090 mg/L) than at SWNR05 (0.390 mg/L). There is little mixing between the two waterbodies at SWNR05, so effects are likely to be overestimated and concentrations diluted further downstream.

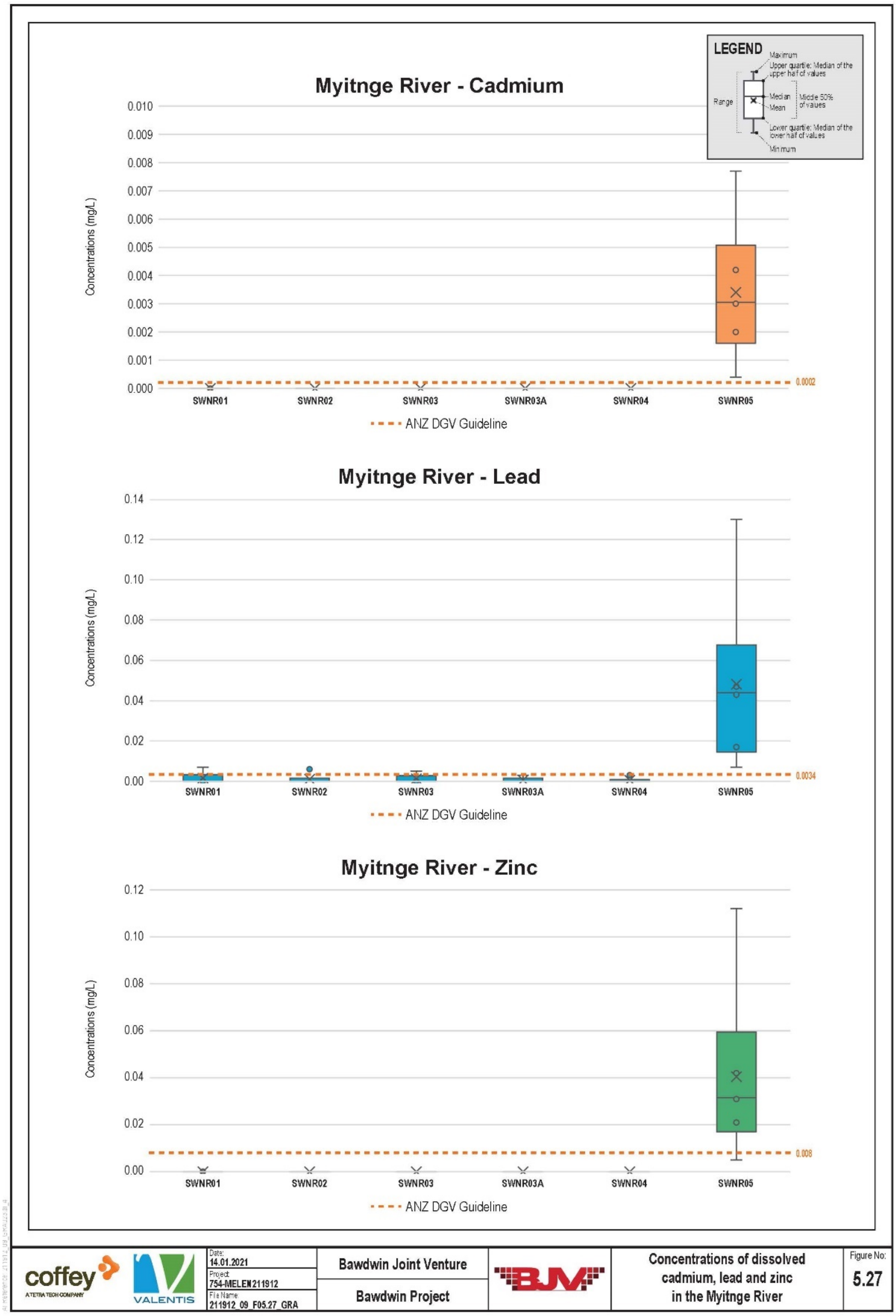

Figure 5.27 Concentrations of dissolved cadmium, lead and zinc concentrations in the Myitnge River

Table 5.44 Total metal concentrations in Myitnge River catchment surface water, compared to NDWQ standards

	NDWQ Standard	SWNR01 Range (mean)	SWNR02 Range (mean)	SWNR03 Range (mean)	SWNR03A Range (mean)	SWNR04 Range (mean)	SWNR05 Range (mean)
NDWQ Health Standards							
Antimony (mg/L)	0.02	<0.0005 - 0.0008 (0.0001)	<0.0005 - 0.0007 (0.0001)	<0.0005 - 0.0007 (0.0001)	<0.0005 - 0.0015 (0.0002)	<0.0005 - 0.0008 (0.0003)	0.0008 - 0.0129 (0.0048)
Arsenic (mg/L)	0.05	0.0019 - 0.004 (0.0026)	0.0018 - 0.0044 (0.0026)	0.0017 - 0.0053 (0.0029)	0.0016 - 0.0106 (0.0042)	0.0018 - 0.0058 (0.0033)	0.0063 - **0.0654** (0.0213)
Barium (mg/L)	0.7	0.02 - 0.04 (0.03)	0.02 - 0.04 (0.03)	0.02 - 0.04 (0.03)	0.02 - 0.06 (0.03)	0.02 - 0.04 (0.03)	0.04 - 0.14 (0.06)
Cadmium (mg/L)	0.003	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001 - 0.0006 (0.0001)	0.0006 - **0.0247 (0.0066)**
Chromium (III+VI) (mg/L)	0.05	<0.001	<0.001	<0.001	<0.001 - 0.005 (0.001)	<0.001 - 0.003 (0.000)	<0.001 - 0.002 (0.000)
Copper (mg/L)	2	<0.001 - 0.003 (0.001)	<0.001 - 0.003 (0.000)	<0.001 - 0.003 (<0.001)	<0.001 - 0.008 (0.001)	<0.001 - 0.018 (0.003)	<0.001 - 0.055 (0.020)
Lead (mg/L)	0.01	<0.001 - **0.017** (0.007)	<0.003 - **0.017** (0.005)	<0.004 - **0.017** (0.007)	<0.013 - **0.128 (0.022)**	<0.007 - **0.062 (0.017)**	**0.054 - 1.01 (0.390)**
Manganese (mg/L)	0.4	0.017 - 0.16 (0.047)	<0.017 - 0.131 (0.035)	<0.017 - 0.135 (0.034)	<0.018 - **0.437** (0.078)	<0.017 - 0.148 (0.041)	0.05 - **1.09** (0.265)
Mercury (mg/L)	0.001	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005 - 0.00008 (0.00001)	<0.00005 - 0.00011 (0.00002)
Nickel (mg/L)	0.07	<0.001 - 0.004 (0.001)	<0.001 - 0.004 (0.001)	<0.001 - 0.004 (0.001)	<0.001 - 0.01 (0.001)	<0.001 - 0.008 (0.002)	0.008 - **0.505 (0.116)**
NDWQ Aesthetic Standards							
Aluminium (mg/L)	0.2	<0.04 - **1.9 (0.37)**	<0.03 - **1.75 (0.32)**	<0.03 - **1.68 (0.30)**	<0.04 **- 3.51 (0.58)**	<0.04 - **1.7 (0.32)**	<0.13 - **0.98 (0.31)**
Calcium (mg/L)	200	38.4 - 43.3 (42.3)	39.6 - 43.3 (41.8)	39.2 - 43.9 (41.7)	37.8 - 43.7 (41.0)	37.4 - 44.2 (41.9)	39.4 - 44.2 (42.5)
Iron (mg/L)	1	<0.072 - **2.45** (0.525)	<0.068 - **2.19** (0.451)	<0.089 - **2.12** (0.422)	<0.095 - **4.91** (0.823)	<0.077 - **2.24** (0.482)	<0.257 - **2.66** (0.824)
Magnesium (mg/L)	150	16.2 - 26.9 (23.09)	16.3 - 26.3 (22.80)	16.8 - 26.5 (22.96)	16.2 – 26 (22.85)	16.3 - 26.3 (22.80)	16.3 - 26.6 (22.41)
Sodium (mg/L)	200	1.4 - 11.1 (4.2)	1.4 - 10.3 (3.8)	1.4 - 11.8 (4.3)	1.4 – 15.0 (5.7)	1.5 - 12.6 (4.5)	1.4 - 16.6 (6.3)
Zinc (mg/L)	3	<0.005 - 0.03 (0.01)	<0.005 - 0.032 (0.01)	<0.005 - 0.036 (0.01)	0.011 - 0.084 (0.03)	0.009 - 0.135 (0.04)	0.135 - **8.4** (2.05)

<LOD = below limit of detection

Values in bold indicate exceedance of the NDWQ standard. Measurements below detection limits were assumed to be zero for the purpose of calculating average concentrations

Table 5.45 Dissolved metal concentrations in Myitnge River catchment surface water, compared to ANZ DGVs

	ANZ DGVs	SWNR01 Range (mean)	SWNR02 Range (mean)	SWNR03 Range (mean)	SWNR03A Range (mean)	SWNR04 Range (mean)	SWNR05 Range (mean)
Aluminium	0.055*	<0.01 - 0.02 (0.003)	<0.01 - 0.02 (0.003)	<0.01 - 0.02 (0.003)	<0.01 - 0.02 (0.004)	<0.01 - 0.02 (0.003)	<0.01 - 0.02 (0.003)
Antimony	0.009	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005 - 0.0024 (0.0008)
Arsenic	0.013**	0.0012 - 0.0032 (0.0021)	0.0012 - 0.0035 (0.0021)	0.0011 - 0.0042 (0.0024)	0.0013 - 0.0051 (0.0031)	0.0011 - 0.0053 (0.0028)	0.0014 - 0.0051 (0.0029)
Cadmium	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	**0.0004 - 0.0077 (0.0034)**
Cobalt	0.0014	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001 - **0.081 (0.022)**
Copper	0.0014	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001 - **0.007 (0.0032)**
Lead	0.0034	<0.001 - **0.007** (0.0015)	<0.001 - **0.006** (0.0010)	<0.001 - **0.005** (0.0012)	<0.001 - 0.003 (0.0006)	<0.001 - 0.003 (0.0005)	**0.007 - 0.13 (0.0482)**
Manganese	1.9	<0.001 - 0.015 (0.004)	<0.001 - 0.002 (<0.001)	<0.001 - 0.005 (0.001)	<0.001 - 0.002 (0.000)	<0.001 - 0.002 (0.000)	<0.001 - 0.254 (0.058)
Nickel	0.011	<0.001	<0.001	<0.001	<0.001	<0.001	0.005 - **0.112 (0.041)**
Zinc	0.008	<0.005 **- 0.022** (0.006)	<0.005 - **0.011** (0.005)	<0.005 - **0.023** (0.007)	**0.008 - 0.014 (0.011)**	<0.005 - **0.014** (0.007)	**0.06 - 1.78 (0.660)**

<xx = below limit of detection

Bold indicates the value exceeded DGV. Values in bold indicate exceedance of the DGV. Measurements below detection limits were assumed to be zero for the purpose of calculating average concentrations

*Guideline is 0.055 mg/L where pH is >6.5, 0.0008 where pH is <6.5. However, as the sites had average pHs of >6.5 over the monitoring period, the 0.055 mg/L guideline value was adopted.

** Guideline is 0.013 mg/L for As(V) and 0.024 mg/L for As(III). In the absence of knowledge of arsenic speciation in the waters, the more conservative guideline value for As(V) has been adopted.

Sediment Quality

Stream sediment from S7, located downstream of the tailings dump at Namtu was reddish-brown gravelly sand. This sediment exhibited a higher alkalinity (4,710 mg/kg) than samples from the Nam Pangyun catchment (S1 to S6) (ranging between 60 and 322 mg/kg). The conductivity in water of the sample from S7 (136 µS/cm) was higher than samples from the Nam Pangyun catchment (11 to 110 µS/cm).

S7 had higher metal concentrations in stream sediment samples compared to those in the Nam Pangyun catchment (Table 5.46). Arsenic, antimony, cadmium, copper, nickel, lead, silver and zinc all exceeded the DGV and GV-high at this site. The concentration of zinc at S7 were greater than 20,000 mg/kg, approximately 50 times greater than the GV-high of 410 mg/kg. PAHs were detected in the sediment from S7 (0.25 mg/kg) at levels lower than the DGV (10 mg/kg).

Table 5.46 Toxicant concentration in stream sediment sample from S7

Toxicant	ANZ DGV	ANZ GV-High	S7
Antimony (mg/kg)	2.0	25	**972.0**
Arsenic (mg/kg)	20	70	**4,800**
Cadmium (mg/kg)	1.5	10	**125.00**
Chromium (mg/kg)	80	370	45
Copper (mg/kg)	65	270	**7,840**
Lead (mg/kg)	50	220	**>5,000**
Mercury (mg/kg)	0.15	1.5	**3.01**
Nickel (mg/kg)	21	52	**2,094**
Silver (mg/kg)	1.0	4.0	**181.00**
Zinc (mg/kg)	200	410	**>20,000**
PAHs (mg/kg)	10	50	0.25
Total hydrocarbons* (mg/kg)	280	550	43

Bold indicates concentration exceeding DGV. Shading indicates concentration exceeding GV-high

* Results are for total recoverable hydrocarbons and the ANZ DGV is for total petroleum hydrocarbons, however the comparison is made for indicative purposes

5.3.4 Summary

Catchment hydrology in the Bawdwin project area is characterised as:

- Steeply dissected vee-shaped valleys in the mountainous region formed by high-energy stream erosion. The resultant steep upland terrain is characterised by high runoff, flash flows during wet months.
- Streams are supported with year-round flow from numerous groundwater springs.
- Surface water in the Nam Pangyun and Nam La catchments support a range of extractive uses including potable water supply, agriculture and industrial uses (predominantly mining and ore processing).

The existing surface water quality at monitoring sites in the Nam Pangyun, Nam La and Myitnge River catchments during the monitoring period shows:

- The physico-chemical water quality parameters (turbidity, pH, TSS, hardness, TDS and EC) rarely exceeded NDWQ standards within the study area, with the exception of turbidity. Turbidity was often above NDWQ standards in the Nam Pangyun and Nam La catchments and in some locations, such as the downstream Nam Pangyun catchment. This can be attributed to other activities causing disturbance in the catchment.
- The Nam Pangyun is highly degraded, due to historical mining activities at Bawdwin. Water quality in the lower catchment is highly contaminated by discharge from Tiger Tunnel, characterised by elevated

levels of total and dissolved metals. Total and dissolved metal concentrations frequently exceeded NDWQ standards and ANZ DGVs.

- Water discharging from the historical mine workings to the Nam Pangyun (predominantly via Tiger Tunnel) exceeds the Myanmar draft national environmental quality emissions guidelines.
- Additional sources of contamination such as anthropogenic contamination (waste and sewage disposal, agricultural practices etc) are present across the Nam Pangyun and Nam La catchments, and artisanal mining in the lower Nam Pangyun catchment are having a measurable effect on water quality.
- Contamination of the Nam Pangyun precludes most beneficial uses of surface water to the downstream communities and has resulted in a significantly degraded aquatic ecosystems.
- Sediments in the lower Nam Pangyun catchment are extensively impacted by mining waste (waste rock and smelter slag) and attract artisanal mining activities. These artisanal mining activities are also contributing to degraded water quality in the lower Nam Pangyun catchment (particularly TSS and total metal concentrations).
- The Nam La is relatively undisturbed compared to the Nam Pangyun, with low concentrations of most metals.
- There was substantial temporal variability between sampling events and seasonal or temporal trends were not apparent (Figure 5.28).
- The Myitnge River has low but increasing concentrations of several total and dissolved metals as it passes the former 32 Mile concentrator and tailings disposal area, and the former Namtu smelter. The contribution of metals from these source areas is likely to be via a combination of surface runoff, contaminated groundwater discharge, and direct leaching of historical mine waste that may have been disposed to the Myitnge River.
- A more significant increase in total and dissolved metal concentrations are observed downstream of the confluence with the Nam Pangyun (SWNR05), where concentrations of several metals became markedly elevated and exceeded NDWQ standards and ANZ DGVs. Reduced water quality in the Nam Pangyun (attributed to discharge from the Tiger Tunnel) is having a measurable effect on the downstream quality of the Myitnge River.
- Despite receiving direct sewage discharge from villages along the Nam Pangyun and Nam La, neither appear to be significantly degraded by this, with both reporting levels of nutrients below the NDWQ standards. The presence of nutrients, albeit below standards, may indicate presence of *E. coli* and faecal coliforms.

Figure 5.29 provides a comparison of dissolved cadmium, lead and zinc in the catchments, an example highlighting the significant degradation of the Nam Pangyun compared to the Nam La and Myitnge River catchments.

Parameters which exceed NDWQ standards suggest the water quality is not suitable for drinking for either health or aesthetic reasons, depending on the parameter. The Australian and New Zealand (ANZ) water quality default guideline values (ANZ DGVs) correspond to different levels of protection based on the condition of the water quality. The watercourses in the study are considered to be slightly to moderately disturbed ecosystems. Exceedance of a DGV implies the parameter is likely to be toxic to slightly to moderately disturbed ecosystems.

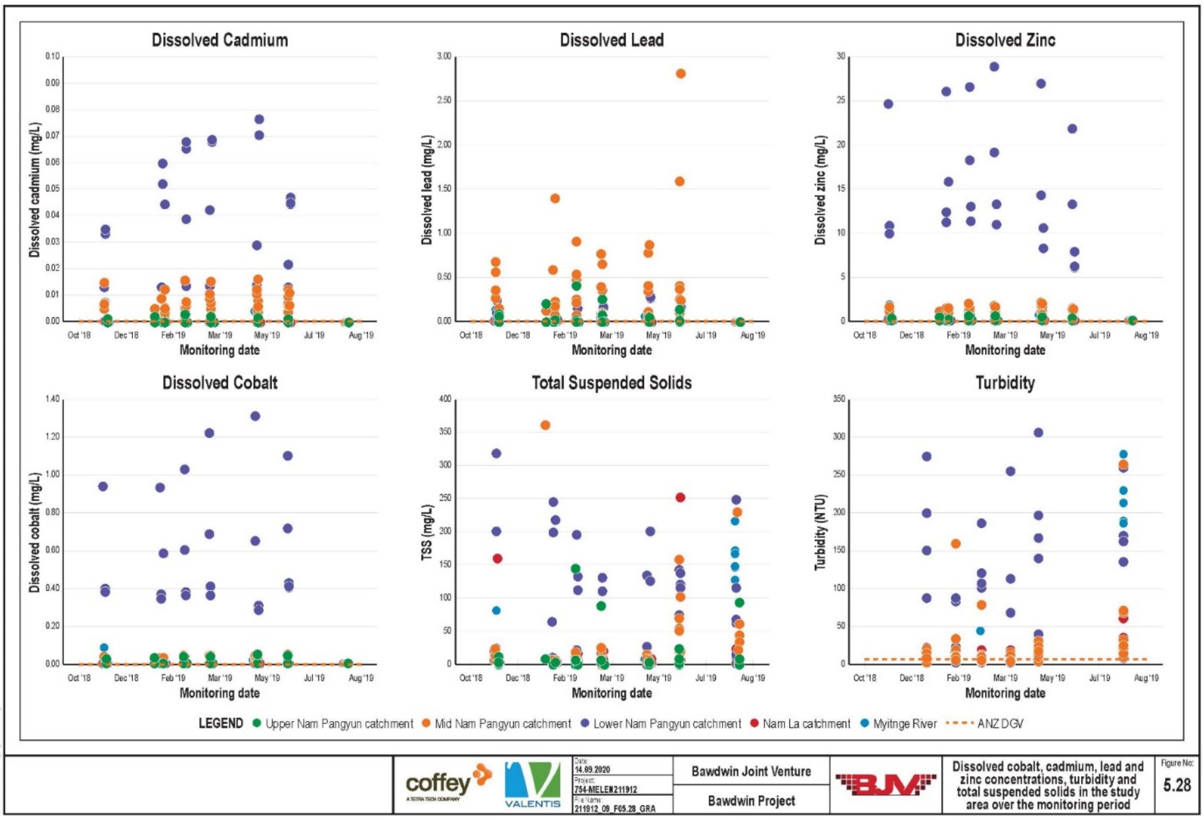

Figure 5.28 Dissolved cobalt, cadmium, lead and zinc concentrations, turbidity and total suspended solids in the study area over the monitoring period

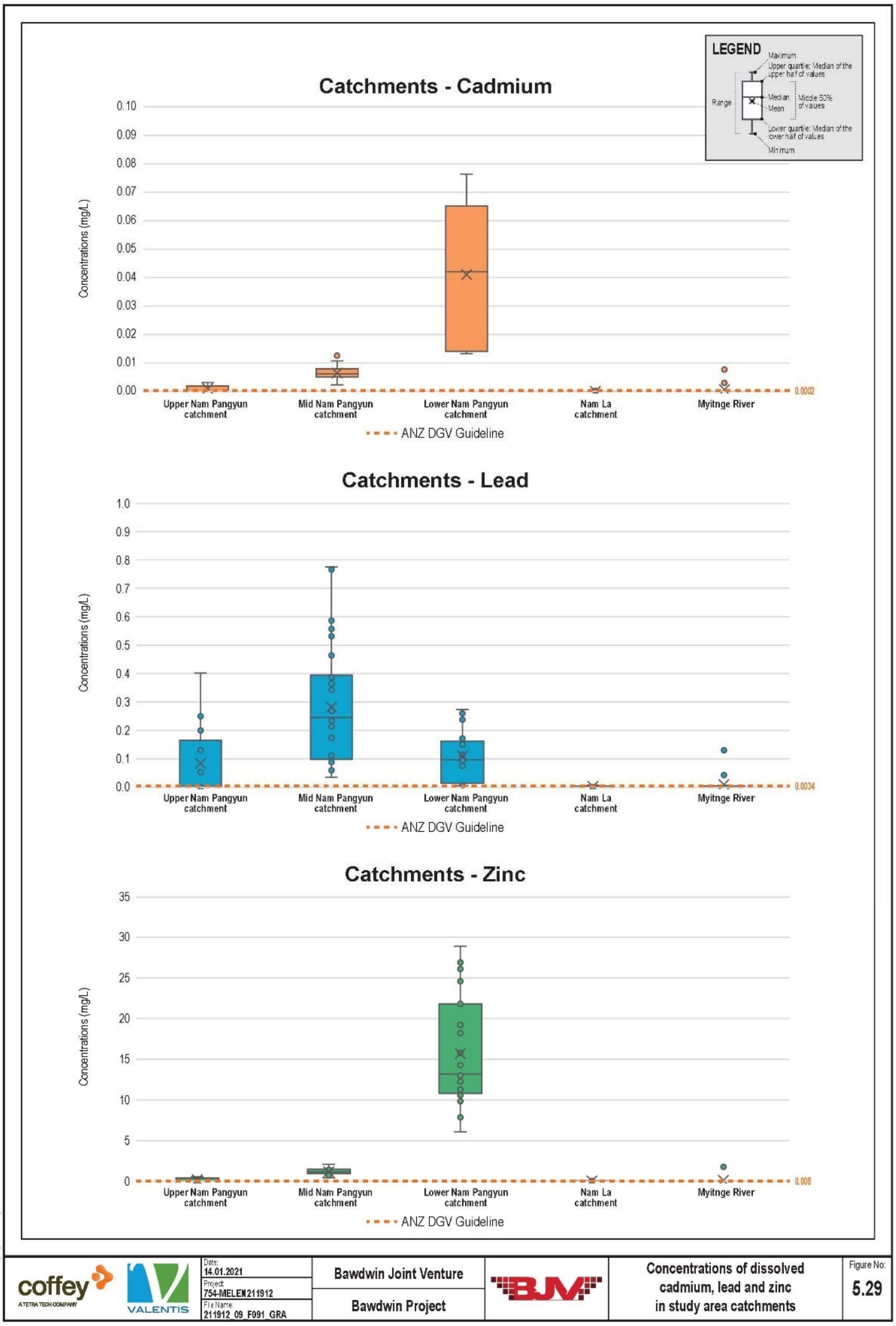

Figure 5.29 Concentrations of dissolved cadmium, lead and zinc in study area catchments

5.3.5 Sensitivity of surface water values

This section describes the overall sensitivity for the key surface water values identified in the study area, the Nam Pangyun, Nam La and Myitnge River, in terms of their importance, vulnerability and resilience. Sensitivity in this context is a quantification of how sensitive the surface water values are to change as a result of the project. Sensitivity is based on the importance of the value, the vulnerability of the value to change, and the resilience of the value in terms of its ability to overcome changes and maintain its inherent value.

The importance of each watercourse was determined by considering the current and potential future uses of the surface water and its intrinsic value. Current uses have been based on observations made in the study area and from consultation with local communities. The potential future use takes into account the water quality limitations for a use. The vulnerability of each value to potential project impacts is defined by considering its location with respect to the project, relationship to other values and current condition. The resilience of each value to potential project impacts is defined by considering the ability of a value to respond to a change/disturbance by resisting damage and/or recovering quickly to its original value.

The surface water-specific definitions for the varying levels of importance, vulnerability and resilience that were adopted in this assessment are provided in Table 5.47. Table 5.48 outlines the importance, vulnerability, and resilience for each value, based on a low, medium and high scale as outlined in Table 5.47.

Table 5.47 Importance, vulnerability and resilience definitions and ratings criteria

	Definition	Ratings criteria		
		Low	Medium	High
Importance	The value that is associated with surface water feature in its current form. This includes the ability of the feature to support ecosystems and beneficial uses.	Has limited or no potential to support aquatic ecosystems or be a source of water for beneficial uses.	Supports some beneficial uses or has medium potential to support aquatic ecosystems or a be a source of water for beneficial uses.	Supports, or has the ability to support aquatic ecosystems and be a source of water for beneficial uses.
Vulnerability	The extent to which the surface water feature is susceptible to change. This includes the existing condition of the feature in terms of its physical and chemical properties and how readily additional change may cause deterioration or loss of associated ecosystems or water use value.	Low susceptibility to degradation (in terms of physical, chemical and streamflow characteristics). High existing contamination.	Medium susceptibility to degradation (in terms of physical, chemical and streamflow characteristics). Medium level of existing contamination.	High susceptibility to degradation (in terms of physical, chemical and streamflow characteristics) Low level of existing contamination.
Resilience	The extent to which the surface water feature can adapt or recover from change. In this context, this relates to how readily the feature could naturally recover from change.	Limited or no capacity to adapt to change and the associated ecosystem value or use cannot be regained.	Some resilience to change. Some of the associated ecosystem value or use can be regained.	Easily adaptable to change and most or all of the associated ecosystem value or use can be regained.

Table 5.48 Summary of surface water values and their sensitivity

Surface water value	Importance	Vulnerability	Resilience	Sensitivity
Ability to support ecosystems and beneficial uses - Nam Pangyun – upper catchment	**Medium** In some areas in the upper catchment water supports aquatic ecosystems and has the potential to support a range of beneficial uses.	**Medium** Currently exhibits moderate water quality, and is of better quality than the mid and lower catchment. Stream habitat is in relatively good condition and is better than the mid and lower catchment. Vulnerable to further deterioration of stream habitat and water quality The vulnerability to flood risk is considered high as the Nam Pangyun catchment is characterised by rapid flood response to high rainfall events.	**Medium** Some resilience to change. Some of the associated ecosystem value or use can be regained.	**Medium**
Ability to support ecosystems and beneficial uses - Nam Pangyun – mid catchment	**Low** Highly modified and degraded watercourse with poor water quality due to historic mining activities. Water is not used for drinking water. Has limited or no potential to support aquatic ecosystems or be a source of water for beneficial uses.	**Low** The watercourse has been impacted by historic mining and ongoing exposure to contaminants, including sewage from Bawdwin villages, there is limited vulnerability to further changes.. The vulnerability to flood risk is considered high as the Nam Pangyun catchment is characterised by rapid flood response to high rainfall events.	**Medium** Some resilience to change. Some of the associated ecosystem value or use can be regained.	**Low**
Ability to support ecosystems and beneficial uses - Nam Pangyun – lower catchment	**Low** Highly modified and degraded watercourse that has limited or no potential to support aquatic ecosystems or be a source of water for beneficial uses.	**Low** The watercourse has been impacted by historic mining, including the discharge of poor quality water from the Tiger Tunnel, habitat is highly degraded. There is little vulnerability to further changes. The vulnerability to flood risk is considered high as the Nam Pangyun catchment is characterised by rapid flood response to high rainfall events.	**Medium** Some resilience to change. Some of the associated ecosystem value or use can be regained.	**Low**
Ability to support	**High**	**High**	**Medium**	**High**

Surface water value	Importance	Vulnerability	Resilience	Sensitivity
ecosystems and beneficial uses - Nam La	Largely undisturbed compared to the Nam Pangyun and is an important source of water for agriculture/irrigation, industrial use, drinking water in nearby communities.	Nam La has relatively good water quality and habitat condition and is vulnerable to degradation particularly during the dry season when flows are limited. Existing conditions in the Nam La are characterised by rapid response to storm events and flash flooding. The catchment is likely to be vulnerable to increased flows, particularly when they coincide with high rainfall events.	Nam La surface water is somewhat resilient to change due to its alkalinity and hardness, which reduce bioavailability and toxicity of some metals.	
Ability to support ecosystems and beneficial uses - Myitnge River	**High** Provides an important source of water for recreation, agriculture/irrigation, industrial use, drinking water and other consumptive uses to communities.	**High** Vulnerable to further changes due to its relatively good water quality and habitat condition compared to the Nam Pangyun	**Medium** May be able to withstand localised and temporary impacts due to its size and flow.	**High**

5.3.6 Uncertainties and limitations

A robust data set relating to the collection of surface water characteristics has been collected over a 10-month monitoring period. Notwithstanding the robustness of this data there were a number of limitations. These included:

- The effect of stream flow on water quality and the responses of water quality to rainfall and storm events is an uncertainty due to the lack of concurrent stream flow and water quality sampling and lack of water quality monitoring during storm events.
- The assessment of stream flow has been based on a limited data set within the mid Nam Pangyun catchment. Further stream monitoring is being collected to gain a full understanding of baseline flow conditions, seasonal trends in flow conditions, and flow conditions associated with storm events.
- Assessment of streambed sediment quality to date has focussed on the Nam Pangyun, which is expected to have been influenced by historical mining activities. No comparison can be made to adjacent areas such as the Nam La catchment.
- Microbiological water quality parameters are subject to short holding times that could not be met due to the inherently long international sample transport time, limited domestic laboratory alternatives of suitable quality, and delays in export permissions. However, key parameters of interest (such as metals) are considered to have lower potential for impact by longer sample holding time, and this is unlikely to have materially affected the conclusions of the baseline groundwater assessment.
- There were no monitoring points in the Myitnge River downstream of SWNR05, located near the confluence of the Myitnge River and Nam Pangyun. Any mixing or dilution of the Nam Pangyun discharge in the Myitnge River further downstream is an area of uncertainty.

5.4 Meteorology

Myanmar, as a whole, has a monsoon climate. However, climatic patterns are heavily influenced by the country's geography lying between the Indian Ocean to the south and extensive mountain ranges in the north. These mountain ranges prevent cold air masses of Central Asia (in November to March) from moving into the interior of the country. Therefore, the climate for most of the country is driven by monsoon winds. The climate has three main seasons: the cool, relatively dry northeast monsoon between late October to mid-February; the hot, dry inter-monsoonal season between mid-February to mid-May; and the rainy southwest monsoon season between mid-May to late October.

From mid-December during the cool season, the calm weather is broken by sporadic low intensity rain events that can continue through January and February. Between March and mid-May during the hot season, there is a continuous and rapid rise of temperature and the winds are variable. The wet season typically commences around May, with storms forming in central Myanmar that are often accompanied by strong winds, hail and torrential rain. By November the monsoon rains typically stop, and then clear skies and fine weather dominates as cool season commences. This season also experiences lower temperatures and humidity compared to other seasons.

Based on the Köppen–Geiger climate classification system, the higher terrain in Northern Shan State is classified as a 'hot-summer Mediterranean climate'. The mine area experiences seasons as described in the section above. The region experiences a monsoonal climate, but is moderated by its elevation of about 1,000 m.

Rainfall (total) and temperature (maximum and minimum) has been recorded manually at the Bawdwin main office on a monthly basis since 1936 using a rain gauge and thermometer. In total there are 62 complete years of monthly rainfall data between 1937 and 2019 excluding two periods where consecutive monthly rainfall data is unavailable (from 1942 to 1947 and from 1981 to 1994). In June 2000, the frequency of rainfall and temperature data collection moved from monthly to daily. In July 2019, an automatic weather station (Davis Instruments Vantage Pro 2) was installed to collect meteorological parameters including rainfall, wind speed and direction, and relative humidity. A second Vantage Pro 2 weather station was installed near the Nam Pangyun Reservoir (Big Dam) in January 2020.

Myanmar is considered to be vulnerable to impacts of climate change (Aung et al., 2017). Climate trends from 19 weather stations across Myanmar between 1981 and 2010 indicate that average daily temperatures increased by 0.25°C per decade and daily maximum temperatures by 0.4°C per decade (Horton et al., 2017). Research suggests that the monsoon season has become shorter by approximately one week on average (Lwin, 2002).

5.4.1 Rainfall

Based on the long-term manual rainfall measurements the average annual rainfall at Bawdwin is 1,569 mm and has ranged from a minimum of 1,130 mm in 2005 to a maximum of 1,953 mm in 1959.

Sporadic heavy rainfall occurs in the wet season typically between May and October, with August being the wettest month, receiving almost 300 mm on average. The wettest month on record was July 2015 in which rainfall of 671 mm was recorded. The maximum daily rainfall on record (between 2000 and 2019) was 108.7 mm.

Average monthly rainfall averages at Bawdwin are presented in Figure 5.30 along with the total monthly precipitation for 2018 and 2019. The average number of rainfall days per month ranges from 14 days in May, peaking at 20 days in July, and then declining. Little rainfall is experienced between November and April. Rainfall at Namtu follows a similar trend to that at Bawdwin, with July experiencing the most rainfall over the highest number of rainy days based on modelled meteorological data.

The lowest rainfall is experienced between December and February with very few rainy days occurring each month.

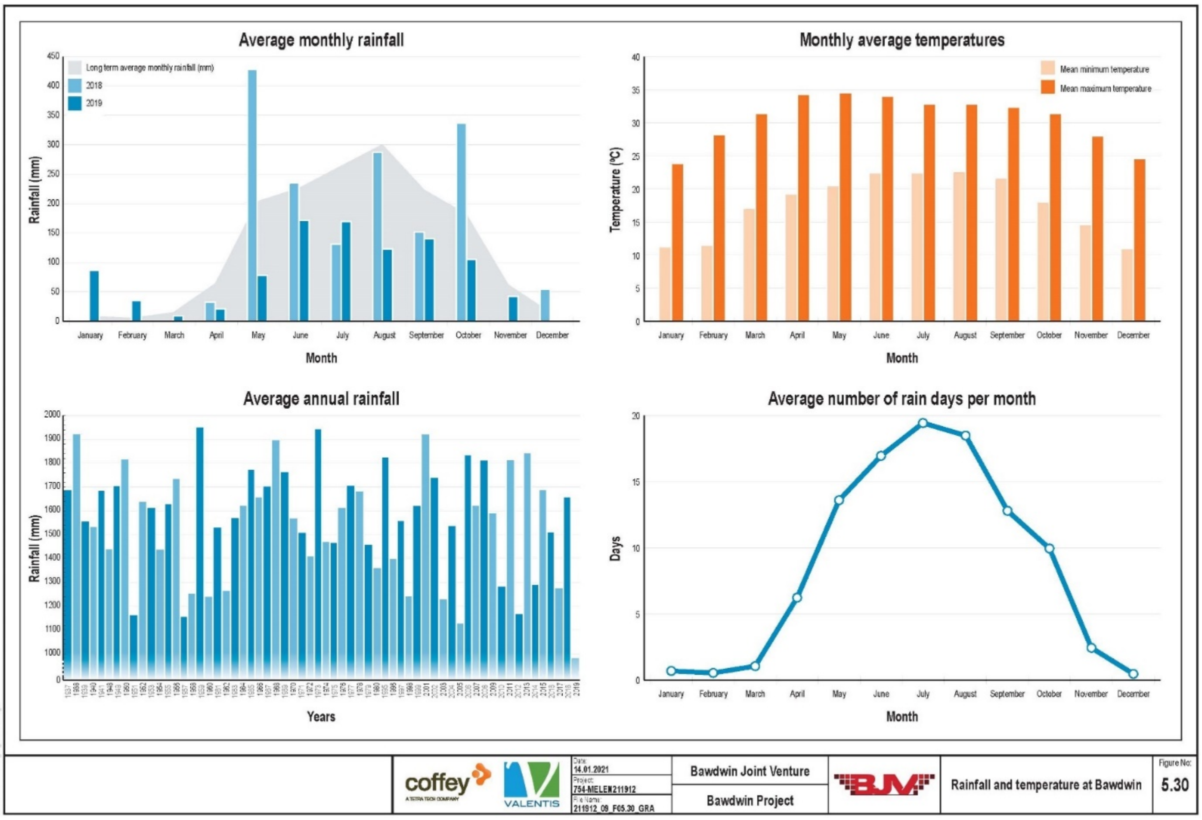

Figure 5.30 Rainfall and temperature at Bawdwin

CSA Global (2020) compared the average monthly rainfall for the 2010 to 2019 (daily records) alongside the 1937 to 2019 period (monthly totals). These showed some minor differences, but the two datasets were closely correlated and showed the same seasonal pattern. Average annual rainfall totals for the respective periods, and typical wet and dry months (represented by 70th and 30th percentile values) are shown in Table 5.49.

Table 5.49 Monthly rainfall averages

Month	Average Rainfall: 2010-2019 (mm)	Average Rainfall: 1937-2019 (mm)	70%ile Rainfall (Wet) 1937-2019(mm)	30%ile Rainfall (Dry) 1937-2019 (mm)
January	16	8	6	0
February	6	6	5	0
March	20	15	18	0
April	47	64	80	32
May	179	203	222	150
June	218	226	262	170
July	260	264	295	212
August	261	298	336	247
September	208	223	259	172
October	198	179	226	120
November	33	57	61	9
December	10	16	6	0
Total	**1,451**	**1,559**	**1,690**	**1,463**

Source: CSA, 2020

Approximately 40% of the monthly rainfall totals in the 1937 to 2019 dataset fall within the range of the respective typical wet (70%ile) and dry (30%ile) month rainfall totals. It is notable that the recorded annual rainfall between 2010 and 2019 was approximately 100 mm (or 7%) less than the historical average between 1937 and 2019.

Knight Piésold (Appendix A) estimated monthly rainfall for average and extreme dry and wet events based on a 1 in 100 average recurrence interval (ARI). The results of the annual rainfall pattern analysis are given in Table 5.50.

Table 5.50 Summary of monthly rainfall analysis

Month	Average Rainfall[1] (mm)	1 in 100 Dry ARI[2] (mm)	1 in 100 Wet ARI[3] (mm)
January	7	9	36
February	5	1	23
March	15	0	8
April	65	6	36
May	205	70	271
June	227	331	363
July	264	160	413
August	304	212	332
September	228	169	332
October	179	106	244
November	55	0	7
December	14	0	1
Total	**1,568**	**1,065**	**2,066**

[1] Mean average of measured monthly rainfall.

[2] Data obtained from scaling the monthly rainfall from the driest year (1957 with 1,158 mm) to provide an annual rainfall depth matching the 1 in 100 ARI dry annual rainfall of 1,065 mm.

[3] Monthly rainfall obtained from scaling the monthly rainfall from the wettest year (1959 with 1,953 mm) to provide an annual rainfall depth matching the 1 in 100 ARI wet annual rainfall of 2066 mm.

5.4.2 Temperature

The mean monthly maximum temperature manually recorded at Bawdwin in the period 2000 to 2018 ranges from 24°C in January to 34°C in April and May. The mean monthly minimum temperature ranges from 11°C in December and January, to 22°C in June, July, August and September (see Figure 5.30).

The average monthly maximum temperature at Namtu follows a similar trend and ranges from 22°C in January to 31°C in April. The mean monthly minimum temperature ranges from 8°C in January to 22°C in June, July and August.

Anecdotal observations suggest that the Bawdwin area does not experience static temperature inversions, which is likely due to the steep valley gradients and free air movement. Such inversions are relatively commonly at Namtu where static atmospheric conditions occur with little movement of air. Surface inversions are caused due to cooling of the ground surface at night due to rapid rate of loss of heat from the ground. The air coming in contact with the cool ground surface also becomes cold while the air layer lying above is relatively warm. Consequently, temperature inversion develops because of cold air layer below and warm air layer above.

5.4.3 Humidity

The weather station at Bawdwin recorded humidity levels daily between September 2019 and May 2020 (primarily the dry season with May being the start of the wet). The results show that January and May recorded the highest average humidity levels of 73.0% and 70.2% respectively. March recorded the lowest average humidity level of 51.4%, this is consistent with humidity levels in Myanmar broadly.

Based on climate models prepared by Meteoblue (Meteoblue, 2020), relative humidity in Namtu in 2019 was highest between June and November with relative humidity typically above 80%. Relative humidity then steadily declined with the lowest relative humidity occurring in April and May with levels below 70%.

5.4.4 Wind speed and direction

Wind patterns at Bawdwin are strongly influenced by the surrounding topography. The weather station at Bawdwin has recorded wind speed and direction from September 2019 to May 2020. During this nine-month period, wind speeds at Bawdwin ranged from calm to a light breeze (0 m/s to 2.4 m/s) and the strongest winds were recorded during January. South-southwesterly winds prevailed in each of the recorded months with the second most dominant wind being in a southerly direction. Figure 5.31 and Figure 5.32 depict wind roses from the months of September to December 2019 and January to May 2020, respectively.

Based on climate models prepared by Meteoblue, the annual prevailing wind at Namtu is in a southerly direction. Here the monsoon creates steady strong winds from December to April, and calm winds from June to September. During 2019, modelled wind speeds were strongest between February and May when northwesterly winds dominated. This is supported by anecdotal observations of strong gusts during this period.

Prevailing winds then eased and shifted to a south-westerly between June through early September before tending south southeasterly between late September through to January.

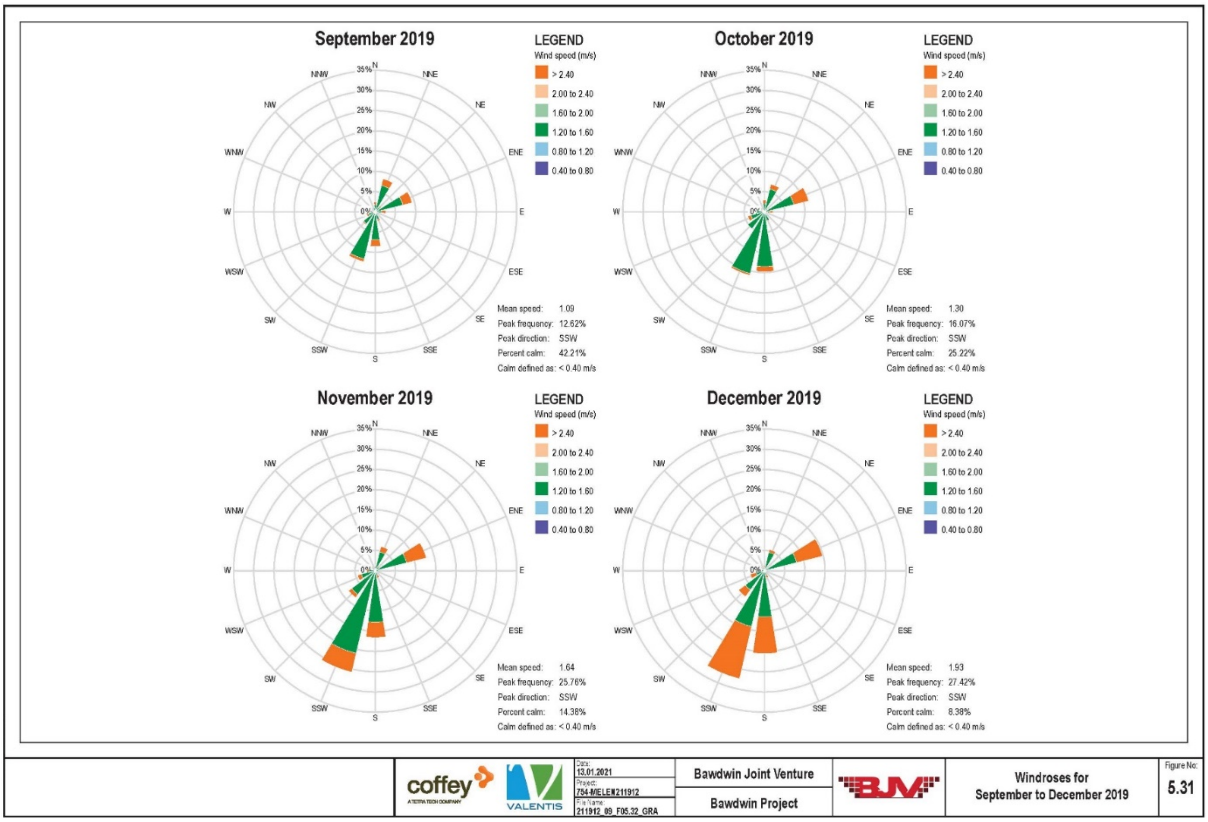

Figure 5.31 Windrose for September to December 2019

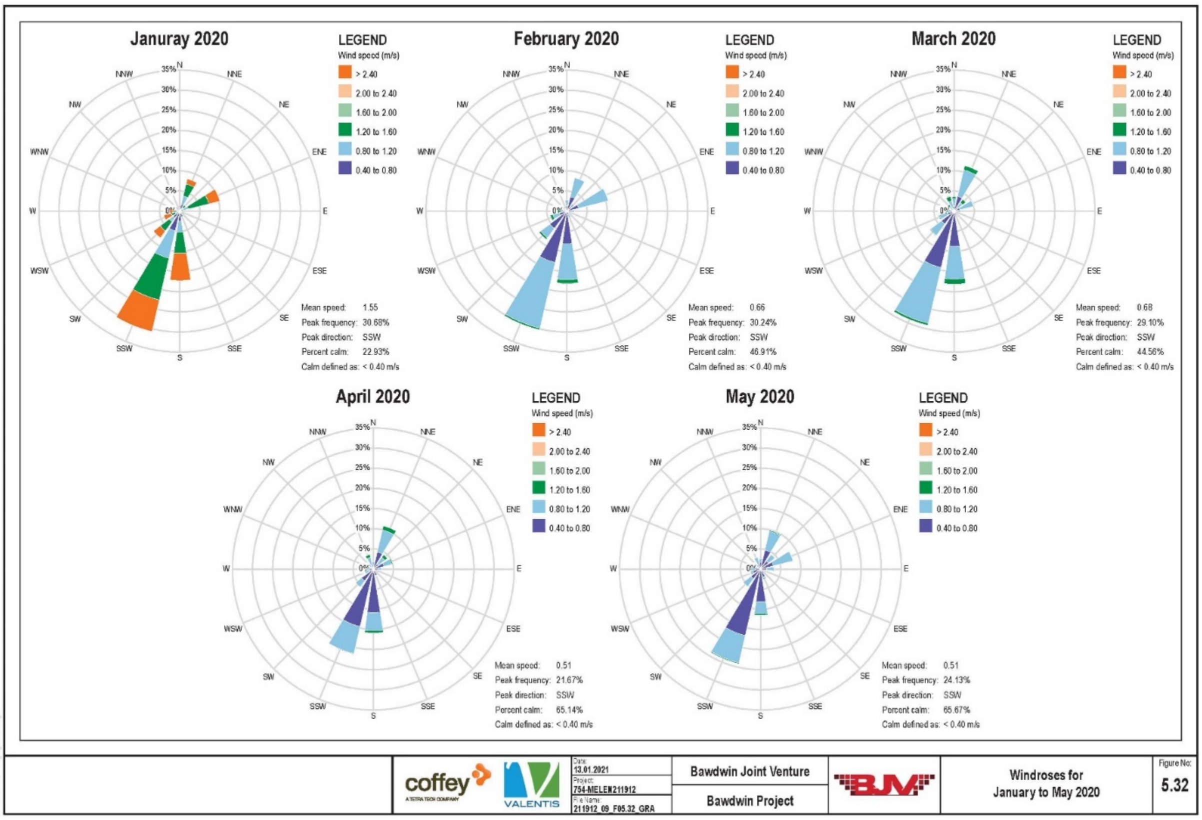

Figure 5.32 Windroses for January to May 2020

5.5 Air quality

This section describes the existing air quality in relation to the Bawdwin project and describes the sensitivity of related environmental values.

The information in this section is largely based on air quality monitoring conducted between November 2018 and September 2019. The monitoring was conducted to characterise the existing air quality within the Bawdwin concession and surrounds. This section is also informed by review of historical reports and publicly available literature.

Considering the context of the Bawdwin project, a brownfields development site in a remote mountainous area, the focus of the air quality characterisation has been on particulate matter, dust, metals in particulates and to a lesser extent, emissions adjacent to roads.

The term particulate matter is used to define solid or liquid particles that may be suspended in the atmosphere, which is commonly used interchangeably with other terms such as smoke and dust. Particulate matter can have adverse impacts on the environment, human health and amenity. The extent of the potential impact is dependent on the size of the particles, the concentration of the particulate matter (i.e., the mass of particulate matter that is suspended per unit volume of air, measured in micrograms per cubic metre ($\mu g/m^3$)) in the atmosphere and the rate of deposition (i.e., mass of particulate matter that settles per unit surface area, measured in grams per square metre (g/m^2)).

Particulate matter can be described with different terms based on its particle size. The terms used in this study are:

- Dust; which comprises solid particles ranging from 1 micrometre (µm) to 100 µm.
- Total suspended particles (TSP); which comprises particles with a diameter of less than 50 µm.
- Particulate matter with diameter less than 10 µm (PM_{10}).
- Particulate matter with diameter less than 2.5 µm ($PM_{2.5}$).

Dust is generated by a range of activities, including industrial activities and traffic and natural sources such as pollen and ash. Particles larger than PM_{10} tend to have a short atmospheric presence and are brought to the ground by gravity. The health impacts of larger dust particles (i.e., greater than PM_{20}) are, generally, not significant as they become trapped in the nose and mouth and can be breathed out. However, dust can impact visibility, causing safety issues on roads and in tunnels, and can also impact the health of plants. Particles this size can build-up on surfaces, including inside buildings.

Particulate matter with a diameter less than 10 µm are associated with health impacts including heart and respiratory diseases. Very fine particles (i.e., $PM_{2.5}$) are generated mostly through combustion processes and vehicle exhaust. These can enter the lungs and bloodstream. Short-term exposure has effects ranging from eye irritation to heart attacks. Long-term impacts can reduce lung function and life expectancy, as well as cause the development of cardiovascular diseases.

Heavy metals can be emitted to the environment as a result of various industrial activities, resulting in elevated concentrations of metals in the air. Mining activities, particularly lead, silver and zinc extraction, have been associated with this kind of environmental pollution and have known adverse impacts to human health. Assessing the concentrations of metals in the environment (i.e., particulate matter) was therefore a focus of baseline air quality monitoring.

Gaseous compounds can also act as pollutants and adversely impact air quality. Such gases include sulfur dioxide (SO_2) and nitrogen dioxide (NO_2). These are commonly generated by air emissions from vehicles and power generators. High levels of exposure to these two components can lead to impacts on human health, as well as the environment.

5.5.1 Method and study area

A monitoring program to characterise existing air quality for the project was conducted between November 2018 and September 2019. This ensured that data was captured during each of the three seasons (i.e., dry northeast monsoon between late October to mid-February, dry inter-monsoonal season between mid-February to mid-May and rainy southwest monsoon mid-May to late October) as described in Section 0.

Air quality monitoring locations are presented in Figure 5.33. The air quality study area covered mine infrastructure and residential areas of the Bawdwin concession and some parts of Namtu township and was designed to characterise the main air sheds of Bawdwin and Namtu. The methods used to characterise the ambient air quality conditions are presented in Table 5.51.

Table 5.51 Air quality study methods

Parameter	Method
Particulate matter (TSP, PM_{10} and $PM_{2.5}$)	A high-volume air sampler (HVAS) (Plate 5.21) was used to monitor PM_{10} and TSP over 24-hour periods. Monitoring was conducted at four locations for nine sampling events. Monitoring locations are shown in Figure 5.33. Filters from the HVAS were submitted under chain of custody to PT Intertek Utama Services, a Komite Akreditasi Nasional (KAN) an accredited laboratory in Jakarta. The laboratory analysed samples for particulate mass and total metal concentrations for the standard suite of metals (i.e., Al, As, Co, Cu, Sb, Fe, Pb, Mn, Ni, Ag, Ba, Be, Bi, Cd, Li, Hg, Se, Sr, Th, Sn, U, V, Zn). Targeted monitoring of particulate matter was also completed in September 2019 at 14 locations. This programme recorded $PM_{2.5}$ and PM_{10} in one-minute intervals over a 24 hour period using a DustTrak II 8530 EP monitor. Monitoring locations are shown in Figure 5.33.
Dust deposition	Dust deposition gauges (Plate 5.22) were installed across the study area at 14 locations to measure monthly dust deposition rates of ambient air between January and August 2019 for seven sampling events. Monitoring locations are shown in Figure 5.33. Dust deposition gauges were submitted under chain of custody to PT Intertek Utama Services, a KAN accredited laboratory in Jakarta. The laboratory analysed samples for gravimetric mass and total metals concentrations.
Gases	Concentrations of sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) were monitored at six locations (see Figure 5.33) in September 2019. This was conducted using a Portable Multigas Meter IMR IX616 (Plate 5.23).

5.5.2 Background context

This section provides a very brief overview of the meteorological conditions and the conditions of the physical environment in the study order to provide import background context.

Meteorology

During the air quality monitoring period rainfall at Bawdwin was below average. There was higher than average monthly rainfall in October and December 2018, and in January and February 2019, but below average rainfall in November 2018, and between March 2019 and September 2019. Total rainfall in 2019 was approximately 38% lower than the long-term average. Typically, humidity for the region is greatest between June and November (>80%) and lower between December and June, when temperatures are highest.

During 2019, modelled wind speeds were strongest (~4-5 m/s) between February and May when northwesterly winds dominated. Prevailing winds then eased (~2 m/s) and shifted to a southwesterly between June through early September before tending south south-easterly between late September through to January.

Plate 5.21 High-volume air sampler

Plate 5.22 Dust deposition gauge

Plate 5.23 Portable multigas meter used to monitor sulfur dioxide (SO_2) and nitrogen dioxide (NO_2)

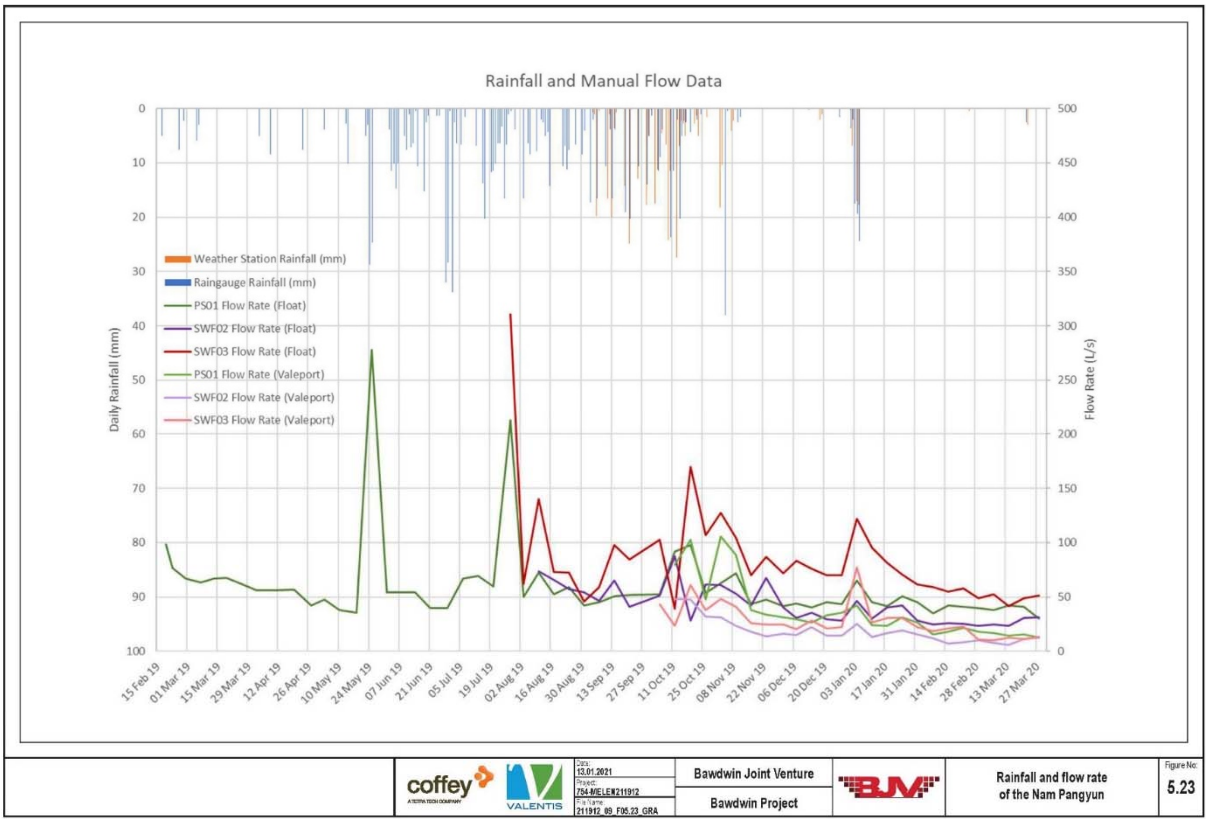

Figure 5.33 Air quality monitoring locations

Data from the automatic weather station at Bawdwin have characterised winds between January to May as generally calm to light breezes of between 0 m/s to 2.4 m/s. The prevailing wind direction during this period is south-southwesterly (see Section 5.4.4). Wind speed at Namtu is generally lower than at the Bawdwin, ranging from an average to 0.7 m/s to 1.5 m/s.

Physical environment

In addition to meteorological conditions, there are numerous factors related to the physical environment that influence the air quality in the study area including:

- Topography.
- Roads around both the Bawdwin and Tiger Camp which are unsealed.

Roads in Namtu, there is a mix of sealed and unsealed roads in Namtu, meaning vehicle traffic generates and disperses dust and particulate matter. Vehicles also emit gaseous emissions such as nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and carbon monoxide (CO).

- Areas of ground that have been deforested and lack groundcover, resulting in exposed bare earth. During periods of high winds or ground disturbance, dust and particulate matter may be generated from these areas.
- Periodic burning of grasslands also occurs during the dry season to stimulate vegetation regrowth for grazing cattle. This burning may create elevated concentrations of particulate matter in the form of smoke and reduce air quality on a local scale.

5.5.3 Applicable guidelines and standards

Ambient air quality standards are designed to protect human health, flora and fauna and other aspects of the environment. The Myanmar National Environmental Quality (Emission) Guideline-2015 outline ambient air quality standards for sulfur dioxide, nitrogen dioxide, particulate matter and ozone. For parameters Myanmar does not have specific ambient air quality requirements for, various international guidelines were adopted to select appropriate screening criteria for relevant parameters.

Table 5.52 lists the guideline values adopted in micrograms per cubic metre (µg/m^3) over a 24-hour averaging period.

Table 5.52 Adopted ambient air screening criteria

Compound	Adopted ambient air screening criteria 24-hour averaging period (µg/m^3)	Source
TSP	150	USEPA (2010)
Particles as PM_{10}	50	National Environmental Quality (emission) Guideline (2015)
	20 (1-year averaging period)	
Particles as $PM_{2.5}$	25	National Environmental Quality (emission) Guideline (2015)
	10 (1-year averaging period)	

In addition to the standard air contaminants, the deposition of dust is also considered to be a nuisance, requiring screening criteria. The adopted criteria for dust deposition are presented in Table 5.53.

Table 5.53 Dust screening criteria

Contaminant	Averaging period	Health screening criteria	Source
Lead	24-hour	0.25 mg/m^2/day	WHO (2000)
Dust deposition	Annual	2 g/m^2/month (1)	(NSW EPA 2017)
		4 g/m^2/month (2)	

(1) Maximum increase in deposited dust level

(2) Maximum total deposited dust level

The Myanmar National Environmental Quality (Emission) Guideline-2015 stipulate requirements for gaseous pollutant levels in air, these are presented in Table 5.54.

Table 5.54 Gaseous pollutant screening criteria

Parameter	Averaging period	Ambient air screening criteria (µg/m^3)	Source
Sulfur dioxide	24-hour	20	National Environmental Quality (emission) Guideline (2015)
	10 minutes	500	
Nitrogen dioxide	1 year	40	National Environmental Quality (emission) Guideline (2015)
	1 hour	200	
Ozone	8-hour daily maximum	100	National Environmental Quality (emission) Guideline (2015)

5.5.4 Air quality environment

The following section presents the results of the air quality monitoring program conducted for the Bawdwin project.

Particulate matter

Monitoring data shows that the 24-hour TSP concentration is highest at the two Bawdwin monitoring locations (Bawdwin office and Nam Pangyun Reservoir) in terms of minimum, maximum, average and total concentrations across all sampling events (Table 5.55). Tiger Camp experiences the lowest total TSP concentrations, while Namtu experiences the lowest average TSP concentration. Monitoring data shows that the 24-hour PM_{10} concentrations were broadly similar between the four monitoring locations. Higher average concentrations were recorded at Namtu and the Bawdwin office (Table 5.55).

Table 5.55 Minimum, maximum and average TSP and PM_{10} concentrations

	Minimum (µg/m^3)	Maximum (µg/m^3)	Average (µg/m^3)	Total (µg/m^3)
TSP				
Bawdwin office	6.7	191.0	84.3	771.6
Tiger Camp	3.2	154.0	72.2	626.8
Nam Pangyun Reservoir	11.6	266.0	84.4	733.9
Namtu	2.2	175.0	70.6	628.9
PM_{10}				
Bawdwin office	5.50	138.00	49.88	438.30
Tiger Camp	9.90	98.00	48.32	431.70
Nam Pangyun Reservoir	2.50	120.00	45.58	390.10
Namtu	1.20	120.00	51.70	458.20

Recorded during the monitoring events in December 2018 to September 2019.

Data show seasonal variation regarding TSP. TSP concentrations were lower during the wet season (May to October) compared to the dry period (November to April). The lowest TSP concentrations were recorded during August and September while the highest TSP concentrations were recorded in May (see Figure 5.34). These results are consistent with the rainfall data for 2019 in which lower rainfall was recorded between February and May. During April and May (the driest months of the monitoring period) a number of sites exceeded the ambient air quality guideline value for TSP of 150 µg/m^3.

A similar seasonal trend was identified for PM_{10} concentrations, with lower concentrations recorded during the wetter months of June to September (Figure 5.34). The monitoring data showed that, on average, the 24-hour

PM_{10} concentrations were frequently above the guideline value of 50 µg/m^3 (WHO 2005) between December and May. No concentrations were above the guideline between June and September.

Figure 5.34 plots the TSP and PM_{10} concentrations recorded over 24-hours periods each month for each site over the monitoring period (December 2018 to September 2019) against the adopted guideline value of 150 µg/m^3 and 50 µg/m^3. Higher values recorded during April and May could reflect the increased wind speeds during this time. Variation in TSP and PM_{10} concentrations throughout the monitoring period may also be a result of other factors such as traffic on unsealed roads.

Figure 5.34 Average monthly TSP and PM_{10} levels and total $PM_{2.5}$ and PM_{10} levels

Targeted monitoring of PM_{10} and $PM_{2.5}$ was undertaken continuously across 24-hour periods in September 2019 at 14 locations (see Figure 5.34). The 24-hour PM_{10} values calculated for the month of September at each site are depicted alongside the 24-hour $PM_{2.5}$ values in Figure 5.34 below. Both PM_{10} and $PM_{2.5}$ values are below the respective guideline values (50 µg/m^3 and 25 µg/m^3) at all monitoring sites. The lowest particulate matter recordings occurred at Wallah Station, with a recorded value PM_{10} of 1.10 µg/m^3 and a $PM_{2.5}$ of 1.09 µg/m^3. The highest recorded levels of particulate matter were found at Marmion Shaft (PM_{10} of 28.37 µg/m^3 and $PM_{2.5}$ = 22.47 µg/m^3).

The minute average of PM_{10} and $PM_{2.5}$ for each hour was calculated and shows temporal variation across the 24-hour period (Figure 5.35 and Figure 5.36 respectively). Both the Bawdwin residential and mine infrastructure sites experience peaks in PM_{10} in the afternoons (4:00 pm to 6:00 pm) (see Figure 5.34). Similarly, the Tiger Camp sites experience a peak in PM_{10} at 5:00 pm, and an additional peak at 6:00 am. The Bawdwin mine infrastructure sites had elevated PM_{10} levels in the mornings coinciding with residents commuting to and from work, meaning an increase in traffic and thereby dust and emissions generation. The Namtu area showed similar results, with a peak in PM_{10} occurring at 6:00 am, 3:00 pm and 5:00 pm which can again be attributed to the dust generation associated with commuter traffic.

The 24-hour $PM_{2.5}$ values calculated for each site correlated with those for PM_{10} and showed the same temporal patterns (see Figure 5.36).

The TSP and PM_{10} material was analysed for the standard total metals suite as listed in Section 5.5.3, Table 5.52. Metals were chosen for analysis considering the area is known to host mineral deposits that have been mined for over six centuries and therefore elevated concentrations could reasonably be expected.

Results showed elevated concentrations (i.e., above the adopted guideline value in Table 5.52) of lead and chromium were present in airborne particulate matter in both the TSP and PM_{10} samples (Table 5.56) at all sites with the exception of Nam Pangyun Reservoir which was only elevated in chromium.

The analysis of total metals concentrations from PM_{10} HVAS filters showed average chromium levels in PM_{10} samples above the adopted guideline value (0.00035 µg/m^3 (OMECC 2019)) at each of the four monitoring sites (Table 5.56). Likewise, average recorded lead levels in PM_{10} were found to be above the adopted guideline value of 0.5 µg/m^3 (OMECC 2019) at two monitoring locations. The analysis for PM_{10} metals found iron concentrations were 4.00 µg/m^3 at the Nam Pangyun Reservoir on 5 May 2019.

The average concentrations of other metals, listed in Table 5.51, across sampling events was below the adopted guideline values, which relates to the protection of human health.

Table 5.56 Average concentrations of chromium and lead from 24-hour TSP and PM_{10}

	Bawdwin Office (µg/m^3)	**Tiger Camp (µg/m^3)**	**Nam Pangyun Reservoir (µg/m^3)**	**Namtu (µg/m^3)**	**Adopted guideline (µg/m^3)**
TSP					
Chromium, Cr	0.003	0.001	0.002	0.003	0.00035
Lead, Pb	1.128	2.041	0.383	0.974	0.5
PM_{10}					
Chromium, Cr	0.002	0.001	0.002	0.003	0.00035
Lead, Pb	0.503	0.987	0.188	0.467	0.5

*Shows only metals which were above the adopted guideline value, detailed results can be found in Appendix G

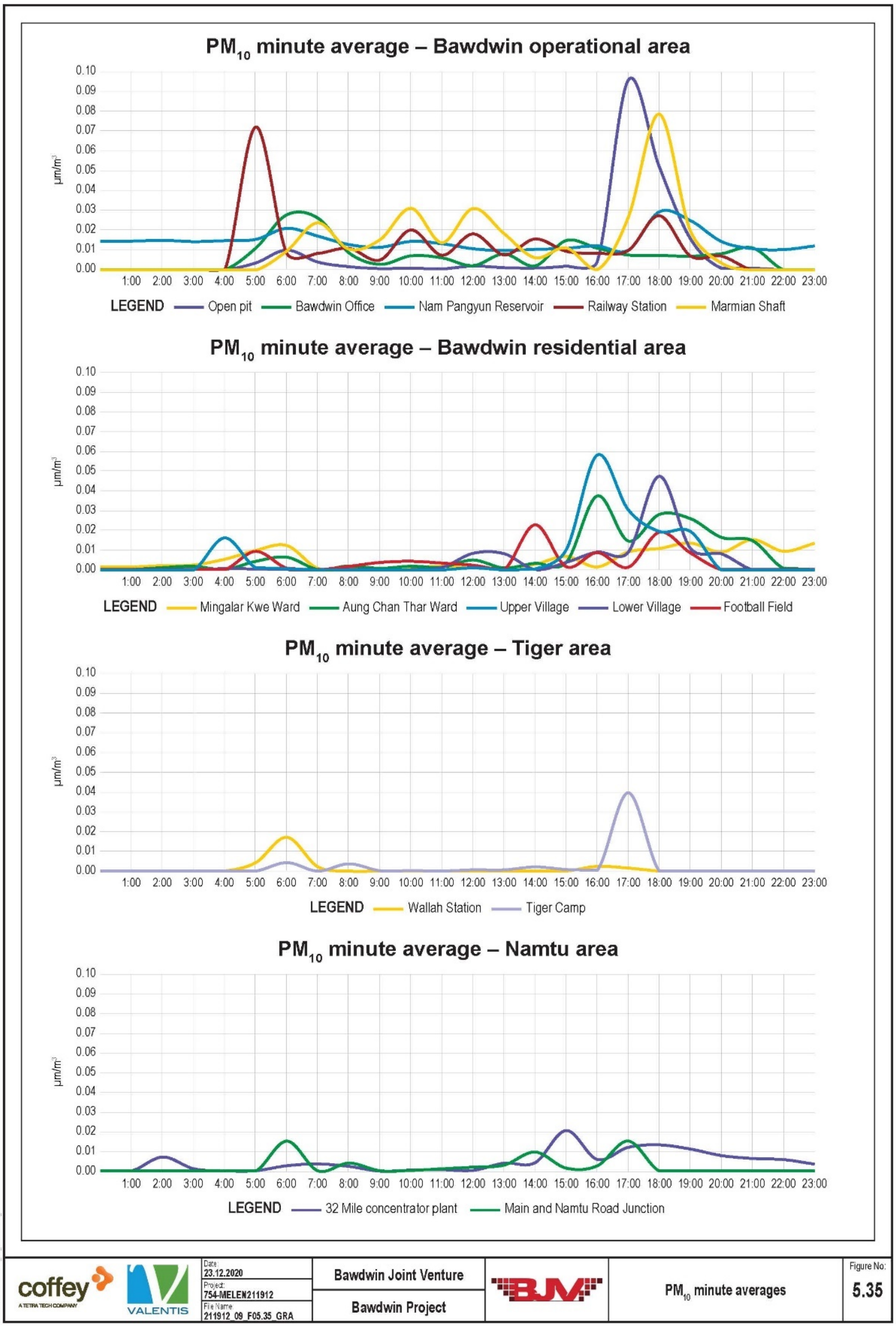

Figure 5.35 PM10 minute averages

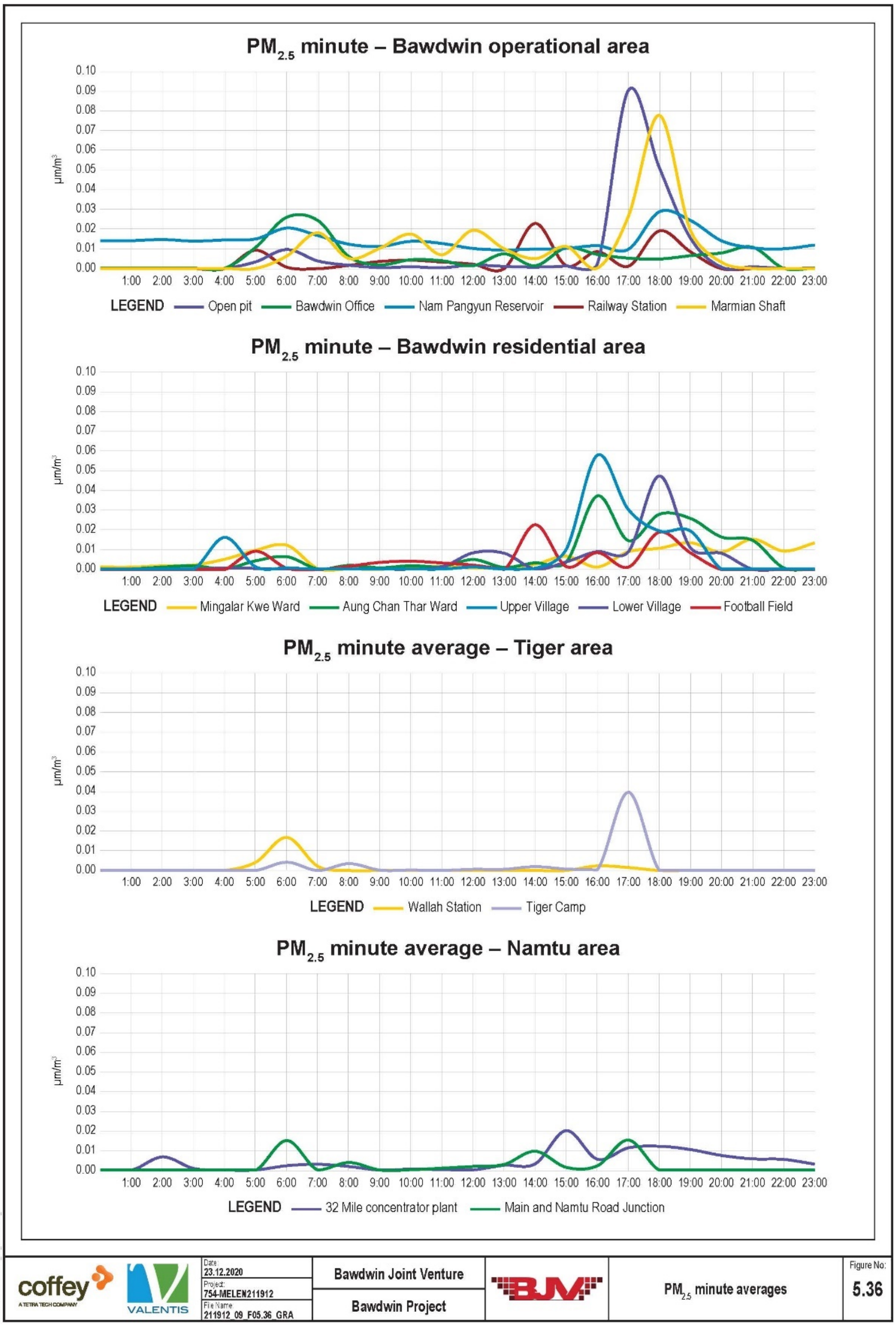

Figure 5.36 $PM_{2.5}$ minute average

Dust deposition and concentration of metals

The dust deposition results, including concentrations of heavy metals within these, are presented in the section below.

Dust deposition was recorded over monthly periods. At each site shown in Figure 5.33, the average of the total monthly recorded values was calculated and presented graphically in Figure 5.37.

The results found that the average results for all of the dust deposition monitoring sites were above the monthly guideline value of 4 g/m^2 (NSW EPA 2017), with the exception of one site near the Bawdwin Village (13 miles). The two sites near Namtu – Namtu town near the bridge over the Myitnge River and Namtu town (32-mile concentrator plant) – had the highest dustfall recordings of 29.9 and 18.6 g/m^2 respectively. The remaining sites recorded values in the range of 5.5 g/m^2 to 13.6 g/m^2 (see Figure 5.37).

The high levels of dust deposition is likely due to activities occurring on areas of exposed earth and traffic from unsealed roads creating dust lift off. Re-mining of tailings at Namtu could also be a contributing factor.

The concentrations of metals listed in Table were measured in dust deposited at each of the 14 sites over one-month periods. Figure 5.37 shows the recorded lead levels in dust at each monitoring location. The highest lead levels were recorded north of the Bawdwin Village. All other recorded metal concentrations were below their respective adopted guideline values as listed in Table 5.53.

Gaseous pollutants

The following section provides the results of the gaseous pollutant monitoring.

Key gaseous pollutants, sulfur dioxide (SO_2) and nitrogen dioxide (NO_2), concentrations were measured at the 14 monitoring locations around Bawdwin depicted in Figure 5.33. The measurements were recorded in September and October 2019. Sources of these pollutants in the project area include vehicle exhausts.

The results are shown graphically in Figure 5.37 and presented in Table 5.57.

Table 5.57 Measured concentrations of SO_2 and NO_2

Location	SO_2 24-hour average (µg/m^3)	NO_2 1 hour (µg/m^3)
Guideline value (GoM 2014)	**20**	**200**
Marmion Shaft	8.16	<LOD
Football field	6.24	<LOD
Railway station	4.00	<LOD
Main and Namtu road junction	3.93	0.3
Lower Bawdwin village	0.48	<LOD
Upper Bawdwin village	0.48	1.9

LOD = Limit of detection

Concentrations of SO_2 were generally low with no exceedances of the Myanmar guideline value of 20 µg/m^3 over a 24-hour monitoring period. The highest recorded levels occurred at Marmion Shaft, probably due to plant and vehicles nearby. The lowest recorded levels were taken at both the Lower Bawdwin village and Upper Bawdwin village.

The average concentrations of NO_2 were also low, with four of the six sites recording no detectable NO_2. The highest average level of NO_2 (1.90 µg/m^3) was recorded at the Upper Bawdwin village over a 1-hour period and 0.3 µg/m^3 at Main Road and Namtu Road junction.

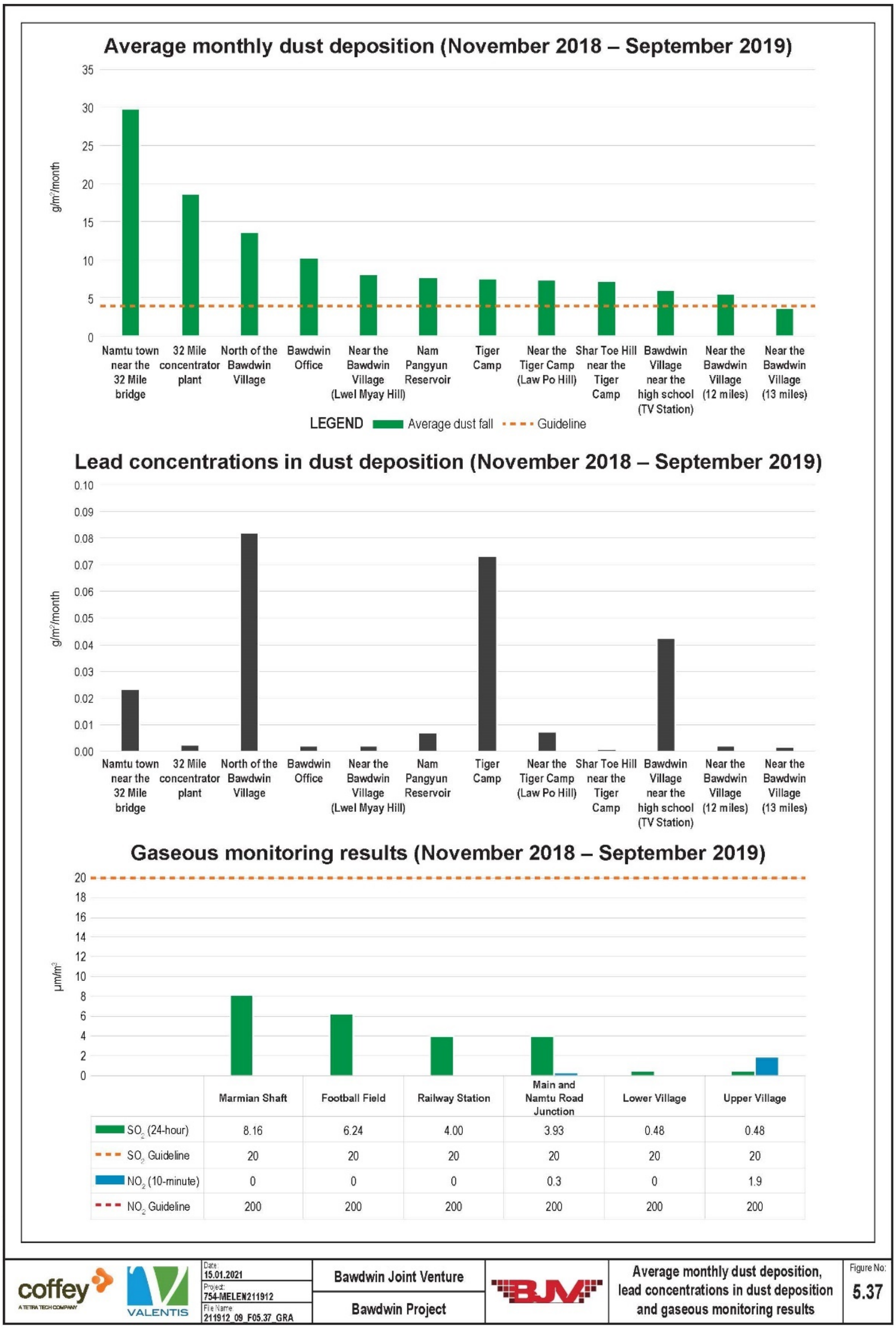

Figure 5.37 Average monthly dust deposition, lead concentrations in dust deposition and gaseous monitoring results

5.5.5 Summary

In summary, the ambient air quality around Bawdwin, Tiger Camp and Namtu monitoring locations shows:

- All study locations had moderate to poor air quality in relation to particulate matter and dust with monitoring results often exceeding guideline values. This was most apparent during the dry season.
- The poorest air quality in relation to particulate matter and dust was at the Marmion Shaft at Bawdwin. High levels of PM_{10}, $PM_{2.5}$ were also recorded here.
- The Namtu airshed also generally had poor air quality, particularly with high levels of dust deposition. This was attributed to the industrial activities taking place here and also the greater volumes of traffic on unsealed roads and is not related to activities at Bawdwin.
- The Tiger Camp area recorded the lowest levels of $PM_{2.5}$ and PM_{10}. However, high levels of lead in dust are present in the area likely due to historical mining and mineral processing activities.
- There were peaks in particulate matter in the afternoon and to a lesser extent morning across the sites, which is attributed to increase in vehicle activity and generation of dust lift off from roads.
- There were elevated concentrations of some metals within particulate matter. These were chromium and lead, which exceed criteria for the protection of human health.
- The concentrations of SO_2 and nitrogen dioxide NO_2 recorded at seven locations were below the Myanmar criteria for the projection of human health.

5.5.6 Sensitivity of defined airsheds

This section defines the overall sensitivity for the key airsheds identified in the study area. An 'airshed' in this context is an air mass within a defined geographic area that behaves in a similar way with respect to the dispersion of emissions. For the purpose of this section, sensitivity is defined as how sensitive the value is to change by considering the importance of the airshed, the vulnerability of the airshed to change, and the resilience of the airshed in terms of its ability to recover.

The key receptor groups that were considered in the assessment of airsheds are outlined in Table 5.58 and shown on Figure 5.38.

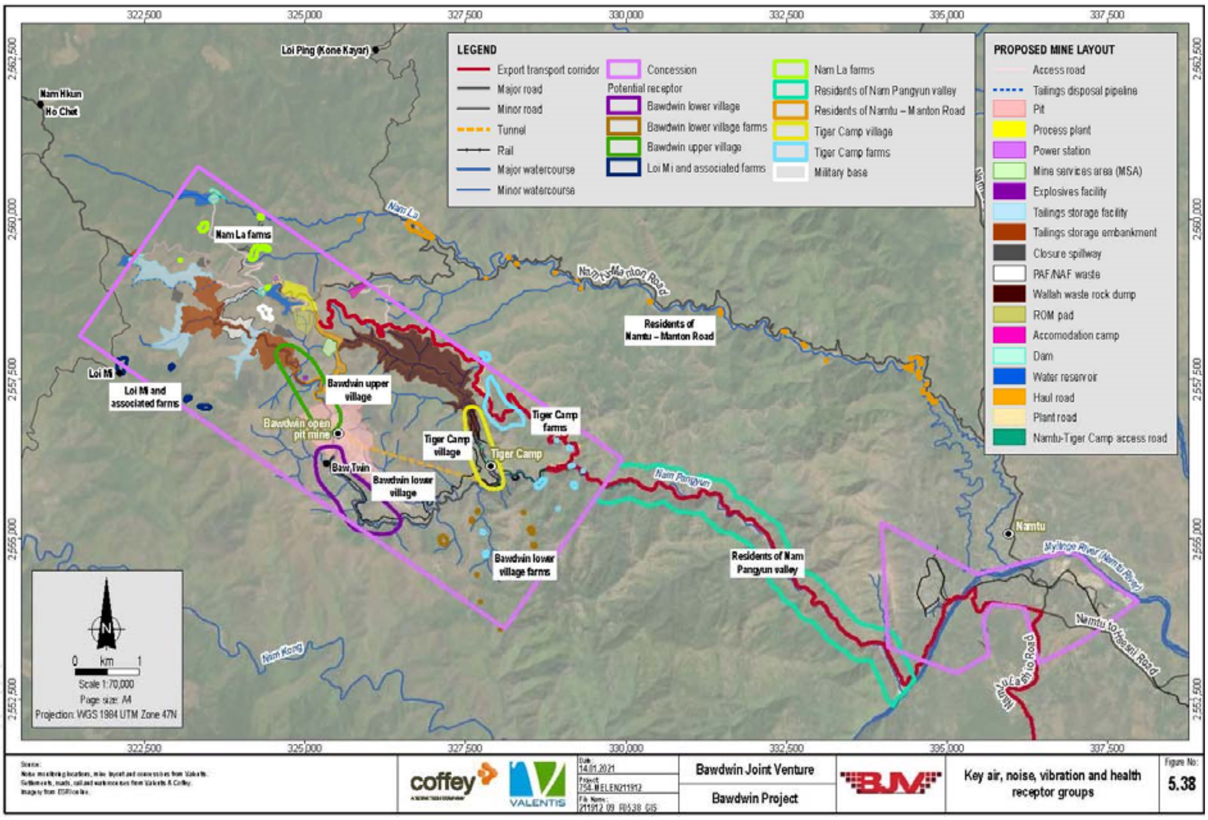

Figure 5.38 Key air, noise, vibration and health receptor groups

Table 5.58 Key air quality, noise and vibration receptor groups

Receptor Name	Description
Military base	Located within Bawdwin concession close to Namtu-Manton Road and less than 500 m from the proposed process plant, power station and TSFB/C embankments and 1 km from the haul road.
Bawdwin upper village	Located immediately north of the current and proposed open pit.
Bawdwin lower village	Located immediately to the south of the proposed open pit and 1.5 km south of the proposed haul road.
Bawdwin lower village farms	Scattered farms and associated houses located up to 1.5 km southeast of the proposed open pit.
Tiger Camp village	Located in Wallah Valley immediately south of the proposed waste rock dump, approximately 1 km to the proposed plant access road and adjacent to the proposed Namtu-Tiger Camp access road.
Tiger Camp farms	Scattered farms and associated houses to the east and northeast of Tiger Camp. These farms and houses are within 500 m of the proposed plant access road and proposed Namtu-Tiger Camp access road.
Loi Mi village and associated farms	Loi Mi village and associated farms located both within and outside of the western boundary of the Bawdwin concession, less than 500 m south of the proposed TSF-B.
Nam La farms	Nam La farms and associated houses located in the northern portion of the Bawdwin concession, between the Nam La water harvesting facility and the proposed process plant.
Villages surrounding the concession	Includes twelve villages within an 8 km radius of the Bawdwin concession: Ho Hoke, Ho Pat, Haik Taung (Pa), Hu Hsar, Haik Taung (Kai), Long Jar, Hu Ngway, Hin Poke, Ho Chet, Nam Hkun, Hsin Li, Loi Ping (Kone Kayar)
Residents of Nam Pangyun valley	Includes artisanal miners and permanent residences associated with agricultural plots along the lower valley downstream of the Bawdwin concession boundary, alongside the Nam Pangyun and existing railway.
Namtu	The township of Namtu.
Residents along the export route.	Residents (including standalone houses, settlements, villages and towns along the export route from Namtu to National Highway 3, approximately 66 km by road to the east of the concession at its closest point).
Residents along the Namtu-Manton Road	Residents (including standalone houses and settlements) along the Namtu-Manton Road between northeast of the concession between Namtu and the accommodation camp area.

Inherent values of airsheds that informed the assessment of the sensitivity of airsheds were based on:

- Cleanliness of air (i.e., air quality) that supports health and wellbeing for humans, and flora and fauna and does not affect health from the presence of particulate matter, or presence of pollutants such as gases and metals.
- Visual amenity (i.e., clear skies and distant views, and absence of nuisance dust or smog).

The definitions used to determine the sensitivity of the airsheds (i.e., their importance, vulnerability, and resilience) are presented in Table 5.59. Table 5.60 outlines the importance, vulnerability, resilience and overall sensitivity for each value, based on a low, medium and high scale as outlined in Table 5.59.

Table 5.59 Definitions for sensitivity of air quality values

	Definition	Ratings criteria		
		Low	Medium	High
Importance	The importance of having good air quality within the airshed based on the sensitivity and reliance of people and ecosystems within the airshed and its land use.	There are no sensitive receptors (people or sensitive ecosystems) living in or reliant on the airshed.	There are no sensitive receptors (people or sensitive ecosystems) living in the airshed and there is only partial reliance on the airshed.	The importance of ambient air, and its capacity to support amenity, human health and ecosystems is inherently high because it is fundamental to the wellbeing of communities and the viability of ecosystems. Unlike other resources (e.g., water, food), alternative supplies of quality air cannot be set aside for use by communities where needed.
Vulnerability	The extent to which the airshed is susceptible to change. This includes consideration of the current air quality of the airshed and how readily additional change may cause impacts to human health and amenity or loss of associated ecosystems.	The airshed has limited anthropogenic disturbance and low levels of dust and gaseous emissions. There are few sensitive receptors in this airshed. The airshed has low vulnerability to change. .	The airshed is moderately disturbed and contains sensitive receptors it has moderate vulnerability to change.	The airshed is highly disturbed, contains sensitive receptors and is highly vulnerable to adverse changes to air quality.
Resilience	The extent to which the airshed can adapt or recover from change.	The airshed is highly disturbed with ongoing elevated dust and/or gaseous emissions. The airshed has limited capacity/resilience to adverse air quality changes.	The airshed is moderately disturbed, with historic and ongoing dust and gaseous emissions. The current airsheds are generally of good quality but intermittently comprise elevated dust and gaseous emissions. has Airshed has moderate resilience to adverse air quality changes.	The airshed is has limited anthropogenic disturbance and little to no historic and ongoing exposure to dust and gaseous emissions. The airsheds is of high quality and has a high resilience to adverse air quality changes.

Table 5.60 Importance, vulnerability, resilience and overall sensitivity of the air quality values

Airshed/receptor	Importance	Vulnerability	Resilience	Sensitivity
Military base	**High** The airshed is of high importance due to it supporting amenity, human health and ecosystems.	**High** The airshed has moderate to high levels of existing particulate matter and rates of dust deposition. It has moderate degree of attenuation by surrounding topography. The airshed is highly vulnerable to changes in air quality due to its close proximity to the project.	**Low** The existing airshed experiences moderate to high concentrations of dust and pollutants. Considering the current quality of the airshed in terms of its physical and chemical properties (i.e., poor quality), there is little capacity to withstand further adverse air quality changes.	**High**
Bawdwin upper village Was established to support the mining operation and is located north of the open pit.	**High** The airshed is of high importance due to it supporting amenity, human health and ecosystems.	**High** The airshed has high levels of existing particulate matter and rates of dust deposition, so has high vulnerability to amenity, health and wellbeing effects from additional air emissions	**Low** The airshed is not resilient to further increases in air emissions due to high levels of existing emissions.	**High**
Bawdwin lower village Was established to support the mining operation and is located immediately to the south of the open pit.	**High** The airshed is of high importance due to it supporting amenity, human health and ecosystems.	**High** The airshed has high levels of existing particulate matter and rates of dust deposition, so has high vulnerability to amenity, health and wellbeing effects from additional air emissions	**Low** Existing airshed of Bawdwin villages experiences moderate to high concentrations of dust and pollutants. Considering the current quality of the airshed in terms of its physical and chemical properties (i.e., poor quality), there is a little capacity to withstand further adverse air quality changes.	**High**
Bawdwin lower village farms Includes farms and associated houses located southeast of the open pit.	**High** The airshed is of high importance due to it supporting amenity, human health and ecosystems.	**Medium** These farms are reasonably well removed from existing project activities and are on relatively high, open terrain meaning dust and contaminants would likely be able to readily disperse and not linger in those areas. Receptor would have medium level of vulnerability to additional dust causing amenity, health and wellbeing impacts given relatively moderate existing dust levels.	**Medium** As the lower Bawdwin village farms are likely to have a less degraded airshed than Bawdwin lower village, the airshed likely has some capacity to cope with further increases in air emissions.	**Medium**

Airshed/receptor	Importance	Vulnerability	Resilience	Sensitivity
Tiger Camp village Tiger Camp is situated in the Wallah Valley downstream of the Bawdwin mine. It has around 600 people in two wards. Like Bawdwin it was established to support the Bawdwin mining operation.	**High** The airshed is of high importance due to it supporting amenity, human health and ecosystems.	**High** The airshed has high levels of existing particulate matter and rates of dust deposition, so has high vulnerability to amenity, health and wellbeing effects from additional air emissions. Additionally, the topography of the Tiger Camp means that it is situated in a valley with little opportunity for airborne particles to be dispersed by wind.	**Low** Existing airshed of Tiger Camp village experiences moderate to high concentrations of dust and pollutants. Considering the current quality of the airshed in terms of its physical and chemical properties (i.e., poor quality), there is a little capacity to withstand further adverse air quality changes.	**High**
Tiger Camp farms Includes farms and associated houses to the east, northeast and south of Tiger Camp.	**High** The airshed is of high importance due to it supporting amenity, human health and ecosystems.	**Medium** The farms are close to Tiger Camp on relatively high, open terrain, meaning dust and contaminants would possibly be able to disperse and not linger in those areas. The existing airshed is likely to be less degraded and consequently less vulnerable than Tiger Camp village due to their location upslope, however dust deposition levels on the nearby Shar Toe Hill exceed guideline levels, so the airshed is still likely to be moderately degraded and have moderate vulnerability to further degradation.	**Medium** Existing airshed of Tiger Camp farms is expected to experience moderate concentrations of pollutants. Considering the current expected quality of the airshed in terms of its physical and chemical properties (i.e., poor quality), there is some capacity to withstand further adverse air quality changes.	**Medium**
Loi Mi village and associated farms Includes village farms, and associated houses located around the western boundary of the Bawdwin concession.	**High** The airshed is of high importance due to it supporting amenity, human health and ecosystems.	**Medium** The farms are removed from existing project activities and the airshed is likely to be less degraded than receptors within the upper Nam Pangyun valley. As the farms are on relatively high, open terrain, emissions would likely be able to readily disperse and not linger in those areas. The airshed would have medium vulnerability to additional dust causing amenity, health and wellbeing	**High** As the farms are expected to have a relatively clean airshed compared to receptors in the upper Nam Pangyun valley, there is likely to be capacity to cope with further increases in air emissions.	**Medium**

Airshed/receptor	Importance	Vulnerability	Resilience	Sensitivity
		impacts given the expected relatively low existing dust levels.		
Nam La farms Includes farms and associated houses located in the north of the Bawdwin concession.	**High** The airshed is of high importance due to it supporting amenity, human health and ecosystems.	**Medium** These farms are reasonably removed from the existing mine, however there are expected to be relatively moderate existing dust levels as dust deposition at the nearby Nam Pangyun Reservoir (500 m away) exceeds guideline values. The airshed would have medium level of vulnerability to additional dust causing amenity, health and wellbeing impacts.	**Medium** As the farms are expected to have a relatively clean airshed compared to receptors in the upper Nam Pangyun valley, there is likely to be capacity to cope with further increases in air emissions.	**Medium**
Villages surrounding the Bawdwin concession Includes twelve villages within an 8 km radius of the Bawdwin concession: Ho Hoke, Ho Pat, Haik Taung (Pa), Hu Hsar, Haik Taung (Kai), Long Jar, Hu Ngway, Hin Poke, Ho Chet, Nam Hkun, Hsin Li, Loi Ping (Kone Kayar). The closest village (Ho Chet) is about 2.5 km from the concession boundary.	**High** The airshed is of high importance due to it supporting amenity, human health and ecosystems.	**Low** These villages are separated from project activities by mountainous terrain and located more than 3 km from project-related air emission sources. It is expected that the existing air quality of the airshed is relatively good and that the airshed has low vulnerability to changes to health and wellbeing due to additional dust; although amenity might be reduced.	**High** These villages are expected to have relatively good air quality and would be able to withstand some amount of additional air emissions	**Medium**
Residents of Nam Pangyun valley Includes artisanal miners and permanent residences associated with agricultural plots along the lower valley downstream of the Bawdwin concession boundary.	**High** The airshed is of high importance due to it supporting amenity, human health and ecosystems.	**Medium** There are relatively moderate existing dust levels and dust deposition at the nearby Law Po Hill exceeding guidelines levels. The narrow valley setting may result in dusty conditions lingering in the area compared to more open terrain. Nam Pangyun valley has low topography with little opportunity for airborne particles and gaseous pollutants to be dispersed by wind.	**Medium** Given the moderate existing dust levels, there is likely some capacity to cope with further increases in air emissions	**Medium**
Namtu Town Namtu Town has a population of more than 13,000 people. Tha Ta La	**High**	**Medium** Existing airshed has a medium to high vulnerability to additional dust causing	**Low** Existing airshed of Namtu Town experiences moderate to high	**Medium**

Airshed/receptor	Importance	Vulnerability	Resilience	Sensitivity
Ward of Namtu Town was established to support the mining and processing operations. As a regional town Namtu has a number of manufacturing and industrial operations.	The airshed is of high importance due to it supporting amenity, human health and ecosystems.	amenity, health and wellbeing impacts given relatively moderate to high existing dust levels.	concentrations of pollutants. Considering the current quality of the airshed in terms of its physical and chemical properties (i.e., poor quality), there is likely to be only a limited degree of capacity to cope with further increases in air emissions.	
Villages along the export route Typical of rural villages next to a major road.	**High** The airshed is of high importance due to it supporting amenity, human health and ecosystems.	**Medium** Villages are located near major roads and are likely to have an airshed already influenced by traffic emissions. The airshed would have medium vulnerability to additional pollutants causing amenity, health and wellbeing impacts.	**Medium** Baseline air quality of these villages are unknown, however potentially experiences intermittent increases in pollutants as a result of traffic along major roads. These villages likely have some capacity to cope with further gaseous emissions.	**Medium**
Residents along the Namtu-Manton Road	**High** The airshed is of high importance due to it supporting amenity, human health and ecosystems.	**Medium** Villages are located near major roads and potentially experience intermittent increases in pollutants as a result of traffic. Increased air pollutants would result in noticeable reduction in amenity. The airshed would have medium vulnerability to additional pollutants causing amenity, health and wellbeing impacts.	**Medium** Potentially experiences intermittent increases in gaseous emissions and dust from traffic along unsealed sections of the road due to existing traffic along the public road. These residents likely have some capacity to cope with further emissions.	**Medium**

5.5.7 Uncertainties and limitations

A robust data set relating to the collection of particulate matter and dust has been collected over a 10-month monitoring period. Notwithstanding the robustness of this data there were a number of limitations relating to air quality. These included:

- Lack of site-specific wind speed and direction data for the entire monitoring period. This includes a lack of data for wind speed and direction for most of the wet season.
- Collection of dust deposition faced a number of constraints due to cattle interacting and destroying dust gauges. This resulted in a number of samples being excluded. Nonetheless a robust dataset was collected with the range of sampling locations.
- Baseline data was not collected at all sensitive receptors with the potential to be impacted by the project.

5.6 Noise and vibration

Noise monitoring was conducted in September 2019 to determine the baseline noise conditions at the Bawdwin site and surrounds.

5.6.1 Method and study area

In the past the Bawdwin community was exposed to mine-related noise and vibration when the mine was active, including disturbances from mining activities such as blasting, the railway, smelter complex and processing plants. However, the Bawdwin area has experienced limited mine-related noise since mining operations ceased in 2009 until the recommencement of exploration activities, including drilling and light vehicle traffic, in 2016.

No baseline investigations of vibration have been conducted. However, the potential sources of significant vibration were anticipated to be minor and limited to heavy vehicle traffic, operation of limited plant for maintenance purposes, earthmoving to support exploration activities and drilling activities.

Noise monitoring took place at 12 locations around the Bawdwin-Namtu area (i.e., the study area) as shown in Figure 5.39 and Plates 5.24 and 5.25. These sites were selected to represent a geographically diverse set of locations that included residential areas and other sites adjacent to roads or industrial areas. Noise monitoring was conducted continuously for up to 24-hours in September 2019. The monitoring programme was undertaken using a Sound Level Meter (NL-42, Rion Co; Plate 5.26).

A number of A-weighted sound levels were recorded. The A-weighting is a filter which is applied to the decibel (dB) level to approximate the human ear's frequency response. People's hearing is most sensitive to sounds at mid frequencies and less sensitive at lower and higher frequencies. When the overall level of a noise has had the A-weighting filter applied to it, it is represented using the A-weighted decibel (dBA). These parameters are described below:

- L_{Aeq}: A-weighted equivalent sound level in decibels (dB) equivalent to the total sound energy measured over a given period of time.
- L_{Amax}: A-weighted maximum sound level in dB measured during a given period.
- L_{A90}: A-weighted sound level exceeded for 90% of a given period. It is representative of the average background sound level.
- L_{A10}: A-weighted sound level exceeded for 10% of a given period.

5.6.2 Applicable guidelines and standards

National Environmental Quality (Emission) Guidelines (MOECAF, 2015) are outlined in Table 5.61. The guidelines also state that noise impacts should not result in a maximum increase in background levels of 3 dBA at the nearest receptor location off-site. These guidelines have been based on the International Finance Corporation (IFC) General Environmental Health and Safety Guidelines (IFC, 2007).

Table 5.61 National Environmental Quality (Emission) Guidelines

Category	One-hour L_{Aeq} (dBA)	
	Daytime 7:00 am – 10:00 pm (10:00 am – 10:00 pm for Public Holidays)	Night time 10:00 pm – 7:00 am (10:00 pm – 10:00 am for Public Holidays)
Residential, educational, institutional	55	45
Industrial, commercial	70	70

Source: MOECAF (2015)

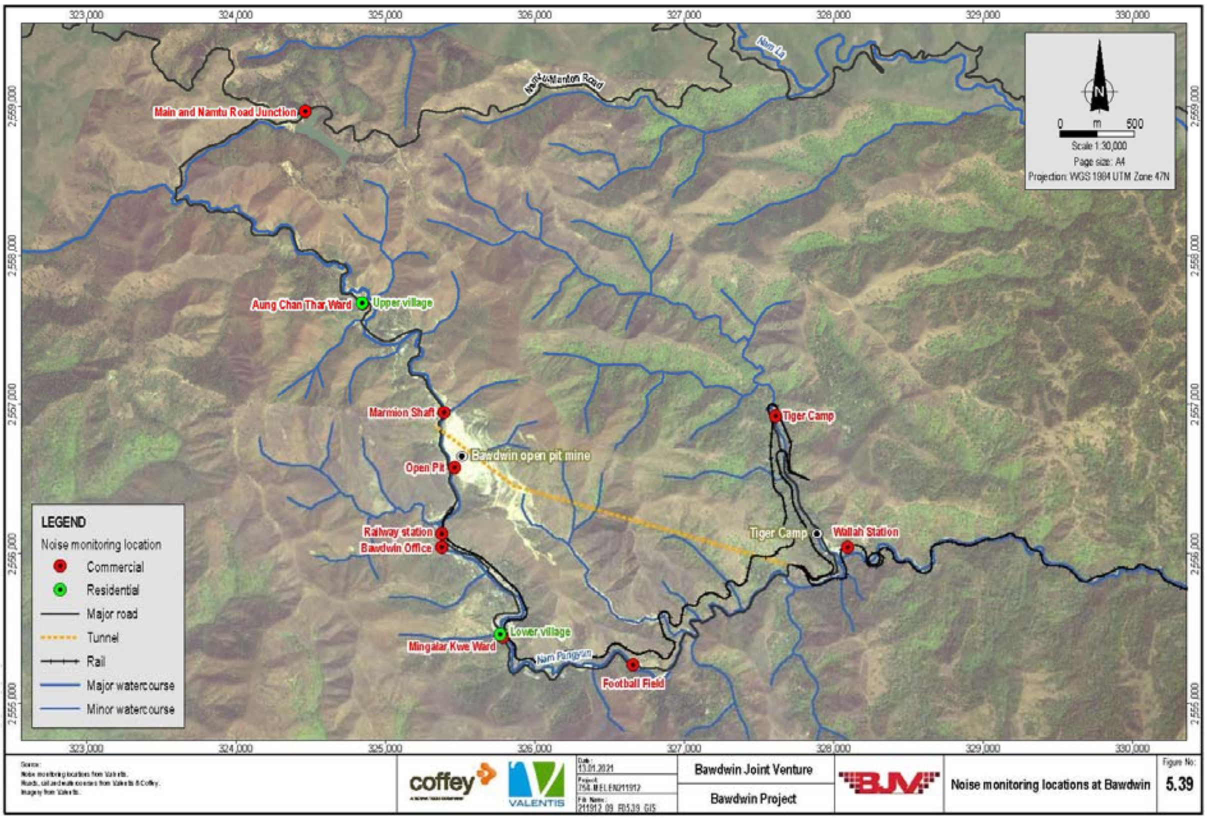

Figure 5.39 Noise monitoring locations at Bawdwin

Plate 5.24 Noise monitoring for the project

Plate 5.25 Noise monitoring at village location for the project

Plate 5.26 Sound level meter (NL 42, Rion Co)

5.6.3 Existing levels of noise

Monitoring of noise levels took place over 24-hour periods at each site shown in Figure 5.39. The sites have been separated into daytime and nighttime periods in order to compare with the prescribed guidelines outlined in Table 5.61. The sites have also been separated into residential and industrial sites (see Figure 5.39). The sound parameters described in Section 5.6.1 were recorded to characterise the baseline noise conditions around the existing Bawdwin mine. The results for each site are shown in Figure 5.40 and Table 5.62.

Table 5.62 Noise monitoring results (L_{A10}, L_{A90} and L_{Amax})

	Daytime 7:00 am – 10:00 pm			Night time 10:00 pm – 7:00 am		
	L_{A10}*	L_{A90}*	L_{Amax}**	L_{A10}*	L_{A90}*	L_{Amax}**
Aung Chan Thar	60.48	48.49	99.80	49.41	55.37	113.3
Bawdwin Office	62.75	47.06	123.90	48.88	58.23	85.5
Football Field	65.57	49.34	118.50	56.70	56.00	91.5
Wallah Station	58.13	48.09	99.40	56.98	58.86	107.6
Main and Namtu Road Junction	59.14	44.00	110.50	58.20	58.50	82.8
Marmion Shaft	64.04	52.27	118.50	64.20	67.30	90.9
Mingalar Kwe	61.22	48.82	104.70	52.08	57.87	97.5
Open Pit	57.00	43.35	101.40	54.00	55.59	112.8
Railway Station	57.00	45.35	101.40	62.45	64.00	101.5
Tiger Camp	63.21	48.17	111.90	56.89	57.19	102.4
Upper Village	59.91	52.65	107.30	85.77	57.60	99.20
Lower Village	66.33	46.88	97.00	61.17	51.00	102.30

* Average value across monitoring period
** Highest recorded value during monitoring period

Figure 5.40 shows the average L_{Aeq} recorded for each site during daytime periods (i.e., 7:00 am to 10:00 pm). Noise levels during the daytime monitoring period at commercial sites were found to be below the Myanmar guideline levels of 70 dBA. However, the L_{Aeq} recorded at each of the residential sites (Upper Village and Lower Village) was found to be greater than the daytime residential guideline value of 55 dBA. These noise levels can be attributed to the passing of vehicles through the villages, as a main road runs through both. Additionally, the villages sit within a steep valley, which can exacerbate noise levels.

The average night time (i.e., 10:00 pm to 7:00 am) L_{Aeq} levels were largely below the Myanmar commercial guidelines (Figure 5.40). The Upper Village and Lower Village were found to have noise levels exceeding the prescribed residential guidelines, with average L_{Aeq} values of 81.63 dBA and 60.60 dBA respectively. The elevated noise levels can be attributed to the residents socialising at night time, watching TV, playing music, and increased traffic movement as people commute to and from work. The noise levels are exacerbated by the villages being situated in a valley.

Figure 5.39 shows the L_{Aeq} levels on a temporal scale, averaged across all monitoring sites. Figure 5.41 shows the L_{Aeq} levels for individual sites over a 24-hour period. The highest noise levels are, on average, recorded during the mornings between 5:00 am and 9:00 am. This is likely to be due to traffic and other activities around Bawdwin. The quietest periods were recorded at night time, between 10:00 pm and 3:00 am. This is expected given that most people would be asleep at these times. Noise levels between 6:00 am and 7:00 pm were consistent, ranging from approximately 60 dBA to 65 dBA. This range is deemed as ‘moderate to loud’ and is comparable to a loud radio or a department store. All hourly averages were below the commercial guideline of 70 dBA, but exceeded the daytime and night time prescribed values.

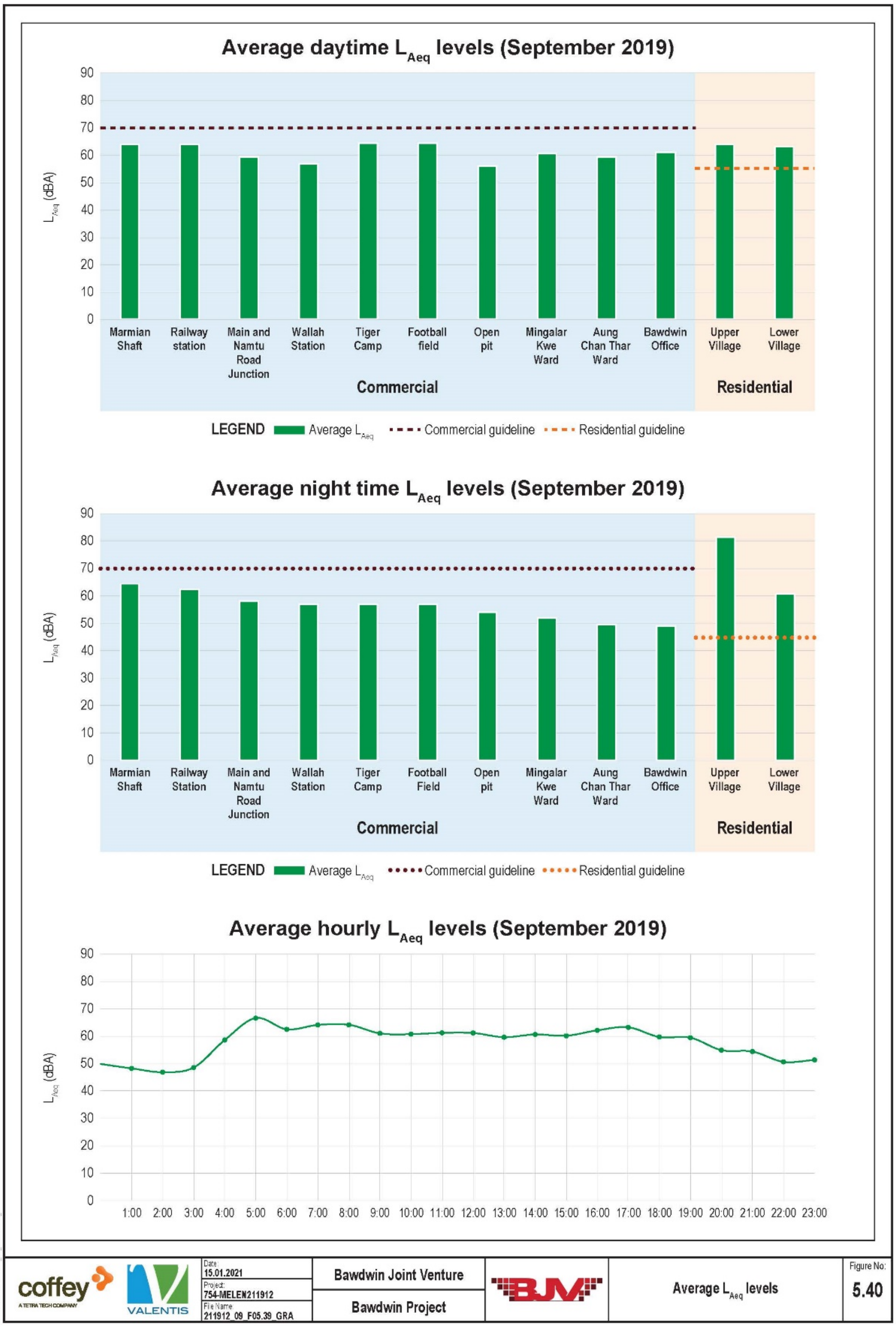

Figure 5.40 Average L_{Aeq} levels

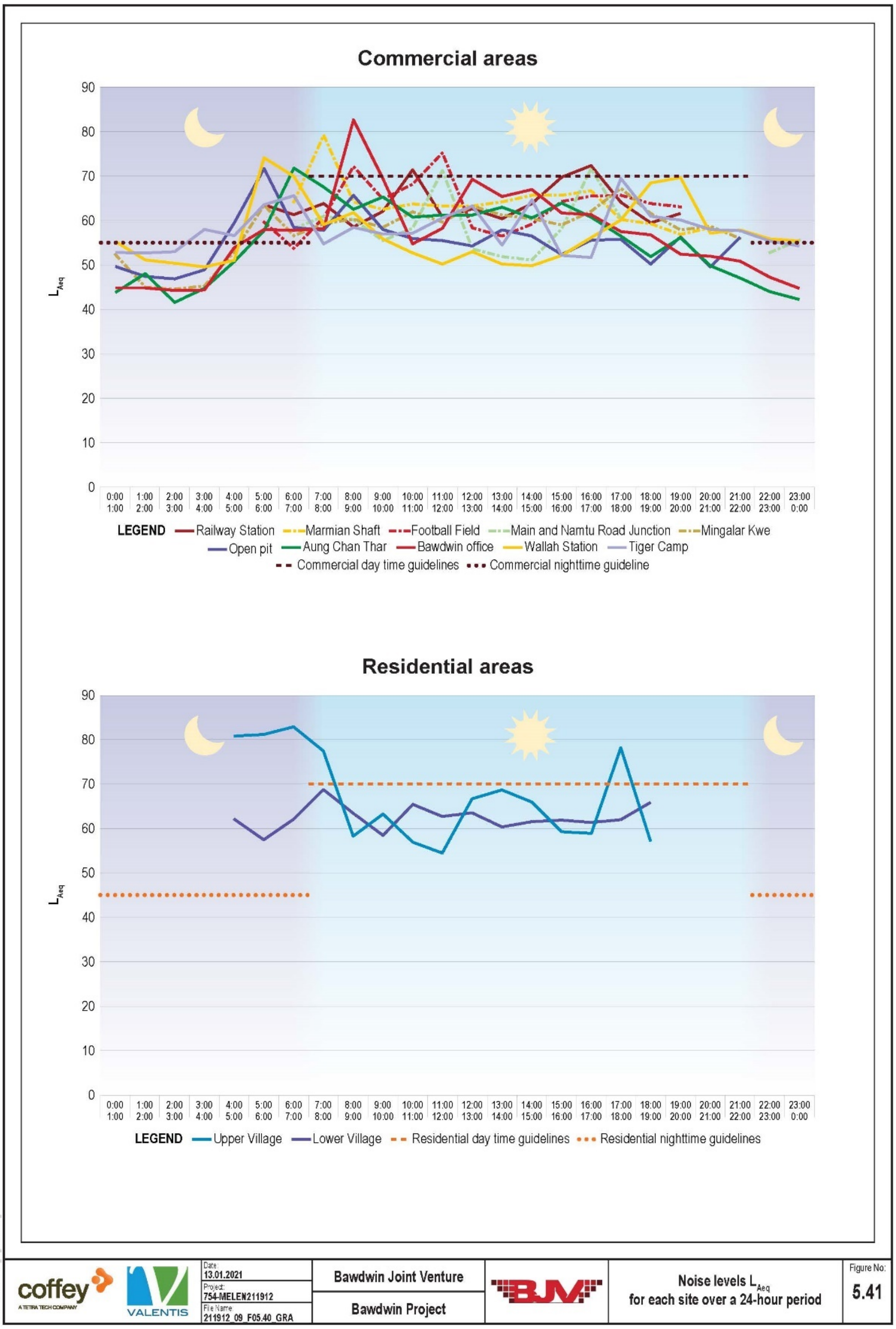

Figure 5.41 Noise levels (L_{Aeq}) for each site over a 24-hour period

Both average and L_{A90} results for the daytime monitoring period are presented in Table 5.62. Noise levels between 50 dBA and 60 dBA are classed as 'moderate to quiet' and are comparable to noise levels in a department store or in an office. The average L_{A90}, i.e., average background noise level, at each site was found to be around this 'moderate to quite' level. The L_{A10} results had similar noise levels across all sites (see Table 5.62).

At the residential sites the average daytime L_{A10} exceed the daytime residential guidelines (55 dBA). However, the daytime L_{A90} levels are within this guideline indicating that in general noise levels in residential areas are acceptable. The residential night time noise levels exceeded the guideline value of 45 dBA for both L_{A10} and L_{A90}. The loudest sound at the residential sites was reported at Upper Village (107.30 dBA). This can be classed as 'extremely noisy' and is comparable to steel grinding.

For the daytime and night time monitoring levels at commercial sites, L_{A10} were within the commercial standard value (70 dBA) across all sites. The average L_{A90} at these sites also fell within the guideline, indicating that the average background sound level is acceptable during daytime and nighttime periods. The highest L_{Amax} was recorded at the Bawdwin Office (123.90 dBA) and occurred in the daytime monitoring period. This is likely due to its proximity to mining activities and associated heavy machinery. This level of noise is comparable to a heavy rock concert and is classed as 'extremely noisy'. Noise levels of 130 dBA and above are classified as intolerable.

5.6.4 Summary

The existing noise baseline can be summarised as follows:

- The high overall noise level can be attributed to the monitoring locations being located in geographically diverse areas, often near roads or villages.
- The monitoring locations in residential areas were noisy and above the prescribed guidelines both during the daytime and night time periods.
- Upper Village at Bawdwin recorded the highest noise levels on average most likely due to normal village activities.
- All commercial sites are within the Myanmar guideline levels however are classed between 'moderate to loud'.
- The loudest period is was typically around 5:00 am, which may correspond to normal village activities and traffic.
- The loudest recorded sound level (123.90 dBA) occurred at the Bawdwin office, which may be as a result of human generated noise e.g., motorbikes.

No baseline investigations of vibration have been conducted.

5.6.5 Sensitivity of receptors to changes in noise and vibration

This section defines the overall sensitivity for the key receptors (defined on the village/community scale as opposed to individual houses). For the purpose of this section, sensitivity is defined as how sensitive the receptor is to change due changes to amenity. For each receptor, sensitivity is determined by considering the importance of the receptor, the vulnerability of the receptor to change, and the resilience of the receptor in terms of its ability to recover from noise and vibration impacts. Table 5.58 (in Section 5.5 above) outlines the receptors assessed for sensitivity to noise and vibration impacts. The key receptor groups that were considered in the assessment of noise and vibration are outlined in Table 5.58 and shown on Figure 5.38.

For each receptor, changes to ambient levels of noise and vibration have the potential to influence:

- Human health and wellbeing characterised by an ambient environment suitable acoustic environment for individuals to sleep; study or learn; and be involved in recreation, including relaxation and conversation.
- Amenity and aesthetic value of the noise environment.

The definitions used to determine the sensitivity of noise values (i.e., their importance, vulnerability, and resilience) are presented in Table 5.63. Table 5.64 outlines the importance, vulnerability, and resilience with respect to noise for each receptor, based on a low, medium and high scale.

Table 5.63 Definitions for sensitivity of noise values

	Definition	Ratings criteria		
		Low	**Medium**	**High**
Importance	The degree to which the ambient noise level supports the amenity, safety and function of an area for people (e.g., a suitable acoustic environment for individuals to sleep; study or learn; and be involved in recreation, including relaxation and conversation).	The area is a recognised industrial zone and therefore elevated noise conditions would be reasonably expected. People have little reliance on low levels of background noise for amenity.	The area already experiences some level of ambient noise due to industrial activities. People live in the area and require suitable levels of background noise levels for amenity, safety and function.	The area experiences low levels of ambient noise. People live in the area and require low background noise levels to maintain amenity.
Vulnerability	The extent to which the receptor is susceptible to change in noise and vibration levels. This includes consideration of how readily change may cause deterioration of amenity and/or effects to human health.	Increased noise would result in limited change to amenity and impacts to human health would be unlikely.	Increased noise would result in some reduction of amenity but impacts to human health unlikely and noise levels in general compliance with guideline values.	Increased noise would result in noticeable reduction in amenity and/or potentially adverse health effects with exceedences of guideline values likely.
Resilience	The extent to which the receptors can adapt or recover from changes in ambient levels of noise, taking existing noise levels into consideration	Receptor currently experiences low levels of noise and relies on these low levels for amenity and wellbeing. Or, receptor currently experiences high noise levels, frequently in exceedance of ambient noise standards. Receptor has limited or no capacity to adapt to increased noise levels.	Receptor currently experiences moderate noise levels with occasional exceedances of ambient noise standards. Receptor has some capacity to adapt to increased noise levels.	Receptor currently experiences low levels of noise and vibration, however, lives in an industrial zone. Receptor is able to readily adapt to noise increases.

Table 5.64 Importance, vulnerability and resilience of the noise receptors

Receptor	Importance	Vulnerability	Resilience	Sensitivity
Military base	**Medium** Although this military base is located close to the current mine, operations have been in care and maintenance and current noise levels exceed Myanmar standards at this receptor. A medium level of importance is placed on the value of the ambient noise environment for amenity and health during the day and night.	**High** Military base is vulnerable to increased noise emissions due to its location in proximity to the project area. Current noise levels exceed Myanmar standards at times and the Military Base is vulnerable to increases in noise-generating project activities.	**Medium** It is expected that this receptor would have medium resilience to increased noise emissions, on the basis that it is a military base.	**Medium**
Bawdwin upper and lower villages Bawdwin villages have around 3,000 people in nine wards and was established to support the mining operations. The environment around Bawdwin has been extensively shaped by the mining operation.	**Medium** Although Bawdwin is located close to the current mine, operations have been in care and maintenance and existing noise sources have been limited. Current noise levels exceed Myanmar standards at these receptors. A medium level of importance is placed on the value of the ambient noise environment for amenity and health during the day and night.	**High** Bawdwin villages are vulnerable to increased noise emissions due to their location in proximity to the project area and noise-generating project activities. Current noise levels exceed Myanmar standards and the villages are vulnerable to any additional increases in noise-generating project activities.	**Medium** It is expected that this receptor would have medium resilience to increased noise emissions, on the basis that it is a village established to support mining operations and is located on a mining concession.	**Medium**
Tiger Camp village Tiger Camp is situated in the Wallah Valley downstream of the Bawdwin mine. It has around 600 people in two wards. Like Bawdwin it was established to support the Bawdwin mining operation.	**Medium** Although Tiger Camp is located close to the current mine facilities, operations have been in care and maintenance and existing noise sources have been limited. Current noise levels exceed Myanmar standards at these receptors. A medium level of importance is placed on the value of the ambient noise environment for amenity and health during the day and night.	**High** Tiger Camp is vulnerable to increased noise emissions due to its location in proximity to the project area and noise-generating project activities. Current noise levels exceed Myanmar standards and the village is vulnerable to any additional increases in noise-generating project activities.	**Medium** It is expected that this receptor would have medium resilience to increased noise emissions, on the basis that it is a village established to support mining operations and is located on a mining concession.	**Medium**
Tiger Camp farms Receptor includes scattered farms and associated houses to the east, northeast and south of Tiger Camp.	**Medium** A medium level of importance is placed on the value of the ambient noise environment for amenity and health during the day and night given the farms rural setting and their location in the mining concession.	**Medium** Tiger Camp farms are vulnerable to increased noise emissions due to its location in proximity to the project area and noise-generating project activities.	**Medium** It is expected that this receptor would have some resilience to mining, traffic and construction related noise and has some capacity to adapt to increased noise levels.	**Medium**

Receptor	Importance	Vulnerability	Resilience	Sensitivity
Lower Bawdwin village farms Receptor includes scattered farms and associated houses located to >1.5 km southeast of the open pit.	**Medium** An elevated level of ambient noise may be expected to occur due to the proximity of the farms to the extensive mining operations that have shaped Bawdwin. However, the last decade has seen relatively lower noise levels. Although existing noise levels exceed Myanmar standards at this receptor, there is still a level of importance placed on amenity during the day and night.	**Medium** Lower Bawdwin village farms have some vulnerability to increased noise emissions due to their distance from the project area and noise-generating project activities. There is little in the way of terrain barriers (i.e., hills and mountains) between most of the farms and many project noise sources.	**Medium** It is expected that this receptor would have some resilience to mining, traffic and construction related noise and has some capacity to adapt to increased noise levels.	**Medium**
Loi Mi village and associated farms This receptor includes farms and associated houses located toward the western border of the concession.	**High** The area is likely to experience relatively low levels of ambient noise given it being remote from existing industrial and traffic noise sources. The receptor is likely to have high reliance on low background noise levels to maintain amenity.	**Medium** Receptor is moderately removed from the project area (1 to 2 km), with mountainous terrain between noise sources and receptor and has a moderate level of vulnerability to increased noise.	**Medium** Receptor has some limited capacity to adapt to increased noise levels given its remote setting and likelihood of amenity value being based on low levels of background noise.	**Medium**
Nam La farms This receptor includes farms and associated houses towards the north of the concession.	**High** The area is likely to experience relatively low levels of ambient noise given it being remote from existing industrial and traffic noise sources. The receptor is likely to have high reliance on low background noise levels to maintain amenity.	**High** Receptor is in proximity to the project area (i.e., within 1 km), with little to no mountainous terrain between noise sources and receptor and is vulnerable to increased noise.	**Medium** Receptor has some limited capacity to adapt to increased noise levels given its remote setting likelihood of amenity value being based on low levels of background noise.	**High**
Residents of Nam Pangyun valley Includes artisanal miners and permanent residences associated with agricultural plots along the lower valley downstream of the concession boundary.	**Medium** The majority of the receptors along the valley are remote from existing industrial and traffic noise sources and would likely experience low background noise levels.	**High** Receptor is in a narrow valley with limited sources of existing noise and is vulnerable to increased noise sources within the valley.	**High** It is expected that this receptor would have some resilience to mining, traffic and construction related noise and has some capacity to adapt to increased noise levels. Many of the individual receptors are known to be transient in their locations and so would have some capacity to temporarily relocate from high noise and vibration emissions when in the vicinity.	**Medium**
Namtu	**Medium**	**Medium**	**Medium**	**Medium**

Receptor	Importance	Vulnerability	Resilience	Sensitivity
Namtu town has a population of more than 13,000 people. Tha Ta La Ward of Namtu Town was established to support the mining and processing operations. As a regional town Namtu has a number of manufacturing and industrial operations.	Due to the number of manufacturing and industrial operations in Namtu elevated noise levels are expected to occur from time to time. However, residential areas are likely to have some reliance on low background noise levels for amenity.	Namtu has current noise levels that exceed Myanmar standards and the town is vulnerable to any additional increases in noise-generating activities.	It is expected that this receptor would have some resilience to mining, traffic and construction related noise and has some capacity to adapt to increased noise levels.	
Residents along the export route Residents (including standalone houses, settlements, villages and towns along the export route from the processing plant to National Highway 3, approximately 70 km by road to the east of the concession.	**Medium** As these receptors are based along a network of existing public roads, a level of ongoing traffic noise would be expected by the receptors with limited reliance on low background noise for amenity.	**High** Increased noise, particularly during the night, could result in noticeable reduction in amenity and potential effects to wellbeing as amenity and health values are more sensitive at night.	**Medium** It is expected that this receptor would have some resilience to traffic related noise and has some capacity to adapt to increased noise levels.	**Medium**
Residents along the Namtu-Manton Road	**Medium** The area is likely to experience some level of noise due to existing traffic noise along this public road. The receptor is likely to have moderate reliance on low background noise levels to maintain amenity.	**High** Receptor is in proximity to the Namtu-Manton Road (i.e., within 1 km), with little to no mountainous terrain between noise sources and receptor. Increased noise would result in noticeable reduction in amenity.	**Medium** Receptor has some capacity to adapt to increased noise levels given they are based along a public road.	**Medium**

5.6.6 Uncertainties and limitations

Baseline noise monitoring characterised the existing noise environment from a broad range of sites across the Bawdwin-Namtu area. Limitations in noise baseline included:

- Baseline data was not collected at all sensitive receptors with the potential to be impacted by the project.
- Noise monitoring took place over a single monitoring campaign in which sites were monitored for 24-hour periods, rather than across consecutive days or weeks. As such, temporal variation may not have been captured. However, major differences in noise levels are not expected to be materially different for example at another point in time.

5.7 Biological environment

This section describes the existing biological environment of the project. A terrestrial and aquatic biodiversity study has been completed for the project to characterise the current biodiversity of the Bawdwin area and is presented in Appendix D. Surveys have been completed for plants, mammals, birds and herpetofauna (frogs and reptiles) to characterise the existing terrestrial biodiversity.

The biodiversity surveys were conducted in December 2018 and February 2019 by a survey team comprising eleven Myanmar nationals all with tertiary education and prior survey experience, led by a biodiversity specialist Dr Aung Aung. Dr Aung Aung and seven members of the survey team hold doctoral degrees from Yangon University, Myanmar.

5.7.1 Method and study area

A biodiversity study was undertaken to describe the existing biological values in the study area. The objectives of the study were to:

- Characterise and map the type and condition of vegetation communities and terrestrial and aquatic habitats.
- Opportunistically record terrestrial and aquatic flora and vertebrate fauna focussing on any species of conservation significance.
- Describe the plants and animals used by local communities.
- Record the presence of invasive exotic flora and fauna species.

Study area

The biodiversity study area covers approximately 8 km by 3 km, centering on the Bawdwin mining concession and extending to the northern outskirts of Namtu. The area captures proposed project infrastructure, including a section of the infrastructure corridor between the mine area and Namtu, and downstream areas to allow for the assessment of potential impacts resulting from construction, operation and decommissioning/closure of the project. The study area includes the Nam Pangyun catchment from the headwaters to the Myitnge River (Namtu River) (where most project activities will occur), the southern portion of the Nam La catchment, and Mt. Lakeland, Mt. Teddy, Shar Htoo Mountain, Russia Hill, and Wallah Valley. The spatial extent of the study area was determined to encapsulate a variety of habitats and the flora and fauna they support.

Method

The terrestrial and aquatic biodiversity baseline study comprised both desktop review and field surveys conducted by experienced Myanmar zoologists and botanists.

Desktop survey

The desktop survey included reviews of available published and unpublished documents, scientific literature and other relevant information/data from published scientific literature on terrestrial flora and fauna, such as peer-reviewed journals, books and private sector, government and non-government organisation reports.

Information collected included the conservation classification of land within the study area, the occurrence of species known or expected to occur in the area and information from questionnaires with local hunters.

Field survey

Field surveys were conducted for terrestrial flora and fauna, and aquatic ecosystems in both wet and dry seasons to capture temporal variability due to seasons. A total of 10 sites were surveyed over the wet season between 19 and 25 October 2018 and the dry season between 7 and 12 February 2019. Methods used during field surveys are summarised in Table 5.65. The biodiversity study area and survey locations are shown in Figure 5.42.

Table 5.65 Biodiversity field survey methods

Taxonomic Group	Description of Method
Terrestrial vegetation	Classification of vegetation was conducted based on a set of selected attributes, such as the taxonomic composition of the community and their morphological and functional traits. The condition of vegetation types was classified based on observations of historical and ongoing land management practices using the categories: • Intact – vegetation communities that exist in unmodified condition. • Degraded – consists of modified habitats composed of native species, such as pioneer species, that have had long term stability through regular anthropogenic intervention. • Transformed – does not represent native vegetation and includes urban areas, bare earth.
Plants	Diversity of plants were recorded during a “walk-through” transect survey by observation and photography (Plate 5.27). Unknown flora species were collected for further verification in the laboratory.
Mammals	Mammal surveys were conducted using direct observation of mammals and tracks and signs, such as footprints and scats, specimen collection, photography and interviews with local hunters (Plate 5.28). Species were recorded using binoculars and photography and their locations were recorded using a GPS.
Birds	Bird surveys used the Fixed Radius Point Count Census Method, which is based on the principle of counting individuals from a defined location within a known radius and estimating the distance to the observed individual. The survey was conducted with direct visual observation using binoculars, call recognition, photography and interviews with local hunters.
Herpetofauna	Herpetofauna surveys were conducted and their habitats were recorded by photography. All collected specimens name, geographic information (elevation, coordinates), locality and microhabitat, and activity of the animals were noted. Some specimens were recorded from interviews with local people.
Aquatic habitats	Surveys of aquatic habitats were conducted at Nam Pangyun stream, Nam La stream, Myitnge River and other representative watercourses including the Nam Pangyun Reservoir, through direct observation and photography (Plate 5.29). Surface water quality sampling at various sites (approximately monthly) was also used to characterise aquatic habitats. In situ water quality was analysed by physical and chemical parameters such as pH, temperature, turbidity, dissolved oxygen, ammonia, alkalinity and hardness.
Aquatic fauna (macroinvertebrates and fish)	Sampling for aquatic macroinvertebrate (benthos) (small animals without backbones that reside in the stream bed) was conducted at Nam Pangyun and along the Nam La stream at an upstream point near the reservoir and downstream in the Bawdwin village. Fish surveys were conducted during the day by direct observation, photography and catching fish by benthos net and hands.

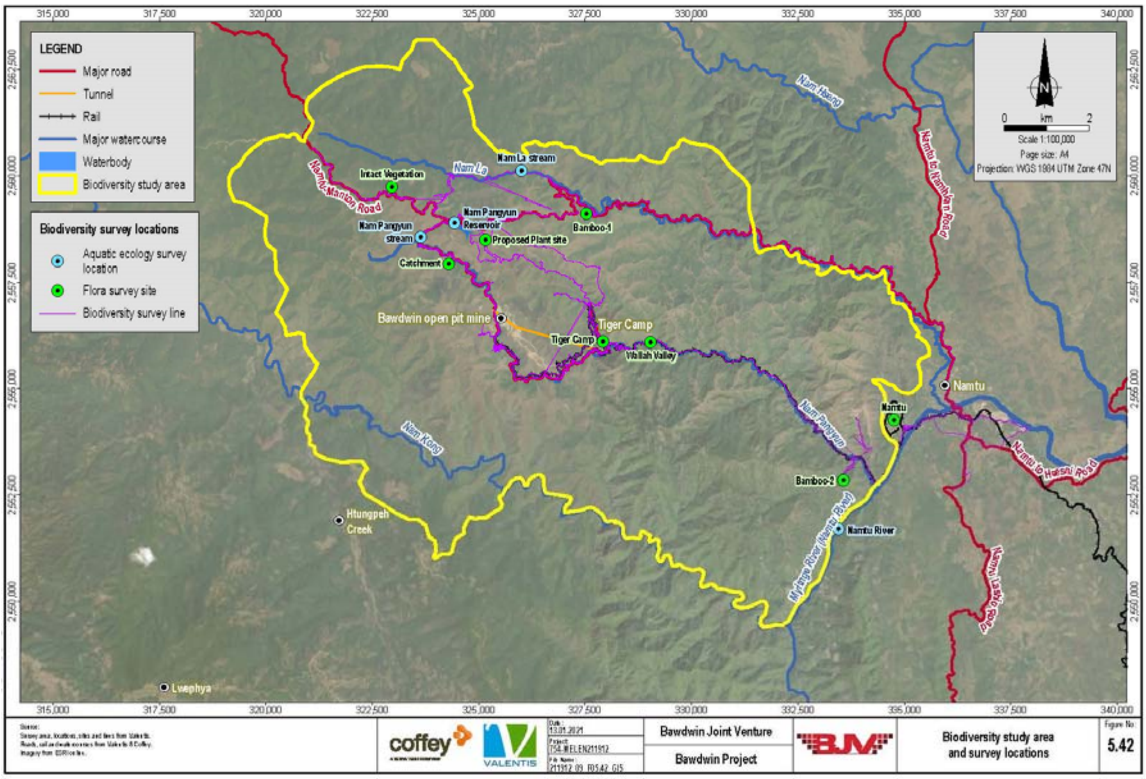

Figure 5.42 Biodiversity study area and survey locations

Plate 5.27 Flora survey team at Bawdwin conducting survey

Plate 5.28 Fauna survey team at Bawdwin conducting day time survey

Plate 5.29 Aquatic survey team at Nam La stream

Conventions

Conventions used for classifying flora and fauna are provided in the following sections and are outlined in greater detail in the terrestrial and aquatic biodiversity baseline report, Appendix D.

A focus of the terrestrial ecological studies for the project has been to identify species that are of conservation significance. These are defined as:

- Species listed as threatened (Critically Endangered, Endangered or Vulnerable) or Near Threatened in the International Union for Conservation of Nature (IUCN) Red List of Threatened Species.
- Species listed under appendices I, II and III of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which aims to ensure international trade of flora and fauna does not threaten their survival:
  - Appendix I: Species threatened with extinction which are, or may be, affected by trade.
  - Appendix II: Species not yet threatened with extinction, but which could become threatened if unlimited trade were allowed, as well as 'look-alike' species closely resembling those on the list for conservation reasons.
  - Appendix III: Species whose trade is only regulated within a specific country if requiring cooperation from other nations to help prevent exploitation.

Habitat types

Habitat types are divided into modified, natural and critical:

- Modified: areas that may contain a large proportion of non-native plant and/or animal species, and/or where human activity has substantially modified an area's primary ecological functions and species composition.
- Natural: areas composed of viable assemblages of mostly native plant and/or animal species, and/or where human activity has not essentially modified an area's primary ecological functions and species composition.
- Critical: areas with high biodiversity value, including habitat of significant importance to Critically Endangered and/or Endangered species and to endemic and/or restricted-range species; habitat supporting globally significant concentrations of migratory species and/or congregatory species (species which gather in globally significant numbers at a particular site during a particular time of their life cycle); highly threatened and/or unique ecosystems; and/or areas associated with key evolutionary processes.

5.7.2 Terrestrial biological environment

Overview of Myanmar's biodiversity

Myanmar occupies the transition zone between three biogeographic regions (MOECAF, 2015):

- Sino Himalayan region in the north.
- Indochinese region in the east.
- Malayan peninsular in the south.

Within these biogeographic regions a broad array of ecosystems occur, ranging from high mountains with permanent snow and glaciers, to a dry elevated plateau, to extensive temperate and tropical forests, and to a long coastline consisting of coastal and marine habitats.

Forest ecosystems globally support the highest levels of plant species richness, among which montane forests and lowland evergreen forests are the most species-rich (MOECAF, 2011). The combination of varied topography, variable rainfall and temperature and an extensive river network has created diverse forest types, ranging from subalpine forest in the north to tropical evergreen forest in the south. Freshwater ecosystems are found in the large, slow-flowing rivers, large lakes and fast-flowing mountain streams. The extensive seacoast with tidal mangroves supports marine ecosystems.

Myanmar is rich in biodiversity and is estimated to include approximately 250 mammal species, at least 1,000 bird species, 370 reptile species and 7,000 species of flora. These include many species that have been assessed to be globally threatened (39 mammals, 45 birds, 21 reptiles and 38 plants) (Simmance, 2013). The majority of Myanmar is located within the Indo-Burma Biodiversity Hotspot, which is one of 35 global hotspots that support high levels of biodiversity and endemism (species unique to a defined geographic location). This hotspot is ranked in the top 10 globally for irreplaceability and in the top five for threats.

Ecoregions

Myanmar has 14 major ecoregions, or relatively large areas of land or water, which each contain characteristic, geographically distinct assemblages of plants and animals. More than half the country is covered by three ecoregions: the Irrawaddy moist deciduous forest (20.6%), the Northern Indochina subtropical forest (20.5%) and Mizoram-Manipur-Kachin rainforests (10.5%) (IFC, 2017).

The project is located in the Northern Indochina subtropical forest ecoregion. These forests are recognised worldwide for their rich biological diversity, with approximately 183 mammal species and 707 bird species reported from the ecoregion across the highlands of northern Myanmar, Laos and Vietnam (approximately 136,723 kilometres squared (km^2) total). This ecoregion has the highest species richness for birds among all ecoregions in the Indo-Pacific region and ranks third for mammal richness (WWF, 2002). It is located where the northern Palearctic and the southern Indo-Malayan faunas mix, providing a crossroad for the South Asian and East Asian floras.

Eight of the forest ecoregions (71.8% of Myanmar's forest areas) are classified as either Vulnerable or Critically Endangered. The four Vulnerable ecoregions are likely to become Endangered and the four Critically Endangered ecoregions face an extremely high risk of extinction if the current factors threatening these ecoregions do not improve. The Northern Indochina subtropical forest is classified as Vulnerable and facing threats from increasing pressure from shifting cultivation, and forest conversion to wood and pulp plantations, and illegal logging (WWF, 2002).

Protected areas

A Protected Area is defined by the IUCN as a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values. There are currently 43 recognised protected areas in Myanmar, ranging in size from 0.5 km^2 to 22,000 km^2. Six of the Protected Areas (Taunggyi Bird Sanctuary, Shwe-U-Daung Wildlife Sanctuary, Inlay Lake Wetland Sanctuary, Loimwe Protected Area, Parsar Protected Area and Panlaung-Pyadalin Cave Wildlife Sanctuary) are located in Shan State, with Shwe U Daung Wildlife Sanctuary being the closest to Bawdwin, located more than 220 km away. Information on these Protected Areas is limited, scattered and not updated.

Myanmar also has 132 Key Biodiversity Areas (KBAs), identified using standardised criteria developed by the IUCN and assessed by KBA Partnership, covering approximately 41% of the country and comprising 194 sites. While KBAs have no legal status, they are defined as sites that contribute significantly to the global persistence of biodiversity in terrestrial and aquatic ecosystems (IUCN, 2016). Approximately 16% of the Northern Indochina subtropical forests are defined as KBAs. Only 1,242 km^2 (1%) of the Northern Indochina subtropical forests ecoregion is designated as a protected area.

Terrestrial ecosystems of Myanmar

The main terrestrial ecosystems/habitats of Myanmar are forest, limestone karst, and freshwater ecosystems and wetlands, and are described below.

Forest

Forest constitutes the dominant vegetation type in Myanmar covering roughly 43% of the country's total land area (approximately 290,410 km^2). Half of this area is described as closed forest, where the canopy cover is greater than 40%, whereas the other half is 'open' or 'degraded' forest, where the canopy cover is between 10% and 40% (FAO, 2015).

Rainfall and elevation have a strong influence on the distribution of different vegetation types. Tropical lowland evergreen rainforest occurs largely in the south in Tanintharyi and the southern Bago Yoma. Tropical hill evergreen rainforest and temperate rainforest are present in the east, north and west, and semi-evergreen rainforest borders the arid central plain particularly in southern Bago Yoma. Myanmar has wet deciduous forest present in Northern Tanintharyi, Bago Yoma, Bhamo and Mogok, and dry deciduous forest in northern Bago Yoma, Chindwin, western Pakokku and the Shwebo Hills. Some coniferous forests occur above 1,200 m on dry slopes, particularly in Shan and Chin states, whereas oak and rhododendron occur on the wetter slopes. Extensive bracken and bamboo brakes also occur in Myanmar. Mountain grassland is present, particularly on the Shan plateau, Chin Hills, Rakhine Yoma, and the northeastern slopes. Indaing forest occurs in small patches along dry ridges of Bago Yoma.

Limestone karst

Karst formations are found in several regions including Tanintharyi Region, Kayin State, Shan State and Kachin State. Some species found in karst habitats, such as molluscs, have very restricted ranges making these formations ecologically important. Nineteen new gecko species have recently been found within karst habitats in Myanmar. The nearest areas of mapped limestone are about 6 km to the east of Bawdwin, there is no mapped limestone geological formations present on the Bawdwin concession.

Freshwater ecosystems

Myanmar supports a diverse range of freshwater ecosystems including large river systems and lakes that are important for biodiversity and have cultural and economic value. Myanmar's eight major river catchments are the Ayeyarwady, Chindwin, Thanlwin, Sittaung, Myit Ma Hka and Bago, several shorter rivers from the Rakhine Yoma and Chin Hills and the Tanintharyi coastal region. The most notable lakes in Myanmar are Inle Lake and Indawgyi Lake, which is one of the largest lakes in Asia.

The Ayeyarwady River corridor is one of the most ecologically valuable stretches of river, extending from north of Mandalay to Bhamo. It supports the Critically Endangered freshwater subpopulation of the Irrawaddy Dolphin, threatened birds and turtles such as the Critically Endangered Northern River Terrapin and the Vulnerable Burmese Eyed Turtle, the Critically Endangered White-bellied Heron and valuable riparian habitat.

Terrestrial vegetation and flora

Overview of Shan State terrestrial vegetation and flora

Shan State consists of evergreen forests, mixed forests, grass- and shrublands, and extensive areas of agricultural land and urban areas. Common trees in the region include conifers, oak, walnut and bamboos, Tamarind (*Tamarindus indica*), Oroxylum (*Oroxylum indicum*), Indian Siris (*Albizia lebbeck*), guava (*Psidium guajava*), citron (*Citrus medica*), some medicinal plants, and pine forests which are strictly protected in Myanmar.

Agriculture plays an important role in the economy of the Shan State including cultivation of rice, wheat maize, groundnut, pulses and beans, fresh fruit and vegetables. There are also cotton, coffee, tea and tobacco plantations. Livestock breeding and freshwater fisheries are also significant. Terrestrial flora in Shan State is poorly known, however, a recent study was conducted at Pindaya township in Shan State, located approximately 251 km from Bawdwin, to identify the common plant species in the area. The study revealed 64 plant species from 27 families and 41 genera in the study area, with Khansue (*Carissa spinarum*) being the most dominant species representing about 10% of the total individuals and Thit poke (*Celtis tetrandra*) being the second most dominant species representing about 9% of the total individuals. The majority of the tree species belong to Lauraceae family (Aung et al., 2018).

Prior to mining at Bawdwin, which is thought to have commenced in the 1400s, Bawdwin would have consisted of hill and temperate evergreen forests primarily comprised of sub-tropical mixed hill and savannah. However, these forests have been significantly reduced by deforestation (primary for firewood to enable ore smelting), the phytotoxic effects of smelting fumes, and to a lesser extent cattle grazing and small-scale agriculture. Vegetation clearing, and repeated seasonal burning has caused conversion of forests to grasslands. Shan State is experiencing some of the highest rates of losses of intact forest (Bhagwat el al., 2017), with fragmented areas exposed to very high pressures from surrounding agricultural uses, and ongoing loss of vegetation from charcoal marketing and firewood collection.

Overview of biodiversity study area terrestrial vegetation and flora

Terrestrial vegetation

Ground surveys of flora and fauna and aerial imagery were used to classify the vegetation types within the biodiversity study area. The four main vegetation types within the study area are:

- Grassland, which widely occurs in the mountain range and in the areas surrounding the Bawdwin mine.
- Bamboo, which can occur in mountain valleys and can be found further away from the mine beyond the grasslands.
- Scrub, which can occur with bamboo and grassland vegetation types.
- Sub-tropical mixed hill forest, which occurs in the northwestern extent of the study area generally outside of the Bawdwin concession.

Some small patches of cultivated areas were found among the bamboo and grassland area. The different vegetation types within the biodiversity study area are shown in Figure 5.43**.**

The dominant vegetation types of the Bawdwin mine area are bamboo forest and grassland. Both of these vegetation types are modified or degraded communities due to many centuries of disturbances from mining activities at Bawdwin. It is likely that topsoils in the Bawdwin area have been largely eroded from hills and steep-sided slopes leaving poor quality soils with low organic material, likely contributing to the conversion from hill forests to grasses and bamboo vegetation types. Sub-tropical mixed hill forests are likely to be relatively intact with some modification at a fine scale. The areas of intact sub-tropical mixed hill forest which occur approximately 4 km northwest from the Bawdwin open pit (although visited during field surveys, was not the focus of the biodiversity studies), likely contains higher biodiversity values and support several rare or threatened species. Other areas of more intact vegetation are located within valleys and along watercourses, which provide areas of potential habitat for various mammal, bird and herpetofauna species identified within the study area (Section 5.2.3).

A description of the main vegetation types in the study area is provided in Table 5.66.

Table 5.66 Description of vegetation types

Vegetation Type	Description
Bamboo (Plate 5.30)	Bamboo occurs in the valleys of mountains in the study area. This vegetation type is dominated by Shwe wa (*Bambusa vulgaris*), Wa bo (*Dendrocalamus giganteus*), Wa net (*Dendrocalamus longispathus*), Hmyin wa (*Dendrocalamus strictus*) and Wa nwe (*Dinochloa maclellandii*).
Grassland (Plate 5.31)	Grassland widely occurs in the mountain range of the study area. This type is dominated by *Andropogon gerardii*, Kyeik (*Coix lacryma-jobi*), *Pennisetum villosum*, Kyu (*Phragmites vallatoria*) and *Sporobolus indicus*.
Scrub	Scrub occurs with both the bamboo and grassland vegetation types. This vegetation type is dominated by Ba Ka or Garmani (*Ageratina adenophora*), Phone-ma-thein (*Blumea balsamifera*), Kyaung-migo (Buddleja asiatica), Be-zat (*Chromolaena odorata*), Phet-kar (*Clerodendrum colebrookianum*), Nga-u-thi (*Rubus ellipticus*) and Pan-swe (*Woodfordia fruticosa*).
Sub-tropical mixed hill forest (Plate 5.32)	Sub-tropical mixed hill forest occurs in the northwestern extent of the study area generally outside of the Bawdwin concession. This vegetation type is dominated by Min baw (*Caryota mitis*), Lettok gyi (*Holarrhena pubescens*), Phet wun (*Mallotus cochinchinensis*), Taung ma yo (*Alstonia scholaris*), Thet yin gyi (*Croton roxburghianus*), Palaung-nga-yoke-kaung (*Toddalia aculeate*) and Thit yar phyu (*Phoebe tavoyana*).

A significant portion of the study area is classified as modified/degraded vegetation as shown in Figure 5.44 and can be seen in Plates 5.33, 5.34 and 5.35. Most forested areas in and surrounding Bawdwin were cleared dating back to the early Chinese mining years. The area extending outwards from Namtu has also been extensively cleared for construction materials and firewood. Approximately 30% of respondents from the 2019 socio-economic surveys in Bawdwin villages and 12% in Namtu reported that firewood was their main source of energy for cooking (Appendix E).

Historical air pollution from smelting which produced sulfur dioxide and other particulates causing acid rain at the Namtu smelter complex, was another driver of vegetation modification in the area. The acid rain has caused deforestation of the hills and ridges around Namtu. Historical air pollution from dust is also likely to have caused contamination of soils in the area as shown from soil samples with elevated heavy metal concentrations (lead, arsenic and nickel). This may inhibit rehabilitation of the area, as growth reduction from changes in physiological and biochemical processes in plants grown in soils contaminated by heavy metals has been recorded (Chibuike and Obiora, 2014).

Plant diversity

The botanical survey collected 177 plant species belonging to 155 genera and 83 families. Collected species consisted of 49 herbs, 37 trees, 35 shrubs, 25 small trees, 17 climbers, eight grasses, five bamboos and one epiphyte. The more intact sub-tropical mixed hill forest in the northwestern extent of the study area has the most diversity in plant species followed by Tiger Camp. The list of all the recorded plant species from the flora study are shown in Annex B of the terrestrial and aquatic biodiversity baseline report, Appendix D.

The most diverse flora families recorded in the study area were from the Asteraceae and Poaceae families which comprised 14 species each. The most commonly recorded flora families within the study area and the number of species in each include: Asterraceae (14); Poaceae (14); Fabaceae (11); Euphorbiaceae (7); Solanaceae (5); Apocynaceae (4); Moraceae (4); Rosaceae (4) and Rutaceae (4).

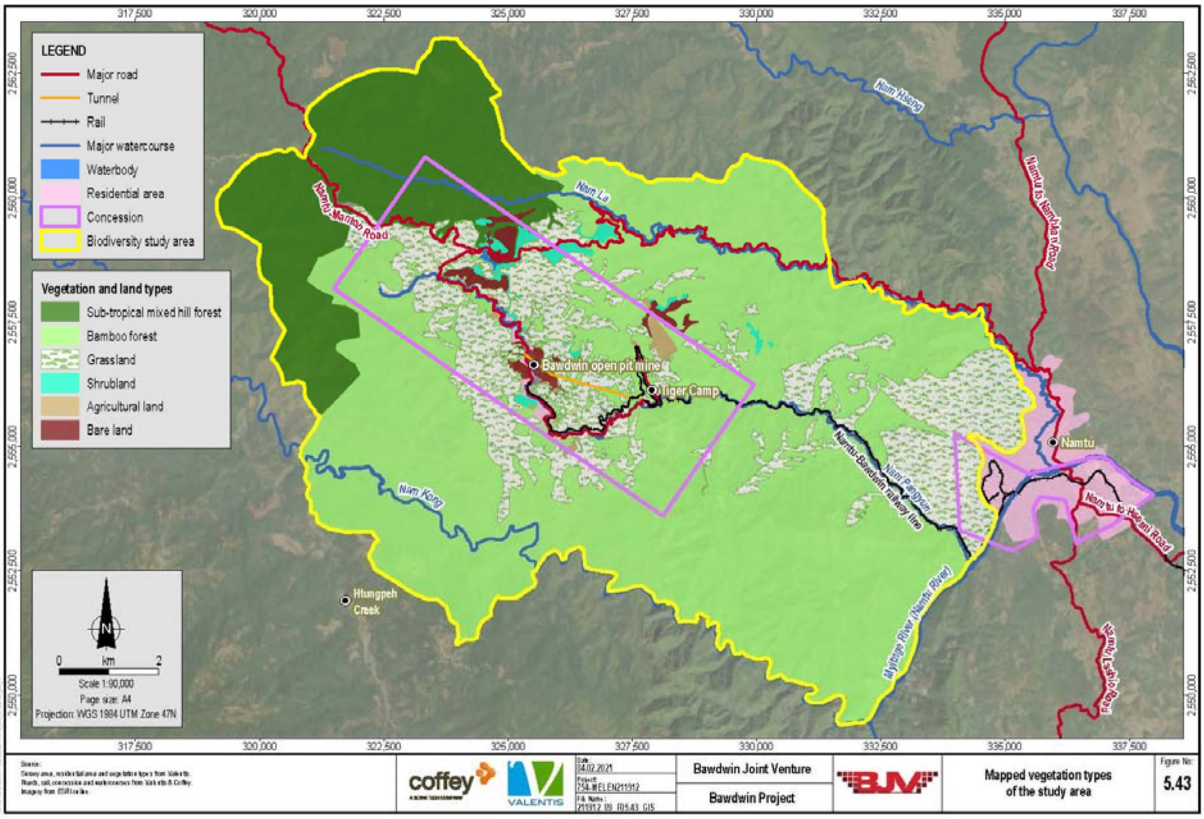

Figure 5.43 Mapped vegetation types of the study area

Plate 5.30 Example of bamboo forest in the study area

Plate 5.31 Example of grassland in the study area

Plate 5.32 Example of sub-tropical mixed hill forest in the study area

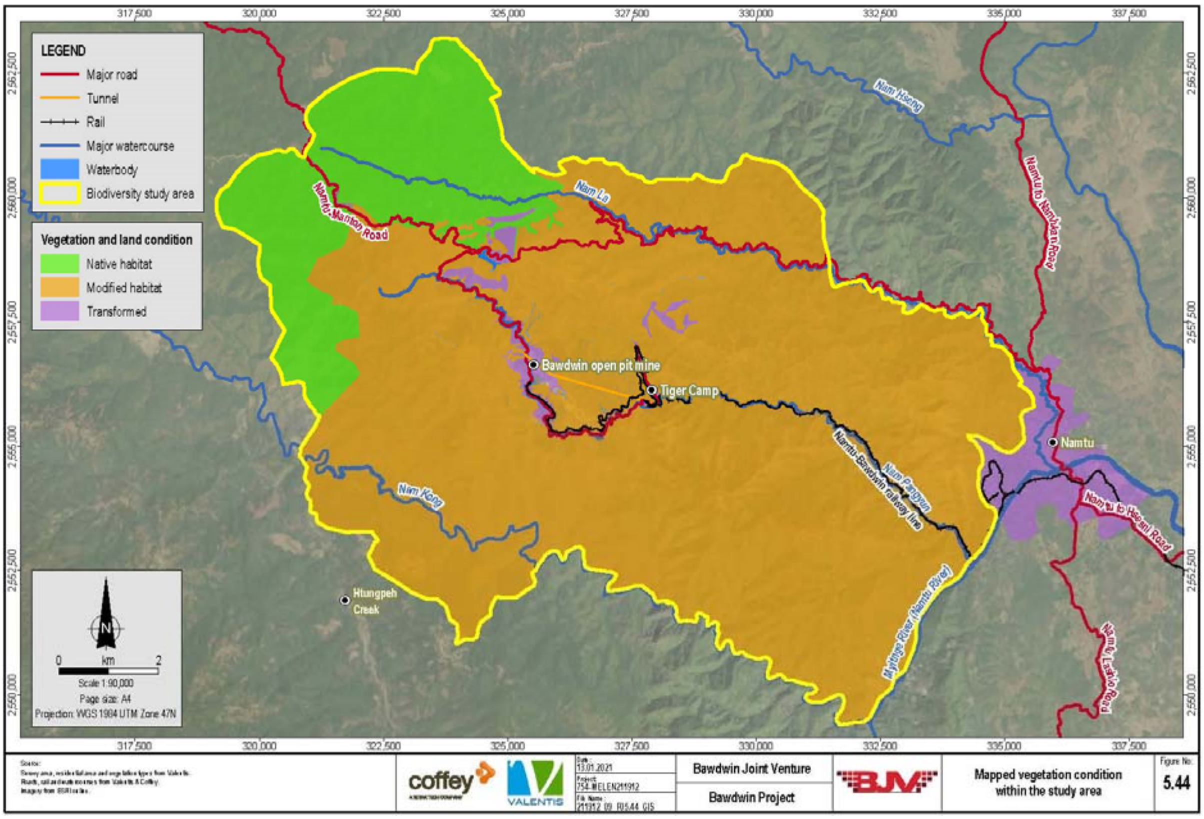

Figure 5.44 Mapped vegetation condition within the study area

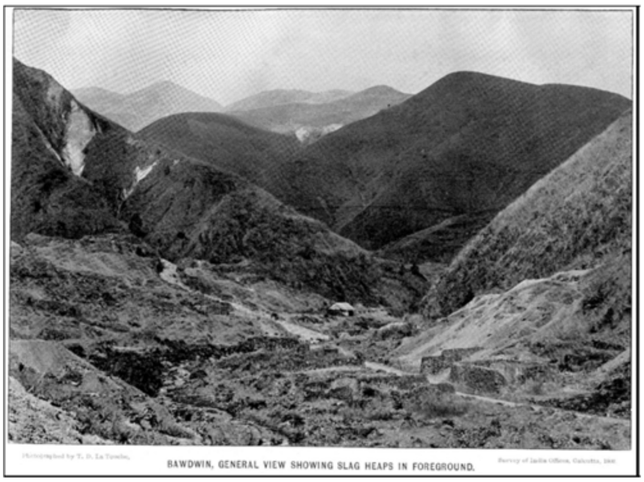

Plate 5.33 The Nam Pangyun valley at Bawdwin in 1907

Plate 5.34 View from the north eastern area of Bawdwin looking east

Plate 5.35 Terraces on the sides of one of the tributary valleys to the north of Bawdwin

Species of conservation significance

Thirty-four IUCN Red List flora species and three CITES flora species were recorded in the study area during the baseline survey.

Two of the 34 IUCN-listed species are considered species that are of conservation significance: the *Cycas pectinata* (Vulnerable) (Plate 5.36) and Burmese blackwood (*Dalbergia cultrate*) (Near Threatened) (Plate 5.37). All other IUCN-listed species were listed as either Data Deficient (Tea plant (*Camellia sinensis*) and Papaya (*Carica papaya*)), Least Concern, or are listed as threatened in their native habitats, but are not considered threatened for the purpose of this assessment given their location in the study area (Arabica coffee (*Coffea arabica*) (Endangered) and Perennial sow thistle (*Sonchus arvensis*) (Near Threatened)).

Of all the flora species listed on the IUCN Red List, almost 90% were located in sub-tropical mixed hill forest habitat. This included the two threatened species *Cycas pectinata* and Burmese blackwood. The *Cycas pectinata* was also recorded in grasslands. The *Cycas pectinata* occurs in medium to tall closed forest in moist conditions. Large populations of this species remain and it is not under any immediate threat of extinction. The Burmese blackwood is a medium sized (20 to 30 m high) deciduous tree which grows in a variety of forest types such as bamboo, humid deciduous and evergreen forests. The species has been extensively exploited for timber which has led to a decline in the population. Both of these threatened species have a low likelihood of occurring in the project area due to a lack of forest in the area.

There may be additional species of conservation significance that were not observed, such as orchids, that are likely to occur in natural sub-tropical mixed hill forest and potentially bamboo forests.

Three CITES-listed species were found in the study area: Bamboo orchid (*Arundina graminifolia*) (Plate 5.38), *Cycas pectinata*, and Burmese blackwood. These species are listed on CITES Appendix II meaning they are not threatened with extinction but could become threatened if unlimited trade were allowed.

Cultivated plant species, fencing plant species and exotic flora species

A total of 17 cultivated plant species were recorded in this study. Cultivated and garden plants are used for food and medicine as well as supporting the ecosystem services for inhabitants. All of these cultivated plants are indigenous.

Four fencing plant species were recorded in this study: *Duranta repens* L., *Lantana aculeata* L., *Bougainvillea glabra* Choisy, and *Euphorbia tithymaloides* L. Fencing plants are important for supporting the ecosystem services for inhabitants. The fencing plant *Lantana aculeata* is a variety of *Lantana camara*, which is considered an invasive species to Myanmar (CABI, 2021). *Lantana camara* tends to grow in a range of habitat, including disturbed areas and the edges of forests (CABI, 2021).

Two exotic (non-native) species, *Ageratina adenophora,* and *Mikania micrantha* were recorded in the study area. According to Kress et. al.(2003, as cited in Appendix D), *Ageratina adenophora* species has not previously been recorded in Myanmar and *Mikania micrantha* species has only been recorded in Taninthayi Region in the checklist of Myanmar. *Ageratina adenophora* is a species of flowering plant in the daisy family native to Mexico and Central America but has become invasive into farmland and bushland worldwide. *Mikania micrantha* is a species of vine that is a multi-stemmed perennial creeper and climber native to the Americas. It rapidly chokes and smothers areas it has colonised and is considered an invasive species in South-East Asia, Indonesia, the Pacific Islands and Australia. These two species were commonly found throughout the Bawdwin biodiversity study area.

Plate 5.36 *Cycas pectinata* (Vulnerable)

Plate 5.37 Burmese blackwood (*Dalbergia cultrate*) (Near Threatened)

Plate 5.38 Bamboo orchid (*Arundina graminifolia*)

Terrestrial fauna

Overview of Shan State terrestrial fauna

Shan State is made up mostly of the Northern Indochina subtropical forest ecoregion, which is recognised for its rich biological diversity, with approximately 183 mammal species and 707 bird species reported across the highlands of northern Myanmar, Laos and Vietnam. This ecoregion has the highest species richness for birds among all ecoregions in the Indo-Pacific region and ranks third for mammal richness (WWF, 2002). Mammal species of conservation significance known to occur within the Northern Indochina subtropical forest ecoregion within Myanmar include, but are not limited to, tiger (*Panthera tigris*), Asian black bear (*Ursus thibetanus*), red mutjac (*Muntiacus muntjac*), wild dog (dhole) (*Cuon alpinus*), gaur (*Bos gaurus*), particoloured flying squirrel (*Hylopetes alboniger*), pigtailed macaque (*Macaca nemestrina*), and back-striped weasel (*Mustela strigidorsa*) (WWF, 2002). Much like the Shan State flora, the fauna is also poorly known.

The recent study at Pindaya Township in Shan State (approximately 251 km from Bawdwin) recorded a total of 94 bird species and 20 butterfly species. Other reported fauna that occur in the region includes muntjac, porcupine, marten, jungle cat (*Felis chaus*), squirrels, Siamese hare (*Lepus peguensis*) and tortoise. Inle Carp (*Cyprinus intha*), recognised as Endangered endemic species, and Himalayan Newts were found in Pwe Hla lake in Pindaya Township (Aung et al., 2018). The report suggested that the Pindaya Township study area is important for biodiversity conservation due to the diversity of species and the presence of migratory and threatened species (Aung et al., 2018).

Overview of terrestrial fauna of the biodiversity study area

Mammals

A low diversity mammal community was recorded within the study area, mostly in areas of mixed hill forest and to a lesser extent bamboo forest. Only one species, the Burmese hare (*Lepus peguensis*), was recorded in grassland habitat. Very few native mammals are predicted to occur within the project area. Hunters have reported that, although declining, they still target deer and wild boar, particularly during the wet season. Hunters have also reported that wild animals are becoming increasingly rare, probably due to deforestation and agricultural practices in the area. Bawdwin residents have reported that larger mammals such as tigers, leopards and Asian black bears previously inhabited the area, but no longer occur locally.

A total of 19 species of mammal belonging to 9 orders and families were recorded in the study area during the fauna survey (see Plates 5.39, 5.40 and 5.41 for examples of three species recorded). Four of these 19 species are species of conservation significance: one Critically Endangered species, the Chinese pangolin (*Manis pentadactyla*); one Endangered species, dhole (*Cuon alpinus)*; and two Vulnerable species, Asian black bear (*Ursust thibetanus*) and hog badger (*Arctonyx collaris*). One of the 19 species, the large-toothed ferret badger (*Melogale personata*), is listed as Data Deficient. Of these five species, only the large-toothed ferret badger was directly recorded, with the other species being reported in interviews with hunters as being historically present in the last decades.

The Chinese pangolin (Critically Endangered) was historically recorded near Tiger Camp, LwePya, and Toneme stream. This species can normally be found in a wide variety of habitats, including primary and secondary tropical forests, limestone forests, bamboo forests, broad-leaf and coniferous forests, grasslands and agricultural fields. The primary threat to this species is hunting and poaching for both local and international use, driven largely by the market demand in China.

The dhole (Endangered) was reported by hunters as occurring near Tiger Camp, LwePya and Toneme stream the timeframes of sighting are uncertain. The latter two locations well beyond the Bawdwin concession. This species can occur in a wide range of vegetation types, including, but not limited to, primary and secondary and degraded tropical, dry and moist deciduous forests, evergreen and semi-evergreen forests, and temperate deciduous forests. The greatest factor contributing to the decline of this species is likely to be due to the depletion of prey as a result of overhunting by humans. Habitat loss and degradation are other major threats to this species both directly and indirectly.

Plate 5.39 Red muntjac (*Muntiacus muntjac*)

Plate 5.40 Wild boar (*Sus scrofa*)

Plate 5.41 Phayre's squirrel (*Callosciurus phayrei*)

The Asian black bear (Vulnerable) has been historically recorded northwest of the Bawdwin area. This species also occupies a variety of habitats, including both broad-leaved and coniferous habitats. They can be found near sea level and up to an elevation of 4,300 m with individuals moving to different elevations and habitats seasonally. Habitat loss from logging, agriculture/plantations, roadway networks and dams, as well as hunting are the primary threats to this species.

The hog badger (Vulnerable) was historically recorded in the Wallah Valley. This species occurs in the extreme lowlands as well as up into the montane zone, in both heavy deciduous and evergreen forests and in non-forested areas such as grasslands. Hunting is the likely cause of the decline in hog badger populations.

The Chinese pangolin, dhole and Asian black bear have a low likelihood of occurrence within the project area due to the lack of suitable habitat. The hog badger has a moderate likelihood of occurrence as it is more adaptable to its environment and lives in agricultural areas and grasslands. Mammals such as the red muntjac (*Muntiacus muntjac*) and wild boar (*Sus scrofa*) are more likely to occur in the project area due to their adaptable ecology and tolerance to degraded habitats.

Birds

A total of 81 bird species from 12 orders and 40 families were identified during two surveys (dry and wet season) in the study area. Fifty-five species were recorded during the wet season and 81 species during the dry season. The additional species recorded during the dry season were primarily migratory birds that were not observed during the wet season. Three of the total recorded species are waterbirds: Chinese pond-heron (*Ardeola bacchus*), black-crowned night heron (*Nycticorax nycticorax*) and red-wattled lapwing (*Vanellus indicus*).

A moderate diversity of bird species was recorded, with the highest diversity recorded near Tiger Camp. No conservation significant bird species were recorded, with all species listed as Least Concern by the IUCN.

All bird species were recorded in the intact sub-tropical mixed hill forest habitat. Approximately 80% of these were also recorded in the bamboo forest habitat and only 40% were recorded in the grassland habitat. Most bird species are generalists or insectivorous species (species that eat insects, worms and other invertebrates) with broad ecological niches.

Plates 5.42, 5.43 and 5.44 show three of the bird species (banded bay cuckoo (*Cacomantis sonneratii*), blue-throated barbet (*Megalaima asiatics*) and ashy bulbul (*Hemixos flavla*) that were recorded during the field surveys.

Herpetofauna

Herpetofauna species richness and evenness tends to be lower in habitats located at higher elevations with cooler climates, such as the study area, than in warmer lowland areas. The habitat types within the study area are dominated by bamboo forest, grassland, streams and the Myitnge River.

A total of 14 species of herpetofauna from two orders and nine families were recorded within the study area. Three species are anurans (tailless amphibians such as frogs or toads) and eleven species are Squamata (scaled reptiles such as lizards, geckos and snakes). The three amphibians that were recorded are the paddy frog (*Zakerana limnocharis*), Khuls stream frog (*Limnonestes kuhlii*) (Plate 5.45) and black-spectacled frog (*Duttaphrynus melanostictus*). Two of the snakes were noted from a local hunter's interview. The specimens of two lizards, Indo-chinese forest lizard (*Calotes mystaceus*) (Plate 5.46) and Oriental garden lizard (*Calotes versicolor*) and two snakes, spotted cat snake (*Boiga multomaculata*) and white-lipped pit viper (*Trimeresurus albolabris*) were observed. The Indo-chinese forest lizard and Oriental garden lizard are listed as Not Evaluated while the other 12 species are of Least Concern. Since the baseline survey was completed, a king cobra (*Ophiophagus hannah*)(Plate 5.47) was observed within the Bawdwin operational area (A. Witcomb, pers. comm. 2020). King cobras are considered Vulnerable on the IUCN Red List and are threatened by habitat destruction and degradation, as well as hunting for bushmeat and medicinal use (Evans et al., 2020). They primarily prey on smaller snakes and can be found in a range of habitats throughout Southeast Asia, though usually in undisturbed forests. When disturbed by human activity, king cobra tend to retreat.

Plate 5.42 Banded bay cuckoo (*Cacomantis sonneratii*)

Plate 5.43 Blue-throated barbet (*Megalaima asiatics*)

Plate 5.44 Ashy bulbul (*Hemixos flavla*)

Plate 5.45 Khuls stream frog (*Limnonestes kuhlii*)

Plate 5.46 Indo-Chinese forest lizard (*Calotes mystaceus*)

Plate 5.47 King cobra (*Ophiophagus hannah*) (Vulnerable)

5.7.3 Aquatic biological environment

Overview of aquatic ecology

Study area context

The broader study area catchment includes a variety of habitats from small creeks to large meandering rivers. Aquatic plants, trees and tree roots line sections of waterways, providing habitat for aquatic fauna. The main watercourse that drains the Bawdwin mine area is the Nam Pangyun. This stream flows southeast starting from approximately 1,400 m above sea level in the upper reaches north of Bawdwin, runs through the mine area then easterly towards Tiger Camp, and then flows again southeast, discharging to the Myitnge River at approximately 560 m above sea level. Two main perennial springs in the upper reaches of the catchment sustain flows to the Nam Pangyun during dry months. The Nam Pangyun catchment covers a total area of 0.01 km^2 (4,780 ha).

A tributary of the Nam Pangyun was dammed at the stream's source to create the Nam Pangyun Reservoir, which was constructed to supply mine water to Bawdwin via a water supply pipeline parallel to the Nam Pangyun. The reservoir receives runoff from a very small surrounding catchment, primarily during the wet season.

Nam La flows west to east in the adjacent catchment to the north of the Nam Pangyun. The Nam La catchment is largely undisturbed with only a few small settlements and minimal industrial activity.

The largest watercourse within the study area is the Myitnge River, which flows south through Namtu. The river receives drainage from the Nam La and Nam Pangyun catchments and is approximately 50 to 70 m wide with a depth of about 10 to 12 m according to local people. A variety of fish species are known to occur within the Myitnge River catchment, including, but not limited to, ba-moong, ba-nin, ba-kayork, and ba-len. Turtles can also be found in this catchment. Villagers living along the Myitnge River in Hsipaw, approximately 55 km south of Bawdwin and about 65 km south of Namtu, rely heavily on fishing in the river, particularly in June and July, when water levels are higher.

Aquatic ecology in the study area has been heavily influenced by anthropogenic activities. Waterways have been contaminated from elevated metal concentrations due to interaction with mineralised areas and workings of the historic Bawdwin mine (primarily the Nam Pangyun stream), increased sedimentation of water sources from mine waste placement, historical deforestation and exposure of soils to erosion (primarily affecting the Nam Pangyun stream), and the disposal of organic wastes directly into the watercourses from sewage disposal (primarily in the Nam Pangyun and Myitnge River). The direct disturbance of aquatic habitats as a result of sedimentation, as well as in-stream physical modification, has also impacted the aquatic ecology of the area. All these impacts have resulted in variable aquatic ecosystems within the study area.

The aquatic ecology is described in the following sections for the key surface water features draining the project area: Nam Pangyun Reservoir, Nam Pangyun stream, Nam La stream and Myitnge River.

Nam Pangyun Reservoir

The Nam Pangyun Reservoir is surrounded by steep banks with riparian vegetation to the water's edge. Aquatic plants grow along the edge of the shallower waters of the reservoir, which are likely to provide habitat for fish and other aquatic fauna. In situ water quality monitoring conducted at the reservoir showed moderate turbidity, total suspended solids (TSS), and dissolved oxygen concentration and pH levels supportive of a healthy aquatic environment. Sediments in the reservoir were observed to be silty, which may explain the moderate turbidity in the water, given finer particles can be readily suspended by currents.

There are no ambient water quality criteria for aquatic ecosystem protection in Myanmar. Therefore, for reference, water quality results are compared to Australian and New Zealand water quality guidelines for slightly-to-moderately disturbed aquatic ecosystems (ANZG, 2018). Dissolved copper, manganese and zinc within the reservoir were slightly elevated compared to Australian and New Zealand water quality guidelines. The detailed results from the in-situ water quality monitoring and the water quality analysis of heavy metal concentrations are presented in Section 5.3.

Nam Pangyun

Stream-bed artisanal mining of residual slag from historical mining at Bawdwin and sedimentation of the stream bed from the ER valley waste rock have significantly modified the physical habitats of the Nam Pangyun.

Aquatic habitats

The broader Nam Pangyun catchment can be separated into three main sections: upper catchment, stretching approximately 5 km from the headwater springs to just upstream of the Bawdwin open pit; mid catchment, stretching approximately 3 km from the Bawdwin open pit to just upstream of where discharge from the Tiger Tunnel enters the stream; and lower catchment, from the Tiger Tunnel discharge point 7 km downstream to the confluence with the Myitnge River.

The Nam Pangyun receives direct sewage discharge from Bawdwin villages which have public toilets on creek banks. Further downstream in the mid and lower catchments, the impacts of historical and artisanal mining are evident. Aquatic biodiversity surveys within the Nam Pangyun recorded a limited community of macroinvertebrates and fish, which are generalist and adaptable species with a high level of resilience.

Based on interviews and observations in the field (Coffey-Valentis, 2019), there is a limited number of freshwater fish in the Nam Pangyun, and there is no reported fishing activity in streams across the Bawdwin and Tiger Camp villages.

The following sections provide descriptions of the three catchment areas along the Nam Pangyun, as recorded during field surveys. The detailed results from the in situ water quality monitoring and the water quality analysis of heavy metal concentrations are presented in Section 5.3.

Upper catchment

The top of the upper catchment is characterised as a slow-flowing, clear-water stream fed by spring systems. The stream substrate comprised boulders, cobbles and pebbles scattered with gravels and sands. Indication of fish and other aquatic fauna habitats was observed, including aquatic plants and woody debris. Turbidity and TSS were relatively low at the time of the survey, and pH and dissolved oxygen levels were found to be within ranges of streams in good ecological health. Rubbish, including plastics and discarded clothing, was observed approximately 2 km downstream of the headwaters, probably originating from the settlements upstream of the site along the Nam Pangyun. Riparian vegetation along this section of the stream was relatively dense to the river edge (Plate 5.48). Dissolved concentrations of heavy metals were elevated above the Australian and New Zealand water quality guidelines, indicating contamination in the stream, likely from historical Chinese mining activities.

Mid catchment

The mid catchment is highly modified compared to the upper catchment. The streambed comprised a mix of boulders, cobbles, pebbles, gravels, sands and silts, which is characteristic of a highly disturbed river system from unnatural sediment inputs such as waste rock and erosion of spoil dumps. Rubbish was observed within and along the edge of the river. There is a lack of riparian vegetation, as the riparian zone is highly modified by housing and access roads, and therefore no edge habitats (e.g., aquatic plants) or woody debris habitats are present).

The stream about 1.5 km downstream of the existing Bawdwin open pit, receives noticeable sedimentation from spoil and historical waste rock dumping. Dumped waste spoil material can be seen eroding into the river resulting in a more orange/yellow coloured bed material compared to the upper catchment. Orange/brown, near neutral pH seepage was observed approximately 2 km downstream of the existing Bawdwin open pit, possibly originating from waste rock stored in the ER valley. At the time of the survey, dissolved heavy metal concentrations were significantly elevated compared to guidelines, greater than at sites in the upper catchment, indicating a highly impacted section of the stream.

Lower catchment

The lower catchment receives water from groundwater seepage and dewatering from the mineralised zone via the Tiger Tunnel, which discharges into the Nam Pangyun approximately 500 m upstream of Tiger Camp, resulting in high dissolved metal concentrations. In situ water quality measurements showed the water was slightly acidic and highly turbid. The water also had very high sulfate concentrations (more than 1,000 mg/L) and dissolved concentrations of nickel and zinc that were significantly higher than the draft Myanmar National Environmental Quality (Emission) Guidelines – Mining (MOECAF, 2014). The river comprises variably sorted substrate material reflecting upstream historical waste rock and spoil inputs.

Further downstream, the Nam Pangyun has sections where waste slag, sediment and waste rock material have accumulated in the valley over the years. Even further downstream, the lower Nam Pangyun becomes highly turbid likely due to a combination of resuspension of finer sediments that have mobilised, as well as disturbance due to artisanal mining activities that occur in this section of the stream. Dissolved metal concentrations in the lower Nam Pangyun waters were highly elevated compared to the guidelines. The combination of high metal concentrations, the extensive sediment and rocks from upstream disturbance and a lack of aquatic plants, indicate that the stream is highly impacted.

Macroinvertebrate sampling

Macroinvertebrate sampling was conducted just downstream of Nam Pangyun Reservoir (Nam Pangyun I) and about 1 km further downstream (Nam Pangyun II). Benthic macroinvertebrates can be good indicators of stream health because the presence/absence of pollution tolerant/intolerant species can provide evidence of whether pollution is or has been occurring. Eight taxa were marked as either present or absent at each of the upper catchment sites. Each taxon's presence or absence can provide information about the condition of the stream.

Caddisflies are sensitive to water pollution (including low dissolved oxygen, contaminants and sediment smothering). Caddisflies were not recorded in the Nam Pangyun. However, mayflies, which are also pollution sensitive, were present at both sites. Midges, which are more pollution tolerant, were recorded at both sites. Blackflies were not recorded at either site, and damselflies were only recorded at Nam Pangyun I near the reservoir. The other taxa (hemiptera, dragonfly and back swimmer) were recorded at both sites.

It is difficult to draw conclusions from this data without additional sampling at this site and nearby reference sites, which would provide better understanding of whether the presence/absence of the eight taxa are indicative of a healthy stream, or otherwise.

Macroinvertebrate sampling was not conducted at SWNP03, but it is likely that habitat quality for benthic macroinvertebrates is low, due to the sands and silts form the eroding waste rock/spoil dumps filling spaces between cobbles and pebbles. Macroinvertebrate sampling was not conducted at any other site along the Nam Pangyun.

Nam La

The Nam La catchment is mostly undisturbed with a few small settlements and minimal industrial activity. Six species of aquatic plant were recorded from within the Nam La stream: Asiatic pennywort (*Centella asiatica*), taro (*Colocasia esculenta*), climbing flower cup (*Floscopa scandens*), water celery (*Oenanthe javanica*), water pepper (*Polygonum hydropiper*), and roundleaf toothcup (*Rotala rotundifolia*). None of these species were recorded within the Nam Pangyun. More intact and diverse vegetation is present along the Nam La stream compared to the Nam Pangyun stream.

Aquatic habitats

Observations of clear water in the upper Nam La water indicate a lack of upstream ground disturbance and subsequent sedimentation. The stream bed was dominated by boulders, cobbles and pebbles with riffle sections created by the shallow flow over rocks. The river edge was lined with grasses and aquatic plants, which provide habitat for fish and other aquatic fauna. The pH and dissolved oxygen levels of the upper Nam La waters are within the healthy ecosystem range.

Three sites along the Nam La were observed and monitored. Monitoring locations and results from water quality monitoring/analysis are presented in Section 5.3.3.

The Nam La stream approximately 12 km downstream of the headwaters (about 2.5 km north of Namtu) and directly upstream of the weir for the Nam La flume intake (provides drinking water and irrigation water to the Namtu township) is characterised by shallow, clear water, with some pools present. The streambed comprised sands, gravels and cobble beds. Sheltered undercut ledges were present along the stream's edge which provide habitat to aquatic fauna. Woody debris and leaf litter were also observed in this section of the stream. The Nam La north of Namtu had relatively low turbidity and TSS and the pH range was within the range for a healthy aquatic ecosystem. Water quality analysis undertaken between November 2017 and May 2019 showed elevated levels of heavy metals, indicating some existing stress on the aquatic environment. The source of these elevated concentrations is not clear. Although greater than the Australian and New Zealand water quality guidelines for aquatic ecosystem protection, metals concentrations were far lower in the Nam La than in the Nam Pangyun.

Approximately 1.5 km further downstream, still upstream of Namtu, the stream is shallow with clear, slightly alkaline water. A large bar of variably sorted sediment material lines a side of the stream, indicating some ongoing sedimentation. Extensive land clearance and bare soils along a 300 m stretch upstream, may explain the observed sedimentation (Plate 5.49). Some rubbish was also present in the stream, likely originating from upstream residences. Accumulated woody debris and edge vegetation was observed which may provide some habitat to fish and other aquatic fauna. A makeshift bridge across the river resulted in the artificial arrangement of cobbles in the centre of the river and diversion of channel flows. In situ water quality monitoring showed relatively low turbidity and TSS. Dissolved copper and lead were only slightly above the guidelines during the January to March 2019 monitoring period, whereas dissolved zinc was significantly greater than the guidelines.

At the confluence with Nam La stream and the Myitnge River, downstream of the Namtu township, the stream is incised in widespread layers of deposited sediments resulting in no riparian vegetation along this stretch (see Plate 5.17 in Section 5.3.3). It is expected that minimal benthic habitat occurs due to the sedimentation of gravels and sands filling gaps between rocks. There was a noticeable increase in turbidity and TSS concentrations compared to sites upstream of Namtu, likely due to sediments originating from the cleared land around and upstream of Namtu, and the high sedimentation observed at the mouth of the Nam La.

Macroinvertebrate sampling

Macroinvertebrate sampling was conducted in the upper Nam La stream at one site. Caddisfly larvae, which are sensitive to water pollution, were recorded in the upper Nam La, which could be reflective of lower pollution of the Nam La compared to the Nam Pangyun.

Mayflies (also pollution sensitive) were also recorded in the Nam La, as well as in the Nam Pangyun. Midges were recorded in both the Nam La and Nam Pangyun and this is consistent with midges typically being pollution tolerant. The back swimmer and hemiptera were the only taxa not recorded in the Nam La.

Much like the macroinvertebrate results in the Nam Pangyun, it is difficult to draw conclusions on the ecosystem health of the Nam La in terms of macroinvertebrate communities without better understanding of the macroinvertebrate assemblages and relative abundances spatially and temporally, including at reference locations.

Fish

Four fish species were recorded during the survey within the Nam La stream: Ceylon snakehead (*Channa orientalis*), spotted snakehead (*Channa punctata*), Indian flying barb (*Esomus danrica*) (Plate 5.50) and golden tank goby (*Glossogobius aureus*). None of these species are conservation significant.

Based on interviews and observations in the field (Coffey-Valentis, 2019), there is a limited number of freshwater fish in the stream, and as such there are no reports of fishing activity in streams across the Bawdwin study area and Tiger Camps. In the Myitnge River of Namtu Tha Ta La wards, communities reported that the water cannot be fished due to pollution.

Myitnge River (Namtu River)

The Myitnge River consists of steep erodible muddy banks, with some sections comprised of steep rocky cliffs. Residential density and land use along the river varies, with land use and riparian modification most pronounced near Namtu town where houses, access tracks and gardens are prevalent. Aquatic plants, trees and tree roots line the river providing habitat for aquatic fauna.

The water was moderately turbid as it passed through Namtu before increasing in turbidity downstream of the Nam Pangyun confluence, due to the high sediment loads in that catchment from mining (See Plate 5.19 in Section 5.3.3). Dissolved metal concentrations were relatively low in the river before the Nam Pangyun confluence, with only slight exceedances of the Australian and New Zealand water quality guideline for zinc. After the Nam Pangyun and Myitnge River join, dissolved cadmium, copper, lead, nickel and zinc became markedly elevated, significantly exceeding the guidelines, highlighting the impact from mobilised dissolved metals in the Nam Pangyun catchment.

Plate 5.48 Representative aquatic habitat of Nam Pangyun upper catchment

Plate 5.49 Lower reach of Nam La prior to Myitnge River confluence

Plate 5.50 Indian flying barb (*Esomus danrica*)

5.7.4 Sensitivity of biological receptors

Terrestrial and aquatic biodiversity receptors were identified and their sensitivity to change or disturbance determined to facilitate the assessment of impacts and development of avoidance and management measures, as presented in Chapter 6 Impact assessment.

The biodiversity receptor sensitivity was determined by considering the importance of the receptor, the vulnerability of the receptor to change, and the resilience of the receptor in terms of its ability to recover. The definitions used to determine the sensitivity of the biodiversity receptors to disturbance are presented in Table 5.67.

Table 5.67 Definitions for sensitivity of biodiversity values

	Definition	Ratings Criteria		
		Low	Medium	High
Importance	The value that is associated with the biodiversity receptor in its current form. This includes the local, regional and national importance of the receptor.	An ecosystem or focal habitat of local importance. An IUCN Data Deficient species.	An ecosystem or habitat, of regional importance, but not national importance. An IUCN Near Threatened species.	An ecosystem or habitat, of at least national and possibly international importance. An IUCN Critically Endangered, Endangered or Vulnerable species.
Vulnerability	The extent to which the biodiversity receptor is susceptible to change. This includes the existing condition of the ecosystem, habitat or population and how readily degradation may occur.	The ecosystem or habitat is degraded, and not very vulnerable to changes in habitat structure or condition.	The ecosystem or habitat is moderately intact and vulnerable to changes in habitat structure or condition.	The ecosystem or habitat is intact and is very vulnerable to changes in habitat structure or condition.
Resilience	The extent to which the biodiversity receptor can adapt or recover from change. In this context, this relates to how readily the ecosystem, habitat or population could naturally recover from change or be rehabilitated.	Abundant, widespread, numerous representative examples occur. Easily adaptable to change	Abundance and distribution are limited. Some resilience to change	Restricted distribution. Limited or no capacity to adapt to change.

Ecological receptors can be assessed spatially or by organisational structure (i.e. individual species' populations). Ecological values within this assessment were defined in two ways:

- Vegetation and habitat types. This definition uses a broad spatial scale and includes forest (and habitat) types and all the encompassing biodiversity within them.
- Species and populations. This definition focuses on the species or population level, primarily conservation-priority species.

Table 5.68 outlines the importance, vulnerability, and resilience for each receptor, based on a low, medium and high scale as defined in Table 5.67.

Table 5.68 Importance, vulnerability, resilience of the biological receptors

Receptor	Importance	Vulnerability	Resilience	Sensitivity
Terrestrial biodiversity receptors				
Sub-tropical mixed hill forest Sub-tropical mixed hill forest occurs in the northwestern extent of the study area generally outside of the Bawdwin concession.	**Medium** Areas of intact sub-tropical mixed hill forest are of moderate importance as they support a higher biodiversity values including several rare or threatened species.	**High** Shan State is experiencing some of the highest rates of loss of intact forest, making those areas that remain of high importance. This forest type is vulnerable from further clearing of forest for land conversion and collection of wood.	**Low** These forests have been significantly reduced by deforestation, acid rain and cattle grazing and small-scale agriculture. Vegetation clearing and repeated seasonal burning have converted these forests to grasslands.	**High**
Bamboo Bamboo vegetation typically occurs in valley areas of the study area and is dominated by species belonging to *Bambusa* and *Dendrocalamus* species.	**Low** Bamboo had a lower diversity of species compared to sub-tropical mixed hill forest and is not considered to provide critical habitat to identified flora and fauna species of conservation significance in the project area.	**Low** Bamboo is a dominant vegetation type within the study area particularly in valleys and widely distributed regionally and nationally.	**High** Bamboo is a resilient vegetation type that can rapidly colonise and is resilient to disturbance.	**Low**
Grassland Grasslands are widely distributed on mountain ridges and hillsides and are dominated by grasses belonging to *Andropogon*, *Pennisetum*, *Phragmites*, *Sporobolus*, and *Coix* genera.	**Low** Grasslands are not considered significant habitat for the identified flora and fauna species of conservation significance, rather supporting common and generalist species.	**Very low** A dominant vegetation type across the landscape occurring in areas that have been previously cleared or disturbed. Grasslands are maintained by continued grazing of cattle and burning.	**High** Grasslands are highly resilient to disturbance and represent a modified community capable of recolonising areas of disturbance.	**Very low**
Flora community 177 plant species recorded, including 49 herbs, 37 trees, 35 shrubs, 25 small trees, 17 climbers, 8 grasses, 5 bamboos and 1 epiphyte, were recorded during the study	**Low** The flora assemblage was not considered to be unique or important, containing mostly common and generalist species.	**Low** Most species recorded during field surveys were generalist and tolerant species that are widely distributed. Therefore, the community as a whole was assessed to have low vulnerability.	**High** Considering most of the study area has experienced extensive environmental degradation and deforestation, the flora community present was assessed to be highly resilient.	**Low**
***Cycas pectinata* (Vulnerable)**	**Medium**	**Medium**	**Medium**	**Medium**

Receptor	Importance	Vulnerability	Resilience	Sensitivity
A palm species recorded in the study area that occurs in medium to tall closed forest in northern Myanmar.	This species is listed as Vulnerable on the IUCN Red List and therefore is of international conservation significance.	Seeds and emergent leaves are used as a vegetable. Although its habitat is continually being reduced, large populations remain, and it is not under any immediate threat of extinction.	Has been recorded from a variety of substrates and has some resilience but also requires medium to tall closed forest on deep soils.	
Burmese blackwood (*Dalbergia cultrate*) (Near Threatened) Medium sized deciduous tree recorded in the study area that grows in humid deciduous, evergreen and evergreen mixed forests	**Medium** This species is listed as Near Threatened on the IUCN Red List and therefore of international conservation significance.	**High** The species has been overexploited for the timber and this has been identified as the main cause of the population decline.	**Medium** Grows in a variety of habitats and assessed to be moderately resilient.	**Medium**
Fauna community A total of 19 mammal species, 81 bird species, and 15 herpetofauna were recorded during the study including the post-survey siting of the king cobra.	**Low** The fauna assemblage was not considered to be unique or important containing mostly common and generalist species.	**Low** Most species recorded during field surveys were generalist and tolerant species that are widely distributed. Therefore, the community as a whole was assessed to have low vulnerability.	**High** Considering most of the study area has experienced extensive environmental degradation and deforestation, the fauna community present was assessed to be highly resilient.	**Low**
Chinese pangolin (*Manis pentadactyla*) (Critically Endangered) Historically recorded near Tiger Camp, LwePya, Toneme stream by hunters.	**High** This species is listed as Critically Endangered on the IUCN Red List and therefore of international conservation significance.	**High** The primary threat to this species is hunting and poaching, both targeted and untargeted, for local, i.e., national level use as well as international trade.	**Medium** Found in a wide range of habitats, including primary and secondary tropical forests, limestone forests, bamboo forests, broad-leaf and coniferous forests, grasslands and agricultural fields.	**High**
Dhole (*Cuon alpinus*) (Endangered) Historically known to occur near Tiger Camp as reported by hunters.	**High** This species is listed as Endangered on the IUCN Red List and therefore of international conservation significance.	**Medium** Habitat loss and degradation and associated prey depletion and human disturbance are considered to be main threats to the species.	**High** The species is a habitat generalist and can occur in a wide variety of vegetation types.	**Medium**
Asian black bear (*Ursust thibetanus*) (Vulnerable) Historically recorded northwest of the Bawdwin area.	**Medium** This species is listed as Vulnerable on the IUCN Red List and therefore of international conservation significance.	**High** Habitat loss combined with hunting for skins, paws and especially gall bladders are the main threats to this species.	**Medium** Occupy a variety of forested habitats including regenerating forests and therefore has some resilience.	**Medium**
Hog badger (*Arctonyx collaris*) (Vulnerable)	**Medium**	**Medium**	**Medium**	**Medium**

Receptor	Importance	Vulnerability	Resilience	Sensitivity
Historically recorded in the Wallah Valley.	This species is listed as Vulnerable on the IUCN Red List and therefore of international conservation significance.	The species has a wide distribution and occurs in a variety of habitats, but hunting is the key threat to the species as it is a valued hunting target. As such the species is considered to be moderately vulnerable.	The species occurs across a wide variety of habitats, from heavy forest to the non-forested grassland-dominated floodplains.	
King cobra (*Ophiophagus Hannah*) Recorded near the Bawdwin mine office	**Medium** This species is listed as Vulnerable on the IUCN Red List and therefore of international conservation significance.	**Medium** The species has a wide distribution and occurs in a variety of habitats, but is threatened by habitat loss and degradation, and hunting. As such the species is considered to be moderately vulnerable.	**Medium** The species occurs across a variety of habitats, though most commonly undegraded forests.	**Medium**
Aquatic biodiversity value				
Aquatic ecosystem of the Nam Pangyun The Nam Pangyun flows southeast from the north of Bawdwin, through the mine area easterly to northeasterly towards Tiger Camp, and southeast to the Myitnge River.	**Low** The Nam Pangyun is a highly modified and degraded ecosystem due to physical modification (sedimentation), reduced water quality as a result of legacy mining impacts. As a consequence, the watercourse has very low biological values.	**Low** The Nam Pangyun passes through the main Bawdwin mining area and receives discharge from the Tiger Tunnel. The Nam Pangyun receives direct sewage discharge from Bawdwin villages. As an already highly degraded ecosystem only the most tolerant and resilient organisms occur in the Nam Pangyun watercourse. As a consequence, the system was assessed to have low vulnerability to change.	**Medium** As a highly degraded ecosystem, the Nam Pangyun has slow species diversity of invertebrate species that are highly adaptable and therefore the system has some resilience.	**Low**
Aquatic ecosystem of the Nam La The Nam La flows west to east in the neighbouring catchment to the north of the Nam Pangyun.	**Medium** The Nam La catchment is largely undisturbed with only a small number of small settlements and minimal industrial activity. The river edges were also lined with grasses and aquatic plants, which would provide	**Medium** The Nam La catchment is mostly undisturbed with a few small settlements and industrial activity. As such the aquatic ecosystem was assessed to be of moderate to good	**Medium** The Nam La is mostly an unmodified stream that receives high runoff from surrounding mountain catchments during the wet season and lower spring-fed flows during the dry season. During the dry season the	**Medium** .

Receptor	Importance	Vulnerability	Resilience	Sensitivity
	habitat for fish and other animals. The presence of caddisflies in the upper Nam La (absent from the Nam Pangyun), which are sensitive to water pollution, supports the high quality of aquatic habitat. Six species of aquatic plant and four fish species were recorded during surveys within the Nam La stream. No conservation significant species were recorded within this stream.	condition and be moderately sensitive to change.	aquatic ecosystem has lower resilience to changes to water quality due to reduced dilution effect.	
Aquatic ecosystem of the Myitnge River The Myitnge River is a major tributary of Ayeyarwady River and receives drainage from the Nam La and Nam Pangyun catchments. The river is approximately 50 to 70 m wide and the depth is about 10 to 12 m according to local people.	**Medium** Major river used for a variety of beneficial uses. The ecosystem also provides food in the form of fish to nearby communities. The river has steep erodible muddy banks, with varying levels of adjacent disturbance and land use along the river. The river is of regional importance from an ecological perspective.	**High** The river is of moderate condition and experiencing a range of threats from anthropogenic impacts from neighbouring land uses, contaminants and runoff from neighbouring villages and roads, and is becoming regulated through upstream and downstream hydropower projects.	**Medium** As a large river, the Myitnge River has some flushing capacity and therefore some resilience to change.	**Medium**

5.7.5 Summary

The terrestrial and aquatic biodiversity within a broad study area around the historical Bawdwin mine is characterised as follows:

- Vegetation within the study area has been heavily influenced by historical mining and processing activities. The area now consists predominantly of grasslands and areas of bamboo forest. These were classified as modified or degraded vegetation communities being represented regrowth and secondary forest. More intact vegetation is present within valleys and along watercourse particularly along the Nam La stream and in the northwest of the study area.

- The highest diversity of plants species was found in more intact sub-tropical mixed hill forest beyond the mine followed by Tiger Camp. Areas of grassland and bamboo forest had lower plant diversity. Two species of conservation significance were recorded in areas of sub-tropical mixed hill forest.

- A low diversity fauna community was recorded from within the study area with most records restricted to areas of mixed hill forest and to a lesser extent bamboo forest. Most species recorded in the grassland habitat were common generalist species.

- Interviews with hunters reported that some hunting for targeting dear and wild pigs still continues (although decreasing) particularly during the wet season. However, they reported that wild animals are becoming increasingly rare due to deforestation and agricultural practices.

- The physical habitats of the Nam Pangyun have been substantially modified as a result of sedimentation of the river bed from the ER valley waste rock dump; and from stream-bed artisanal mining of residual slag from historic mining at Bawdwin. Aquatic biodiversity surveys within the Nam Pangyun recorded a depauperate community of macroinvertebrates and fish. Those species that were recorded are generalist and adaptable species with a higher level of resilience.

- The Nam La catchment is largely unmodified with only a small number of small settlements and agricultural plots. The presence of caddisflies in the upper Nam La (absent from the Nam Pangyun), which are sensitive to water pollution, supports the hypothesis that this watercourse represents higher quality of aquatic habitat.

- The largest watercourse within the study area is the Myitnge River, which passes through Namtu flowing southwards. Aquatic plants, trees and tree roots line the river providing habitat for aquatic fauna.

5.7.6 Uncertainties and limitations

The study area is located within a region of Myanmar where there is limited existing information. The study area is large, geographically diverse and relatively remote. Characterising biodiversity in the study area presents a number of limitations including:

- Temporal variability. The presence and/or detectability of many species varies between seasons. This is most pronounced for migratory fauna species (e.g., most commonly birds), but also effects resident species that can be sensitive to climatic patterns (e.g., frogs). Other taxa can be less active during certain conditions (e.g., frogs are less detectable under extended dry conditions). Field surveys were completed over two periods (wet season and dry season) in an effort to capture this variability.

- Spatial variability. The study area covers a broad and topographically diverse area including mountainous areas with steep valleys to broader floodplains. The area has also experienced extensive anthropogenic disturbances over five centuries resulting in a complex and modified environment. The nature and scale of the study area meant that rapid assessment techniques to characterise representative habitats were required. Survey locations were chosen largely based on ability to access sites with these typically being located a short walking distance from existing roads. During the field surveys the team was unable to access certain areas and use camera traps due to security concerns due to armed conflicts.

5.8 Cultural heritage existing environment

5.8.1 Introduction

This section describes the history, and existing archaeological, historic and religious cultural heritage in relation to the Bawdwin project.

The information in this section draws primarily from the Bawdwin Mine Project Cultural Heritage Baseline study conducted by Southern Archaeology Ltd (2019) (Appendix H). That study characterised cultural heritage within the Bawdwin concession and surrounds in terms of tangible heritage – i.e., sites, places, structures/buildings and artefacts; and their associated intangible heritage values – i.e., aesthetic, historic, scientific, technological, social and spiritual values. The Southern Archaeology study involved a literature review, field survey and community consultation. The field survey was based on surface inspection with no archaeological excavation conducted.

In order to provide a holistic appreciation of the significant cultural heritage areas in the Bawdwin concession and the surrounding landscape, other significant areas and sites outside the concession boundary were included in the baseline study. These additional areas included adjacent ridge systems and hillsides of the Nam Pangyun valley and, where relevant, mining-related features that extend outside the concession (e.g., the Namtu smelter area, Mansam Falls power station and the narrow railway corridor that extends down the Nam Pangyun valley and along a portion of Myitnge River).

Figure 5.45 shows the location of the Bawdwin concession and broader cultural heritage study area.

5.8.2 Cultural heritage in Myanmar and Shan State

Myanmar is a multiethnic country, having some of the richest and most diverse cultural heritage in southeast Asia (Facchinetti, 2014). Although the country has a rich and complex history and numerous historic sites, the investigation and documentation, management and conservation of cultural heritage is limited (Facchinetti, 2014; Myat, 2016). As a result, records and literature on cultural heritage in Myanmar are sparse and many archaeological sites are in poor condition.

Information on intangible[1] heritage in Myanmar is particularly lacking, with records pertaining almost entirely to tangible, or 'built', heritage such as temples and monuments. Additionally, there is no national baseline heritage survey with which to make valid comparisons with heritage at Bawdwin.

Due to years of exclusion from the international community, it has only been in the last decade that Myanmar has commenced a push to ratify international conventions in relation to cultural heritage (Facchinetti, 2014).. In 2013, the country ratified the 1970 Convention on the Means of Prohibiting and Preventing Illicit Import, Export and Transfer of Ownership of Cultural Property; and in 2014 it ratified the 2003 Convention on the Safeguarding of the Intangible Cultural Heritage. Myanmar is a 'State Party' to the UNESCO World Heritage Convention Concerning the Protection of the World Cultural and Natural Heritage. As a State Party, Myanmar has a duty to ensure the identification, protection, conservation, presentation and transmission to future generations of the country's cultural heritage. In 2014, UNESCO endorsed the appointment of Myanmar's first World Heritage cultural property – the Pyu Ancient Cities. In more recent years, UNESCO has been working with Myanmar to assist with developing an inventory and conservation guidelines for the protection of other cultural heritage sites on the tentative list for World Heritage status (Facchinetti, 2014). In 2019, the Bagan Archaeological Area and Monuments, an area of 80 km^2 containing some 2,500 monuments constructed between the 10^{th} and 14^{th} centuries, was added to the World Heritage List.

[1] Intangible heritage is defined in Appendix H as '*the practices, representations, expressions, knowledge, skills – as well as the instruments, objects, artefacts and cultural spaces associated therewith – that communities, groups and, in some cases, individuals recognize as part of their cultural heritage and transmit from generation to generation*'.

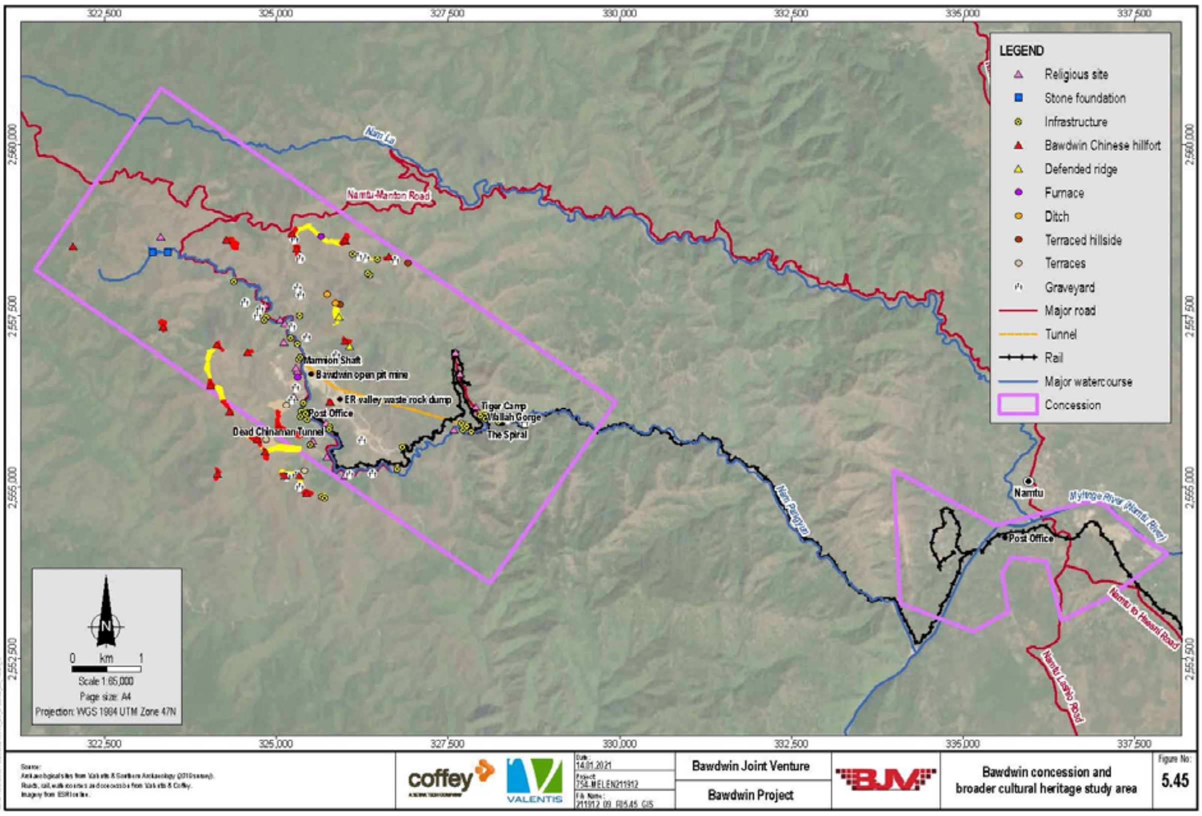

Figure 5.45 Bawdwin concession and broader cultural heritage study area

This internationally renowned site is emerging as a target for national and international conservation projects largely due to it being the capital of the first unified Burmese Kingdom and since it contains murals and stone inscriptions providing '*a unique and irreplaceable testimony of Myanmar's intellectual, social and political history*' (Facchinetti, 2014).

Shan State is the largest ethnic minority state in Myanmar and while it is rich in history and culture, the government to date has only officially recognised one heritage region in that state, which is the Neolithic Padah-Lin cave located in the Taunggyi District (Myat, 2016). Historically, the Shan people had a sophisticated culture built on the back of successful rice production (Ott, 2008). This allowed religious and political elites to flourish and for development of a class of craftspeople skilled in preparation of a range of products including textiles, furniture, silverware, lacquer ware, pottery and basketry (Ott, 2008). However, much of the practising of local craftmanship was abandoned by the end of the 19th century when sourcing raw materials for craft work became difficult and foreign goods such as cotton began to be imported. It is not known in literature how much of the Shan's knowledge and skills in local craftmanship has been preserved or how they were handed down between generations (Ott, 2008).

Of high heritage value in the Shan State are 'haws' (palaces), which historically served as abodes of rulers in the region (Myat, 2016). Haws are revered places by Shan people and form a unique typology in Shan architecture.

5.8.3 Context of cultural heritage at Bawdwin

Overview

The Bawdwin mine is one of the longest operating base metals mines in the world, being in operation since the early fifteenth century when initial lodes were mined for silver by the Chinese. As a result of continuous human occupancy over six centuries, the Bawdwin area has a rich and complex history associated with mining activity. This has led to creation of an intense and complex archaeological landscape abundant in cultural heritage features and values around the mine site.

The history of human activity at Bawdwin can be separated into five key periods:

1. The early discovery and possible initial mining activity – prior to 1412.
2. Mining by the Chinese – from 1412 to 1868.
3. Mining by Kachin/Shan peoples – from 1868 to ca. 1901.
4. British colonial period and post-colonial period – from ca. 1901 to 1962 when the mines were nationalised.
5. The modern period – from 1962 to the current day.

These key periods have resulted in numerous cultural heritage features densely clustered around the mine site, with features from different periods occurring in proximity to one another and in, some cases, directly overlapping (e.g., where Chinese defence fortifications were upgraded and added to in the British colonial period, resulting in a heritage feature from two different chronologies; and similarly, where old Chinese building terraces were re-used by the British in the early twentieth century). The combination of these periods has also meant that in some places human occupation has been continuous from the Chinese period through to the modern day. For these reasons, and since the importance of a cultural heritage feature is often not realised when treated in isolation, the baseline study (Appendix H) and this section focus on characterising cultural heritage values based largely on thematic and geographic factors, each having chronological elements. For example, one of the groupings characterised herein is 'graveyards' as these are common to all time periods. Notwithstanding, many artefacts and objects are also highly significant, particularly those in relation to the mining heritage of Bawdwin and these are also described and characterised in this section.

Each of the five key periods that contributed significantly to the heritage landscape at Bawdwin are described in more detail below.

Early discovery and possible initial mining activity

Historical literature indicates mining at Bawdwin was not conducted by the Shan people during their rule of the region between the fifth and thirteenth centuries. The Shan region came under 'Chinese' control after the Chinese invaded in the mid-fourteenth century. It is not clear when during this period that the Chinese discovered, and commenced working, the mineral-rich lodes at Bawdwin and little else is known about human activity in the area during this period. No evidence of heritage, including archaeological material, predating the Chinese arrival at Bawdwin has been found to date.

Mining by the Chinese

Records indicate that the Chinese commenced mining at Bawdwin in 1412 during the Ming Dynasty. Although the ore was rich in lead, it was the silver that was smelted and sent back to China. The lead-rich slag (waste material from smelting and refining) was left behind. Little is known about the miners during this period, although it is assumed that most would have been from Yunnan and the number of miners would have been in the thousands – possibly as high as 20,000 (Appendix H). Historic accounts suggest that the Chinese hillforts constructed at Bawdwin were to not only keep threats out, but to imprison at least some of its workers who may have been convicts or prisoners of war (Coggin-Brown 1918: 176 as cited in Appendix H). This was evidenced by skeletons being discovered still wearing manacles.

For the next 450 years the Chinese continued to mine and smelt silver until a civil war in the southern Chinese state of Yunnan broke out in 1868. At this time, the mines were abandoned without being completely worked out.

Most of the adits mined by the Chinese were within a narrow gorge of the Nam Pangyun valley. When the British arrived in the early 20th century they found approximately 300 old mine openings that included tunnels, shafts and open cuts (La Touche and Coggin-Brown 1908: 248 as referenced in Appendix H). It was thought that ore was transported to the Nam Pangyun valley for smelting. One of the main access points to the underground lodes was via a tunnel known to the British as Dead Chinaman Tunnel. The deepest Chinese workings were about 20 m below the level of the Dead Chinaman Tunnel. The Chinese also practiced open cut mining, the largest of which was referred to by the British as The Amphitheatre and was located within the current open pit.

Evidence of Chinese ore sorting and smelting was well preserved when the British arrived at Bawdwin and the locations of these appeared to correlate with sites suitable for access to fuel and water for ore dressing rather than being dependent on proximity to the workings. Mineral refinement was practised by the Chinese using gravity washing methods where a mixture of the ore/water was allowed to flow down stone-lined channels, allowing separation of the heavier ore from the lighter waste material (La Touche and Coggin-Brown 1908: 246 as referenced in Appendix H). The smelting of the concentrated material was conducted in large furnaces built on the hillsides around Bawdwin at a distance above the valley drainage. This allowed sufficient room for discharge of the waste slag. The furnaces were structures made of stone or large bricks and contained a fire-clay bed hearth of circular or oblong shape. The ore was mixed with charcoal and fired in the furnace, with the reduction process causing the lead to run down to the front of the hearth where it was collected. Further refinement of the lead was conducted in cupel furnaces (Plate 5.51), many of which were in good condition when the British arrived at Bawdwin. These furnaces use a shallow, porous pot (or cupel), which collected the molten assays of lead material during smelting.

Plate 5.52 shows the Nam Pangyun valley at Bawdwin in 1907 with ruins of Chinese stone huts in the right foreground and slag heaps along the valley sides.

In accordance with Myanmar legislation: The Protection and Preservation of Ancient Monuments Law (2015) and The Protection and Preservation of Antique Objects Law (2015); any artefacts, sites, features or places from the Chinese mining period would be considered 'historic' as they are more than 100 years old. As such, they would be protected by the legislation.

Mining by Kachin/Shan peoples

While the civil war in Yunnan took a major toll on the Chinese (estimated three to four million deaths) and control of the Shan states by the Burmese kings was lost, Kachin and Shan peoples occupied Bawdwin between 1868 to about 1901. During that time, they reworked and smelted old lead-rich slag left behind by the Chinese. It was this lead that was used for bullet manufacture by the Kachins.

The Kachins focussed on smelting the richest slags (at least 50% lead) using furnaces filled with ore/charcoal mixtures and covered with a heap of earth and turf. These furnaces were fired from below and the lead collected in hollow structures below the furnace. These Kachin furnaces (Plate 5.53) were smaller than those used earlier by the Chinese, although it was thought the Kachins copied the Chinese design (La Touche and Coggin-Brown 1908: 246 as referenced in Appendix H).

In accordance with Myanmar legislation: The Protection and Preservation of Ancient Monuments Law (2015) and The Protection and Preservation of Antique Objects Law (2015); any artefacts, sites, features or places from the Kachin/Shan mining period would be considered 'historic' as they are more than 100 years old. As such, they would be protected by the legislation.

British Colonial period and post-colonial period

European interest in the Bawdwin mines was first recorded in 1795, but it was not until the turn of the twentieth century that the British showed active interest in mining the area. The British were initially interested in the vast piles of residual high-lead-content slag. Later, the focus shifted to the orebodies themselves.

One of the earliest British ventures was the Great Eastern Mining Company Ltd, which, after being granted a small mining lease, commenced construction of a narrow-gauge railway up the Nam Pangyun valley before encountering difficulties and abandoning the project. The railway was to transport slag to the smelters. It was then that Herbert Hoover, mining engineer and future United States President, after hearing of the resource through a Great Eastern Mining Company acquaintance commenced an evaluation of the mines. After estimating there were 115,000 tonnes of slag available for reprocessing, the Burma Mines Railway and Smelting Company Ltd was formed and the interests of the Great Eastern Company were purchased. The company recommenced construction of the 46-mile-long railway from Namyao to Bawdwin and in 1911 the railway was complete. From 1912 to 1913 some 32,000 tonnes of slag was processed. By 1915 the old Chinese slag piles were almost exhausted and focus turned to the underground orebodies. Three main orebodies were found – the Shan, the Burman and the Chinaman (recently renamed the China lode) orebodies.

In 1913, the company become the Burma Corporation Ltd, with Herbert Hoover the largest shareholder. Hoover was instrumental in the development of a new tunnel to access the Chinaman orebody at considerable depth – known as the Tiger Tunnel. This tunnel was key in allowing ore to be hauled out of the mine as well as allowing drainage. Electric locomotives brought the loaded ore cars to Tiger Camp for emptying into storage bins via revolving tipple drums. The ore in the bins was then loaded into railway wagons and hauled along the narrow-gauge railway to a smelter at Namtu for processing. Power to the mine was achieved by development of a hydro-electric power station at Mansam Falls, 61 km from the mine.

During the colonial period, people from a variety of nationalities worked at Bawdwin. These included mainly Indian and Chinese workers during exploration before Chinese (mostly from Yunnan state) formed the bulk of the underground mining workforce. Smaller numbers of Nepalese and Indian workers were also employed for underground mining during this time. People working on surface operations (i.e., not underground mining) were from a wider range of locations including broader China, Nepal, Indochina and Afghanistan. Europeans were employed for the higher skilled roles.

Plate 5.51 Chinese cupel furnaces at Bawdwin from the Chinese mining area

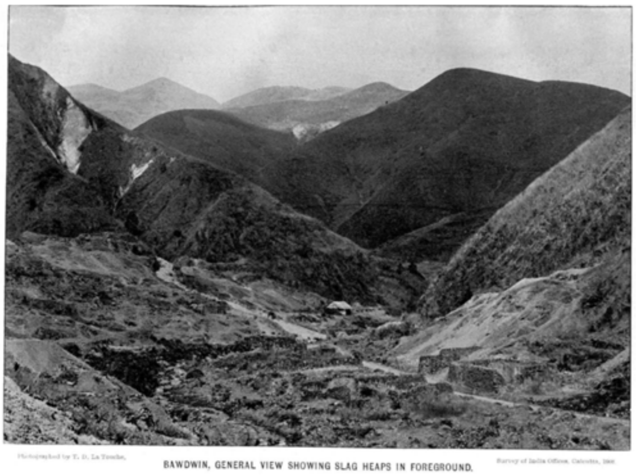

Plate 5.52 Nam Pangyun valley at Bawdwin in 1907 with ruins of Chinese stone huts in the right foreground and slag heaps along the valley sides

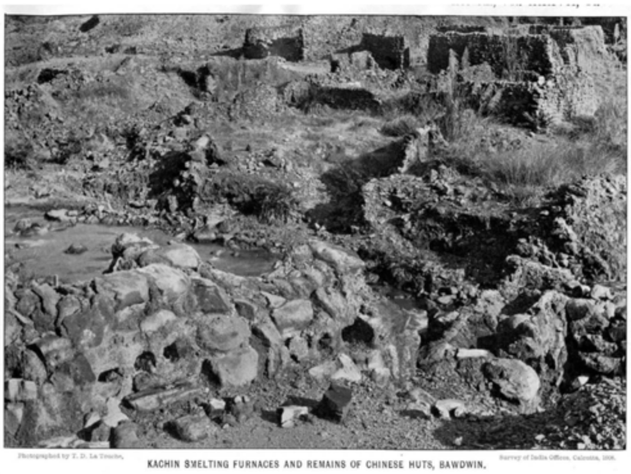

Plate 5.53 Remains of Kachin smelting furnaces from the Kachin mining area with Chinese hut ruins in background

In accordance with Myanmar legislation: The Protection and Preservation of Ancient Monuments Law (2015) and The Protection and Preservation of Antique Objects Law (2015); any artefacts, sites, features or places from the British colonial mining period prior to 1920 (e.g., the railway, Dead Chinaman Tunnel, Marmion Shaft and Tiger Tunnel) would be considered 'historic' as they are more than 100 years old. As such, they would be protected by the legislation.

The highest production rate for the mine was achieved from 1928 to 1938 during which time up to 500,000 tonnes of ore was mined annually. Most of the production during this period was from the Chinaman Lode. However, the start of World War II in 1939 led the decline of the mine. In 1941, during the Japanese invasion, the British retreated to the north and west with many having to walk out. Over 400,000 people died during the retreat. As the British withdrew they destroyed or disabled strategic assets so they could be of no use to the Japanese. This included destroying vital plant at the Bawdwin mines. Notwithstanding this, the Japanese were able to continue to work the mine during the war albeit at a lower production rate than the pre-war period (in the order of 200,000 tonnes of high grade ore was mined from 1942 to 1945. After the war, the Burma Corporation once again took control of the mines. It was during this time that larger numbers of local skilled employees began rising to higher positions at the operation.

Post-war production levels were low and in 1951 the mine was sold to a joint venture, Burma Corporation (1951) Ltd, of which the Government of the Union of Burma had a 50% share. Involvement of the government was a strategy to acquire technical, administrative and commercial knowledge associated with mineral extraction and processing so they could be nationalised at a later stage.

Over the following years extensive repair work was undertaken in order for resumption of large-scale mining and processing; however, ore grades were declining. Significant international prospecting (land surveys and drilling) of the site ensued.

The modern period

In the 1960s the political situation in Myanmar grew more and more unstable, and following a military coup in 1962, the parliamentary regime was replaced by the Revolutionary Council. Throughout the 1960s heavy industry, business and other commercial sectors were nationalised. The mining industry was nationalised in 1965 and the mine was taken over by the government. At this time there was a mass exodus of locally-born Indians, Chinese and other minority groups along with Europeans. Some of the local mixed-ethnicity community stayed at the mine. In the 1980s, additional upgrades were made (including a new concentration plant) at Bawdwin to counteract the depleting ore grades but the smelter at Namtu was kept in operation. In 2009, operation work ceased in the mine and smelter, and since that time the site has been maintained by a reduced staff. Residual slag heaps continue to be mined by local artisanal miners to this day. One major area where this still occurs is at the sides of Gurkha Hill. Artisanal mining also occurs along the bed of the Nam Pangyun all the way downstream from Tiger Camp to Myitnge River and occasionally with Bawdwin village.

In June 2018, WMM, Myanmar Metals and EAP entered into a contractual agreement to form a joint venture arrangement for the purposes of developing the Bawdwin project.

Features from the modern period are not considered 'historic' heritage under Myanmar legislation, as The Protection and Preservation of Ancient Monuments Law (2015) and The Protection and Preservation of Antique Objects Law (2015) defines ancient monuments, antique objects, and historic and archaeological sites as being older than 100 years. However, religious and cultural sites (including graveyards) of all time periods are considered an important aspect of the local communities' cultural heritage, even if 'historic' attributes have been replaced or upgraded with modern structures and objects.

5.8.4 Existing cultural heritage features and values

This section describes the key existing cultural heritage features and values in the study area. As the study area includes hundreds of known (to potentially thousands of unknown) individual features of cultural heritage value it is not feasible to individually describe and assess each one. This section therefore characterises existing cultural heritage for key structures and buildings but also for defined areas or 'precincts', which have a higher collective heritage value than their components individually. This approach also allows for consideration that in many cases, the heritage value of a site, place or feature relies on a broader context such as its setting in the landscape or its proximity to other important sites.

The focus of this section is to identify each key feature and briefly summarise its attributes and associated values.

Chinese heritage

Hillforts, defences and occupied ridges

Bawdwin is surrounded by a ring of hillforts and ridges, fortified by ditch and bank structures (Figure 5.46). For the purpose of the field surveys and characterisation, a hillfort was defined as a distinct hilltop or promontory that was completely encircled by defences (numbers shown on Figure 5.46 indicate the order in which they were visited during the field survey). The hillforts were probably connected by a network of tracks; however, some of these were difficult to distinguish during the survey. Many of the interconnecting ridges between hillforts also appear to have been fortified, and there is some surface evidence (ceramics and processed slag) that they were occupied.

Hillforts were designed as defences to guard the mine from external threats but are also believed to have been used to observe mining activity and the settlement areas within the valley. This interpretation is based on the field of view from the outer ring of hillforts compared to the inner hillforts, which were lower in height than the outer hillforts and would have only allowed views of the mine and valley floor villages. In total, 20 hillforts were recorded during the field survey.

The hillforts were re-used by the Myanmar Army at various times and it is possible that they were used by the Japanese during World War II, as modern military trenches are located within more than one hillfort.

The ring of Chinese hillforts and occupied ridges may contain technological evidence and significance. The hillforts and occupied ridges represent a 500-year period of mining and occupation by the Chinese. While fortified towns and cities are common features in Myanmar and southeast Asia more broadly, the extensive nature of the Bawdwin defences with a largely intact protective ring system of hillforts defending a mountain valley is unique. This collective system has only lost one small hillfort from the original configuration and as a result is considered to be of exceptionally high cultural heritage value.

Artefacts and evidence of Chinese occupation in Nam Pangyun valley

Due to the historic disposal of waste rock and residual slag in the central area of Bawdwin (i.e., in the vicinity of the mine office, post office and railway station), much of the remains from earlier Chinese occupation in the lower valley are likely to be deeply buried. At higher elevations along the hillsides there may be remains of Chinese terraces in a less modified form. These terraces are likely to have experienced extensive degradation over the centuries.

Further north of the open pit, occupation terraces were found in one of the side tributary gullies in the valley. Here evidence of terraces is present on the lower valley margins and valley floor (Plate 5.55). It is possible that these terraces are of Chinese origin, although archaeological investigation would be needed to determine this.

Old Chinese bridge

In the early twentieth century, the British colonialists noted several perfectly preserved Chinese stone bridges in the Nam Pangyun valley. The last of these Chinese stone bridges was washed away in a flood about two years prior to the baseline field survey according to advice from a local informant (Chandra Kumar, pers. comm as cited in Appendix H). While it was replaced by a modern concrete bridge, the old stone abutments (Plate 5.54) are still in place at this bridge.

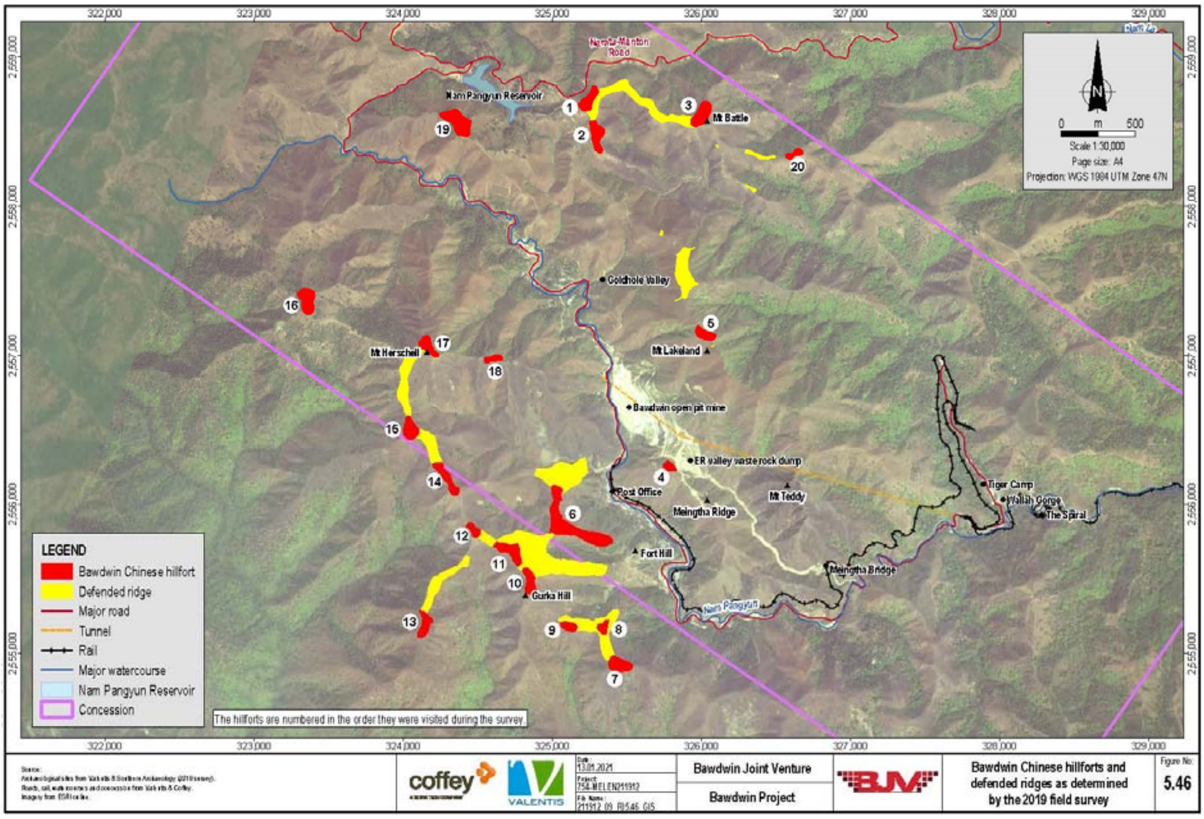

Figure 5.46 Bawdwin Chinese hillforts and defended ridges as determined by the 2019 field survey.

The field survey (which focused on surface observations only and no archaeological excavation) observed widespread scattering of artefactual material around the Bawdwin area. Artefacts comprised primarily ceramic fragments and Chinese slag. The ceramics were almost all of distinctive Chinese types and designs (e.g., blue and white vitrified ware and celadon green ware) (Plate 5.56). It is not clear which time periods each of these artefacts is from. Other artefacts found included part of a Chinese coin, a ferrous tube of undiscernible use and a grindstone. It is possible the latter was used for the crushing of small amounts of ore.

To further examine the historical and scientific value of historic Chinese occupation evidence and artefacts, sub-surface archaeological excavations would be needed.

Mining and smelting evidence

The main area of Chinese mining was the Chinaman Lode, which was within the areas mined during the colonial period and the current open pit. Therefore, much of the evidence of Chinese workings in this area has been destroyed. However, numerous Chinese workings survive in peripheral areas around the mine site, including the areas of the current open pit, in Goldhole Valley and on Meingtha Ridge. The early access to Chinese underground workings of the Chinaman Lode, the Dead Chinaman Tunnel, still exists and its portal is located near the Bawdwin timber yards. It is not always possible to distinguish between the Chinese and British underground workings but in general the Chinese workings are smaller and more irregularly shaped than the more modern British workings. Typical Chinese and British underground workings are shown in Plate 5.57 and 5.58, respectively.

Chinese workings are also evident on the rocky face downstream of the current open pit mine and in the gorge between Bawdwin and Tiger Camp.

There were numerous surviving smelting furnaces at Bawdwin when the British arrived in the early 20th century. However, none of those documented and photographed from that time are known to exist now. However, two furnaces have been located, one on Camp Ridge about halfway between Hillforts 2 and 3 and one on a steep hillside opposite from the open pit, which was found by a drilling crew in 2019. These furnaces are similar in design and comprise a chamber excavated into the hillside with a small rear flue (Plates 5.59, 5.60 and 5.61). While only two Chinese furnaces have been found it is possible that many more undiscovered furnaces exist at the site.

Additionally, ceramics associated with smelting are found in numerous areas, most prolifically on Gurkha Hill. Numerous fireclay rods (Plate 5.62), which were possibly part of the old Chinese furnaces, are also found in this area amongst where slag artisanal mining now occurs.

Residual Chinese slag fragments are found scattered around Bawdwin. Much of this slag is glassy, black slag with relatively low lead content. The higher lead content slag (more porous and stonier in appearance) has mostly been mined, although some of this material is also found around the site.

The remaining evidence of Chinese mining at Bawdwin is of significant cultural heritage value. This is because during that period, Bawdwin played a key role in the early historic metals exchange network, linking mineral trade throughout Southeast Asia, India and China, and this history of the early historic metals exchange network has not been studied in detail, thereby placing a degree of importance on the remaining cultural heritage features. Archaeological interpretation of Chinese mining and smelting operations at Bawdwin is expected to be important in the overall interpretation of Chinese occupation in the area and will be of high value to region-wide studies of archaeometallurgical processes. It has been noted in literature that Myanmar has been notably underrepresented in recent investigations of archaeometallurgy in Southeast Asia despite the country having a potentially central role in the long-distance mineral exchange networks linking India, China and other Southeast Asian neighbours (Pryce et al., 2017).

Plate 5.54 Stone abutments of the old Chinese bridge beneath the modern concrete bridge

Plate 5.55 Ancient Chinese terraces on the sides of one of the tributary valleys to the north of Bawdwin

Plate 5.56 Chinese ceramics found on Hillfort 1

Plate 5.57 Chinese underground workings in Goldhole Valley

Plate 5.58 Probable British drive in Goldhole Valley, immediately adjacent to Chinese workings

Plate 5.59 Remains of Chinese furnace cut into hillside at Camp Ridge (

Plate 5.60 Interior of the Chinese furnace at Camp Ridge with the flue clearly visible

Plate 5.61 Furnace found during drilling at Bawdwin main pit

Plate 5.62 Fireclay rods on Gurkha Hill amongst found amongst a slag artisanal mining area

Graveyards

Numerous graveyards are present at Bawdwin and surrounds, ranging from those with clear surface markings and tombstones situated on ridgetops overlooking nearby valleys, to those that have little to no surface evidence and are overgrown by vegetation on the valley floors and sides. These graveyards pertain to all periods of occupation at Bawdwin, from the Chinese to the current day.

During the 2019 field survey, 21 graveyards were recorded, and information was obtained on three additional graveyards not visited.

Figure 5.47 shows the locations of these graveyards. Based on early accounts of British colonialists at the site, thousands of graves were scattered across the hillsides and it is likely that there are many undiscovered graveyards and/or graves at Bawdwin – particularly as many of these will not have surface evidence or at most, very minimal surface evidence such as a mound or hummock. The large number of graves is not surprising given that the large numbers of Chinese miners were engaged in extremely hazardous work at Bawdwin over a prolonged period.

There are also graveyards at Bawdwin where people from the colonial and modern era of mining are buried and several of these remain in use today. It is difficult to interpret the ages of many of the graveyards and burials because Chinese labour was used both in the Chinese and colonial occupation at Bawdwin. As a result, Graves with Chinese headstones could belong to either period. Based on the 2019 field survey, it appeared that the ancient Chinese preferred to locate graveyards on ridgelines, in particular the sloping ends of the ridgelines. Later miners, such as the British and Chinese during the colonial period, preferred to use valley floors, ridgetops and hillsides for burials.

Table 5.69 summarises the assumed ethnicity and time period for each of the graves visited during the 2019 field survey.

Table 5.69 Details of graveyards recorded during the 2019 field survey

Graveyard number	Location	Ethnicity/Religion	Additional notes (from Appendix H)	Period of use
1	Drill track above the Police Station.	Unknown, possibly Chinese	• This was found accidentally during construction of a drill access road up to Yegon ridge. • Human skeleton found in an ancient horizontal adit (Plate 5.63). • The extent of the graveyard is unknown but no other remains have been found in the proximal area to date.	Possibly Chinese
2	Below Hillfort 1	Chinese	• Comprises a number of stone-ringed mounds and piles of displaced stone, which mark the graves (Plate 5.64). • Several headstones visible with Chinese writing. (Plate 5.65).	Chinese
3	Below Hillfort 2	Chinese	• Located on a crest of a ridge. • Similar in nature to Graveyard 1 with a range of grave types, including simple mound as well as more elaborate graves with headstones. The headstones are all written in Chinese. • Evidence of artisanal mining in and around the graves.	Chinese
4	Meingtha Ridge	Chinese	• Graves located on the crest of Meingtha Ridge and marked by stone mounds. • Several graves have distinctive rectangular shape with rounded ends (which is the case in many of the Chinese graveyards at Bawdwin).	Chinese

Graveyard number	Location	Ethnicity/Religion	Additional notes (from Appendix H)	Period of use
5	Sand Plant Ridge	Chinese	• Located on the crest of a ridge just beyond the site of the old sand plant. • Consists of approximately 12 visible stone mounds.	Chinese
6	Very end of Sand Plant Ridge	Chinese	• On the end of the ridgeline beyond Graveyard 5. • Two distinctive stone mounds were observed beside two large earth mounds, with more graves scattered down the ridgeline. • Appears to be very similar to Graveyard 5.	Chinese
7	Bawdwin, side valley	Burmese	• Located in a small side gully off the main Nam Pangyun valley. • Still in use.	Current
8	Behind Catholic Church	Unknown	• Located on the hillside beside the Catholic Church. • No grave markers, so it is not possible to determine whether the graves are all associated with the church.	Unknown
9	Hillfort 7	Gurkha	• Located in and above the ramparts of the defended ridge below Hillfort 7. • Some graves are simple earthen mounds, while several graves have cement structures with inscriptions (in English, Myanmar and an Indian script).	Probably recent (1970s)
10	Hillfort 8 (near new cellphone tower)	Christian	• Located immediately to the west of the ramparts of Hillfort 8. • At least two graves: one is just a pile of stones, the other is a cement tomb with a Christian cross on the top.	Possibly recent
11	Hillfort 9	Unknown	• Consists of a single visible grave at the eastern end of Hillfort 9. • Consists of a mound of stones.	Unknown
12	Tiger Camp	Mixed	• Located immediately below the spiral on the railway, downstream from the Tiger Camp. • Graveyard has been used until recently (at least 1991). • Graves range from simple piles of stones to more elaborate concrete tombs. Site overgrown by vegetation.	Recent
13	Lower Bawdwin	Buddhist and Christian	• Located at the lower end of Bawdwin on both sides of a small tributary. • Cemetery is still in use and is bi-denominational.	In use
14	Lower Bawdwin	Possibly Muslim	• Located in lower Bawdwin, a short distance downstream from the Zi Nat Man Aung Buddhist temple. • Located on the hillside above the road. Site is mostly overgrown. • Graves are on terraces on the steep hillside.	Probably colonial to recent
15	Upper Bawdwin	Chinese	• Chinese cemetery on a vegetated ridge that runs up from an old Police Station/Library building. • Graveyard is overgrown and not in use.	Possibly Colonial

Graveyard number	Location	Ethnicity/Religion	Additional notes (from Appendix H)	Period of use
16	Upper Bawdwin	Chinese and Christian	• Located on the next ridge to the northwest of Graveyard 15. • Chinese, Christian and Myanmar graves were all observed and vary from small piles of stones and small headstones to larger cement tombs.	Probably recent and in use
17	Below Hillfort 3 (Mt Battle)	Chinese	• Located on the ridgeline to the southeast of Hillfort 3 (Mt Battle). • Consists of a number of stone mounds on the crest of the descending ridge.	Chinese
18	Hillfort 20	Chinese	• Located on the ridge to the east of Hillfort 20. • Graves are marked by stone outlines and low stone mounds.	Chinese
19	Above Goldhole Valley	Chinese	• Located on Mt Teddy on the northeast flank of the Nam Pangyun valley. • Number of graves with stone mounds, one of which is inscribed with a Chinese character.	Chinese
20	Above open pit (slopes of Mt Lakeland)	Chinese	• Located on a spur above the main pit on a ridgeline that descends from Mt Lakeland (Hillfort 5). • Several stacked rock graves in typical rectangular form with rounded ends and a larger grave with a semi-circular terrace in front of the main tomb mound.	Chinese
21	Below Tiger Camp (downstream from spiral)	Chinese	No notes recorded.	Possibly Colonial

Source: Southern Archaeology Ltd (2019) (Appendix H)

All graveyards, irrespective of their age, are of high cultural heritage value as they have high social and spiritual value. As these sites contain human remains, they need to be treated with care and respect. The graveyards from the Chinese period have great potential for bioarchaeological research to reveal how this ancient mining population worked and lived. For example, human burial sites can tell us a lot about the origins, health, cultural/societal practices and quality of life of those people. Many graveyards are particularly sensitive as they are prone to disturbance during mining activity, as their locations are not obvious from the surface.

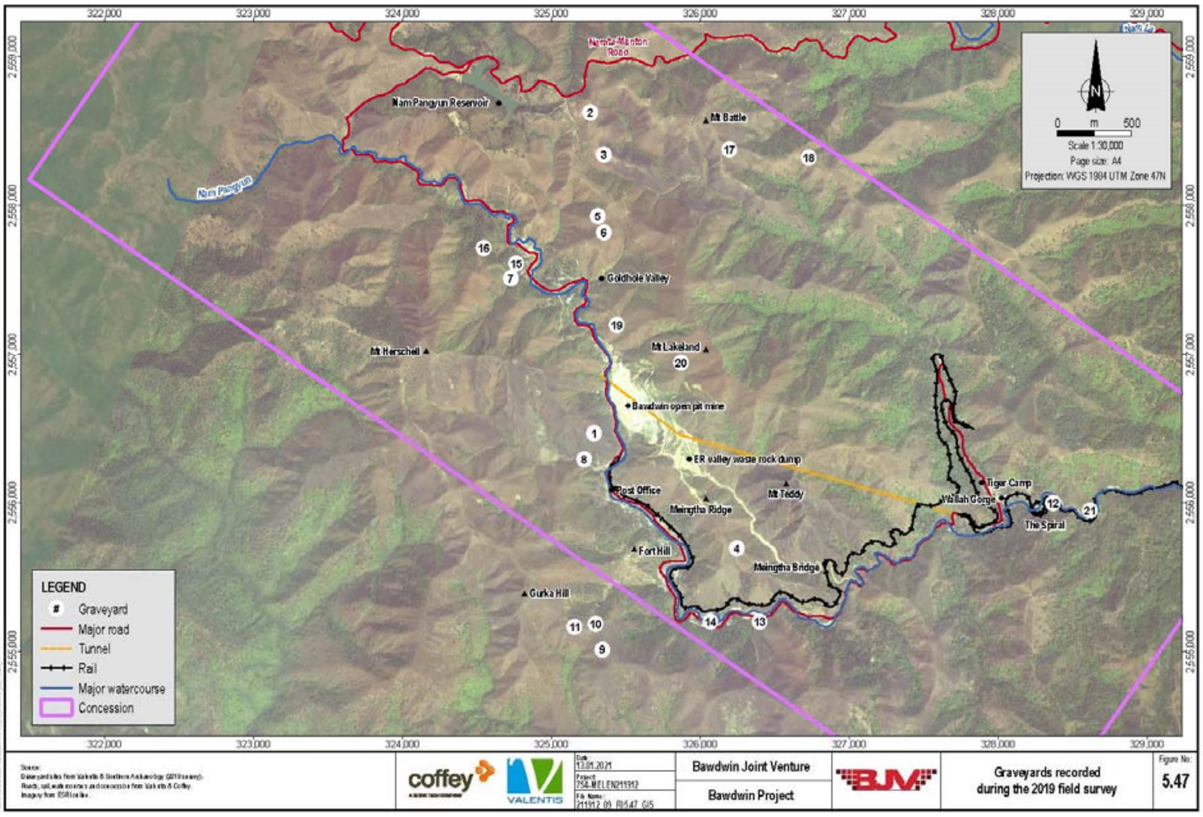

Figure 5.47 Graveyards recorded during the 2019 field survey

Plate 5.63 Burial at Graveyard 1

Plate 5.64 Chinese grave at Graveyard 2

Plate 5.65 A small Chinese headstone at Graveyard 2. The scale is 0.5 m long.

Graveyards from the colonial period will also contain similar bioarchaeological evidence and value to the Chinese graveyards, but more recent graves have higher importance to current communities at the site as they are where people who were known to them were buried.

Colonial-period mining heritage

Bawdwin mines and infrastructure

This section describes the components of the mine and associated infrastructure, the cultural heritage value of which ranges from those that have high value in their own right (e.g., the Marmion Shaft winding house), to those that contribute to a broader collection or system of high value (e.g., buildings in the central Bawdwin precinct). Figure 5.48 shows the locations of key mining infrastructure from the colonial period.

The key cultural heritage values associated with colonial-period mining heritage are discussed below.

Marmion shaft and winding house complex

The Marmion Shaft and associated winding equipment are associated with the most productive years of the Bawdwin Mines, when it was a world-leading lead producer. The Marmion Shaft winding house comprises a shaft collar, distinctive steel headframe, winding house, winding equipment, rail yards, offices and an electrical substation. Plate 5.66 shows the Marmion Shaft headframe and winding house.

The winding house is a corrugated iron clad building with a steel frame and painted in lead oxide red. In it two electrically-powered winders are housed. One of the winders and associated winding gear is used to this day as workers still access the shaft. Both winders and associated equipment are well-maintained in relatively good condition. There is no evidence of major upgrades, modifications or replacements to the original equipment.

The Marmion shaft is an excellent and rare example of a complete British 20th-century winding plant located in remote Myanmar mountains that is largely in its original condition. Other similar winding plants around the world are (or are part of) UNESCO World Heritage Sites – for example, the winding gear at Big Pit coal mine in Blaenavon in Wales and the Geevor tin mine in Cornwall, England.

Independence monument

The Stone Pillar of Independence, which commemorates the independence of Burma from colonial rule, is located in the grounds of No.1 Primary School in Yadanar Myay ward, north of the Chinese Bazaar buildings and existing mine pit.

Central Bawdwin precinct

The central Bawdwin precinct is an area comprising a group of key buildings and structures from the Colonial period. These buildings and structures relate to both the mine operation and functioning of the wider community and together form a key heritage precinct at Bawdwin.

The central Bawdwin precinct comprises:

- **Compressor house**. This comprises Ingersoll and Bellis air compressors and associated electric motors and control equipment (Plate 5.67). The compressor house is a large corrugated iron-clad building that housed the compressors that provided compressed air to the tools (e.g., rock drills) used in the underground workings. This house remains largely in its original condition. The compressors are excellent examples of early twentieth century British and American air compressors and open-frame electric motors. The oldest compressor still in place was manufactured between 1911 and 1923 (Plate 5.68).

- **Mine office.** The mine office (Plate 5.69) is largely in its original condition and contains its original furniture and hard copies of old and recent company files. The construction date of this office is unclear but it was likely in the 1910s during early mine development by the British. The office is used in the current day.

- **Post office**. The post office is still in service and has changed little since 1946.

- **Company store**. This store is still in use.
- **The Bawdwin railway station and the adjacent railway line**. However, the railway as a whole is characterised in the following section due to its unique values.
- **Mine Superintendent's and staff bungalows**. Accommodation quarters for higher-ranked mine workers. Many of these bungalows remain in use.
- **Dead Chinaman Tunnel**. This tunnel, originally constructed and used by the Chinese miners, was refurbished by the British. This was the main access to the Bawdwin lodes before the Marmion Shaft and Tiger Tunnel were constructed. It represents a period where British mining interfaced with older Chinese mining and is one of the few remaining structures associated with the very early British workings at the Bawdwin mines.
- **Bawdwin timber yard**. This timber yard was critical for early mine operations as timber to support underground workings was essential – particularly as timber frequently needed to be replaced in this damp, tropical environment. The yard contains open-sided timber buildings that house several saw benches and two large drop saws, some of which are still in use today.

The central Bawdwin precinct is the core area of early colonial-era Bawdwin, centred around the mine office, post office, clubhouse and railway station. The buildings themselves are likely to be of medium scientific and archaeological value because they are typical examples of buildings from that era in terms of their design and construction. This area would have had important social value as it was during the colonial period, and continues to be, a social centre for the mine workers and local community.

The mine infrastructure from the colonial period collectively has high historical, scientific and technological value. Those people who have spent their whole working life at the mine are likely to have a stronger connection to the mining infrastructure. Internationally, and particularly to the British, the cultural value of the mines and infrastructure is generally high. This is complex because the colonial-period sites at Bawdwin have different value to the people in Myanmar compared to those of the British and international community.

Tiger Camp precinct

The Tiger Camp precinct comprises two main features – the Tiger Tunnel area and Wallah Gorge area. The key features in this precinct are shown in Figure 5.49.

The Tiger Tunnel area comprises the Tiger Tunnel portal (Plate 5.70) and electric railway (Plate 5.71), railway yards, electric substation, office, clubhouse, stone store and police station. Commencing in 1914, development of the tunnel was led by Hebert Hoover, and this allowed access to the resource rich Chinaman orebody. The tunnel was not only a significant engineering feat, but it was a crucial element in the mine's early success as one of the world's leading lead mines. The area is industrial in nature and the stone revetments and gorge setting add aesthetic value. Overall, the Tiger Camp area has industrial archaeological importance as it contains evidence for the early development of the mine and use of electromotive power during the colonial period. The Tiger Tunnel is renowned for being an excellent engineering feat for its time and the associated railyard still operates to this day. Overall, the area has high physical, historical and cultural values.

The Wallah Gorge area includes the tippler (Plate 5.72) (a pair of electrically powered rotating drums that emptied ore carts from the mines onto the conveyor belt to the storage bins), ore bins (Plate 5.73) and Wallah Gorge Railyards from the colonial period. This industrial area and the stone store, ore loading bins and tippler structures, along with the gorge setting, add to the aesthetic value of the area. As per the case for the Tiger Tunnel, this area too was a critical part of the mine's operation during the colonial period. It was this area where all of the ore produced was transferred to the railway for transport to the smelters at Namtu.

The tippler, ore loading bins and railyards area has changed little since the 1920s.

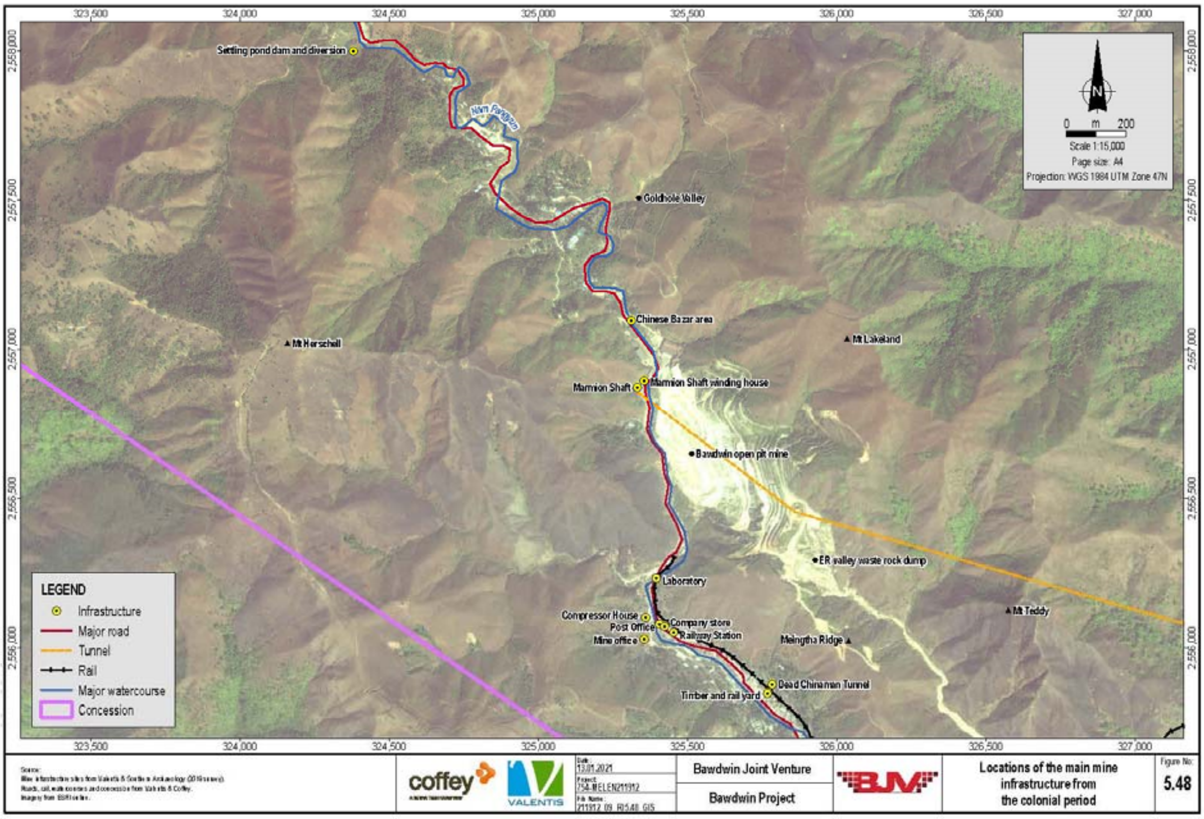

Figure 5.48 Locations of the main mine infrastructure from the colonial period

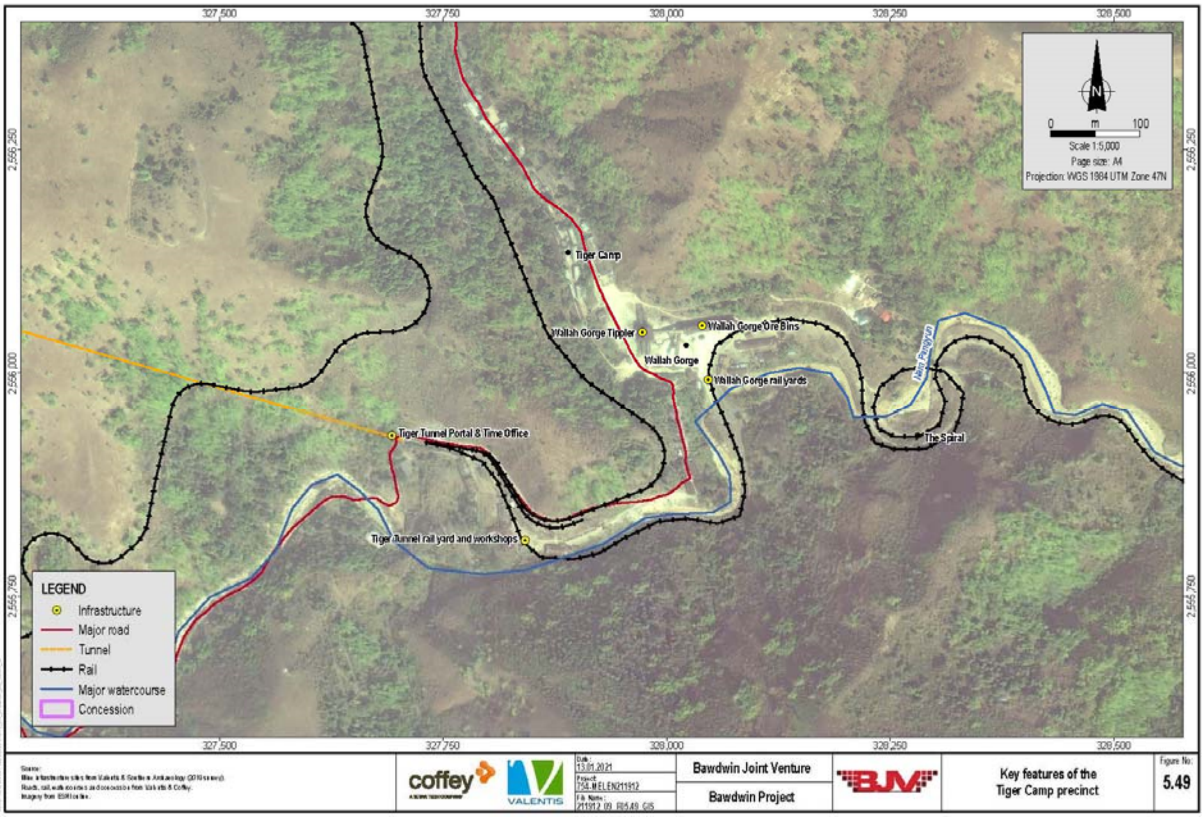

Figure 5.49 Key features of the Tiger Camp precinct

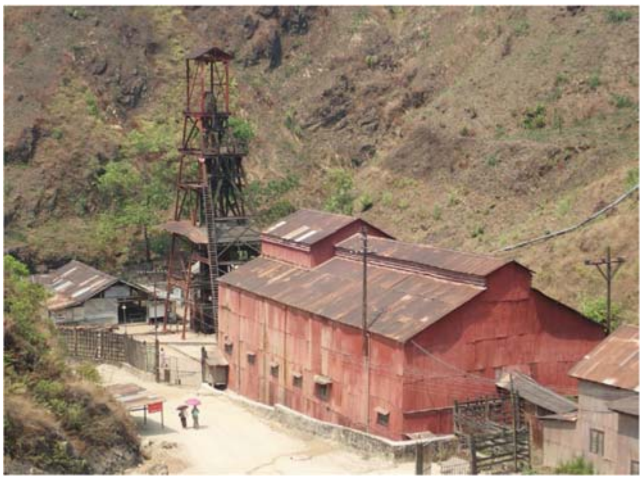

Plate 5.66 Marmion Shaft headframe and winding house

Plate 5.67 Compressor house at Bawdwin

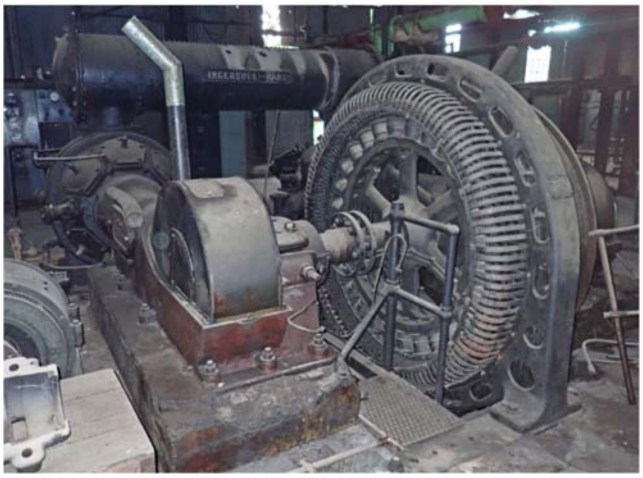

Plate 5.68 Ingersroll-Rand air compressor and synchronous motor in the compressor house

Plate 5.69 Bawdwin Mine office

Plate 5.70 The Tiger Tunnel portal

Plate 5.71 Tiger Tunnel electric railway with two cars waiting to travel into the mine portal

Railway

The railway was constructed between 1905 and 1911 and allowed transfer of slag and ore from the mines at Bawdwin to the smelters at Namtu.

The railway comprises two main sections – the section between Bawdwin and Namtu along the Nam Pangyun valley, which is mostly still operational; and the line between Namtu and Namyao that was abandoned in 2009. Figure 5.50 shows the location of the railway.

The section of railway between Tiger Camp and Bawdwin is currently in limited use since the ER Valley bridge was destroyed during flooding. The abandoned Namtu to Namyao section of the line is outside the study area and is not discussed. The electric railway associated with the Tiger Tunnel is a separate line and is included in the discussion in the section above.

The railway is a 2-feet gauge line, comprising almost entirely of timber sleepers (apart from some concrete replacements). The railway bridges are masonry or a mixture of masonry and steel. The route through the Nam Pangyun valley is picturesque as it traverses the valley sides and narrow gorges. The line includes several reverses (Plate 5.74) to allow the line to change elevations sharply between Bawdwin and Wallah Gorge. The Spiral (Plate 5.75) is a particularly interesting feature of engineering design. The spiral shape of the railway crosses the Nam Pangyun via two masonry bridges and allows the railway to rapidly gain height as it approaches Tiger Camp from Namtu.

The Bawdwin Railway Station (Plate 5.76) is located in the central Bawdwin precinct (see section above) alongside the Post Office and Company Store. The station is a timber building, in need of some maintenance.

The line from the timber yards to the Dead Chinaman Tunnel is now partly lifted (although some rails and the turntable are still in place), as is the section from Bawdwin Railway Station to Marmion Shaft where the railway once terminated.

From Bawdwin to Wallah Gorge the line traverses a narrow bench cut into the flank of the Nam Pangyun valley. A section is missing where the major bridge crossing the ER Valley was washed out in a flood. Moving eastward, the railway then traverses several cuttings through spurs, before crossing the Nam Pangyun several times between Wallah Gorge and Namtu. The railway has extensive stone revetment in place along much of its length in the Wallah Gorge.

The railyards at Namtu (Plate 5.77) include rolling stock and locomotive storage and maintenance facilities. At the railyards, the field survey noted several steam and diesel locomotives in various conditions (Plate 5.78, Plate 5.79 and Plate 5.80). Two steam locomotives remain in operation and several non-operational steam locomotives are on display. The present rail traffic comprises railcars, including two interesting examples that were converted from Hino road trucks.

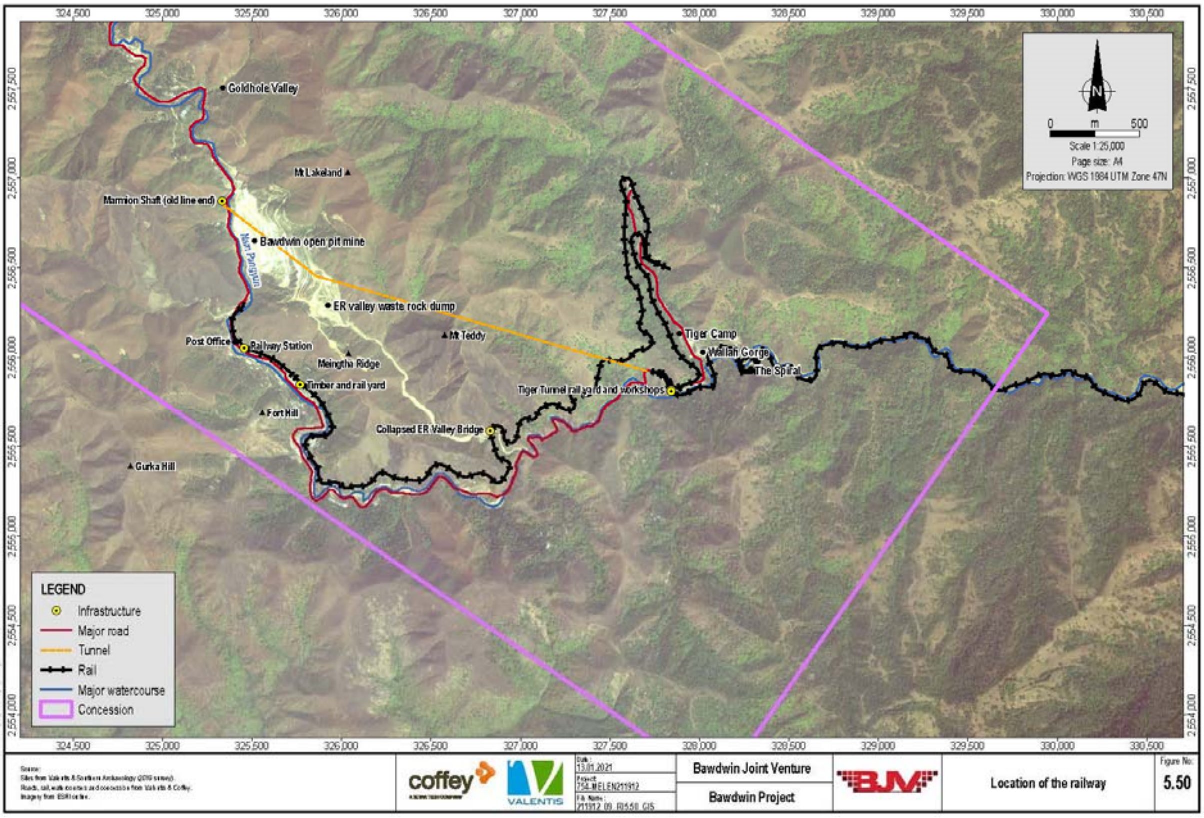

Figure 5.50 Location of the railway

Plate 5.72 The tippler with two rollers visible

Plate 5.73 The ore loading bins (extreme right) with the tippler (right rear) and the railway line to Namtu visible at centre bottom

Plate 5.74 The rail reverse in Wallah Gorge

Plate 5.75 Rail spiral crossing the Nam Pangyun via two masonry bridges

Plate 5.76 Bawdwin railway station

Plate 5.77 The Namtu railyards

Plate 5.78 Kerr Stuart Huxley Class tank engine, built in 1914

Plate 5.79 Bagnall tender locomotive

Plate 5.80 Part of the row of old steam engines and carriages at the Namtu railyards

The railway route is aesthetically spectacular. The following features are key elements of the railway system and are of particular heritage importance:

- The railbed and line from Namtu to Bawdwin (approximately 19 km).
- Bawdwin and Namtu railway stations (including the Namtu train control system).
- Wallah Gorge reverses.
- Wallah Gorge yards and turning triangle.
- Tiger Camp Spiral and masonry bridges.
- Namtu yards and workshops.
- Namtu iron truss railway bridge.
- Rolling stock at Namtu and those which use the railway, especially all steam locomotives (operational, non-operational and parts), carriages, railcars, diesel locomotives.

The railway has been the subject of international rail enthusiasts and, from the late 1990s to the early 2000s, heritage rail tours were conducted. The railway has significant tourism potential, particularly if the steam locomotives are operational. Numerous other narrow-gauge railways exist around the world, including many examples in India (some of which are UNESCO listed).

The railway is an internationally recognised industrial archaeological feature due to its engineering significance, its importance in the history of Bawdwin, and its highly picturesque and challenging mountainous setting, and associated social value and tourism potential.

Religious sites

Bawdwin religious sites

During the field survey, 19 religious places or sites were identified in the Bawdwin area. These are summarised in Table 5.70 and the locations shown in Figure 5.51.

Table 5.70 Details of religious sites recorded at Bawdwin

Name	Religion/ethnicity	Type	Ward	Comments
Unknown ruin	Unknown	Temple/Shrine	NA	Small abandoned temple or shrine found on hillside in 2019. Age and association are presently unknown, but it is likely to date to the Chinese occupation
Aye Say Di	Buddhist	Temple	Yadana Mye	First Buddhist temple at Bawdwin in the 'modern' era and is one of the three main Buddhist temples at Bawdwin (Plate 5.81). Build date is not clear. The Chedi is shown in Plate 5.82.
Dha Mi Kha Ya Ma	Buddhist	Temple/Monastery	Thiri Mingalar	Second Buddhist temple to be established at Bawdwin. Located on a hilltop and is reached by climbing steps from where the last Chinese bridge was located. Possibly built in 1956.
Zi Nat Man Aung Temple	Buddhist	Temple	Aung Theikdhi	Possibly on site of Muslim graveyard. Temple is a relatively modern complex (Plate 5.83): the hall was built in 1975, and other parts of the complex in the 1990s and 2000s.

Name	Religion/ethnicity	Type	Ward	Comments
'Light of Dhama'	Buddhist	Chapel	Pyi Taw Aye	Repurposed house. Converted into a small Buddhist chapel by the locals (probably about 7 to 10 years ago).
Dha Pu Nya Karyi	Buddhist	Chapel	Aung Chan Thar	Constructed in 1974 and serves the local community as a chapel and Buddhist school.
Thiri Mingalar Ward Library and Buddhist Chapel	Buddhist	Chapel	Thiri Mingalar	Built 2014 by the local community. Also houses a library.
Chinese Temple	Chinese	Temple	Yadanar Myay Ward	On top of steep hill on western side of Nam Pangyun valley. Age of the buildings uncertain, but the main temple building looks likely to be of colonial-era.
Bawdwin Mosque	Muslim	Mosque	Pyi Taw Ayi	Colonial era.
Shree Krishna	Indian	Indian Temple	Aung Tha Pyay (Gurka Hill)	Built in 1915.
Maha Karli	Indian	Indian Temple	Aung Tha Pyay (Gurka Hill)	Possibly built in 1915. Modified since.
Sikh Temple	Sikh	Temple	Yadana Mye	No longer used. Building used as a house.
Catholic Church	Christian	Church	Pyi Taw Aye	Appears well maintained, although one local source stated that it was no longer in use and is tended by one family who live in the associated buildings. Build date unknown.
Union Baptist Church of Bawdwin	Christian	Church	Mingalar Kwe Ward	Existing church built 1962.

Source: Southern Archaeology Ltd (2019) (Appendix H)

The vast majority of the recorded religious sites are in current use or were used until recently.

During the colonial period the Burma Mines Corporation (and its later reincarnation as Burma Corporation) provided places of worship for the different religions of the workers at Bawdwin. Since that time, local communities have established and developed existing, or created additional, religious sites.

As, over the years, the mining workforce has transitioned from predominantly Chinese to mixed race and Burmese, the Chinese temple is now hardly used and is only known to be occupied by one monk. Also, the Sikh temple has been abandoned and is now used as a private residence. Conversely, the Buddhist temples and chapels and Baptist church have strong congregations, reflecting the more common religions in the modern period.

In Asia, it is common for temples and places of worship to significantly change over time, typically through generations of modifications and renovations. This is also the case at Bawdwin and an example is the Dha Mi Kha Ya Ma Buddhist temple, which in 1958 stood alone, but today is at the centre of an extensive building complex.

Plate 5.81 Aye Say Di Temple from above. The Sikh Temple is mostly obscured in the trees to the right

Plate 5.82 The Chedi at Aye Say Di Temple

Plate 5.83 Zi Nat Man Aung Temple complex

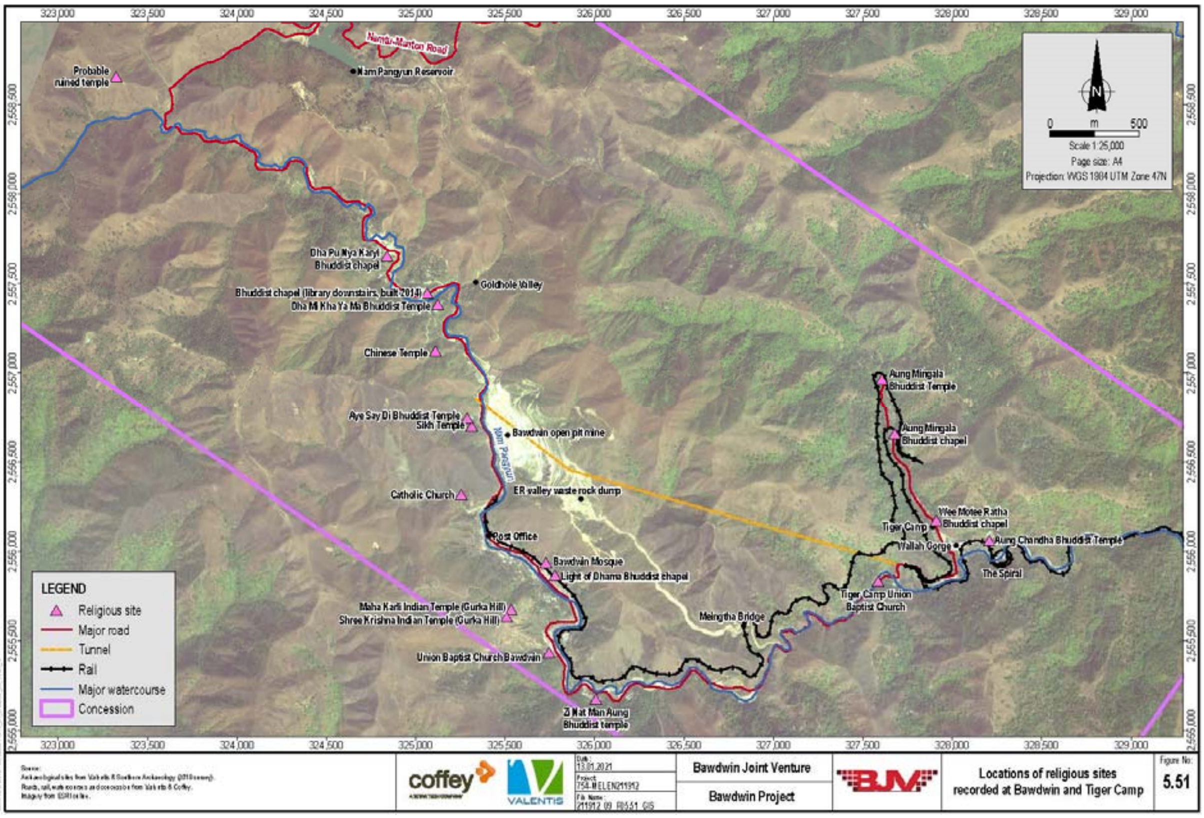

Figure 5.51 Locations of religious sites recorded at Bawdwin and Tiger Camp

Tiger Camp religious sites

During the field survey, five religious places or sites were identified in the Tiger Camp area. These are summarised in Table 5.71 and the locations shown in Figure 5.51.

Table 5.71 Details of religious sites recorded at the Tiger Camp area

Name	Religion/ethnicity	Type	Comments
Aung Chandra Temple	Buddhist	Temple	Located on a spur overlooking the Wallah Gorge Rail Yards and the Spiral. Was originally the site of a Gurkha temple but was re-used for the present temple as there is no longer a local Gurkha population. Temple shown in Plate 5.84.
Aung Mingalar Temple	Buddhist	Temple	Situated at the top end of the Wallah Gorge settlement. Relatively modern, built in the 1980s (Plate 5.85).
Wee Motee Reitha	Buddhist	Chapel	Small wooden building in the lower Wallah Gorge. Appears to be from the colonial period. Also referred to as Pali. Still in use by local community. Chapel shown in Plate 5.86
Aung Mingalar Chapel	Buddhist	Chapel	Wooden post and brick infill building, constructed in about 1970 to replace an earlier timber chapel.
Union Baptist Church	Christian	Church	Timber building situated beside the track between Bawdwin and the Tiger Camp.

Source: Southern Archaeology Ltd (2019) (Appendix H)

Summary of religious sites

Religious sites identified can be categorised as either those that are still in use and those that are no longer used for their original purpose. Of the sites still in use, only a small number have significant tangible heritage values because they have been continuously and significantly remodelled over a prolonged period. Although, to the local community even highly modified places may have high heritage value. Therefore, the determination of significance of religious sites is difficult without considering the views of the local communities.

Many of these religious places are similar to those found in other small communities throughout Myanmar.

The Indian and Chinese temples and the Wee Motee Reitha chapel and mosque are all part of historic structures and will have some value to the local communities that use them. The Chinese Temple appears to have little (or possibly no) community that uses it and probably is the reason why it remains largely unmodified over a long period. It is possible that it occupies the site of an earlier Chinese temple as it is situated atop a distinctive spur. Further investigation would be needed to understand the full significance of this site in terms of scientific and spiritual values.

The Sikh temple is now used as a house and is likely to have limited heritage value to the local community.

Further discussions with local communities are needed to confirm the importance of the Buddhist temples.

The Baptist and Catholic churches have low to medium aesthetic and historic significance and low scientific and technological significance. Discussion with local communities is needed to confirm the heritage value of the Baptist and Catholic churches. But, given the Baptist Church still has a strong congregation, it is likely that it has high value to the community. The Catholic Church did not appear to have an active congregation when visited during the field survey.

Plate 5.84 The hall at the Aung Chandra Temple

Plate 5.85 Aung Mingalar Temple, with Chedi visible

Plate 5.86 Wee Motee Reitha Chapel

Bawdwin and Tiger Camp village buildings

The buildings in the Bawdwin and Tiger Camp villages vary in age, quality and condition. Most of the buildings probably were constructed in the mid-twentieth century, particularly during the post-World War II construction period in the 1950s. Most buildings are of timber construction, while some are built from stone or contain stone structures.

Specific buildings/structures and areas of significance in the villages are:

- **Remaining stone buildings in the Chinese Bazaar area** (adjacent to concentrator plant). These buildings are evidence of the early colonial-era Chinese community at Bawdwin.
- **Stone stores at Tiger Camp**. These are an example of the development of permanent community resources at Bawdwin.
- **Goldhole Valley area**. This area has some remaining stonework revetments both upstream and downstream of where the last remaining Chinese bridge was located before it was washed away in a flood.
- **Areas and structures that are of pre-World War II construction.**

Modern defences

The Bawdwin mine, due to its considerable mineral abundance, has been subject to centuries of careful protection for threats. Much in the same way the early Chinese hillforts system guarded the mine, modern defences are in place at the site to this day. The Myanmar Army base uses Hillfort 19 as a guarding site to protect the mine against insurgents. In the past the army has also occupied other protective locations such as Fort Hill (Hillfort 10).

The defence sites include a ring of modern-era army trenches at Hillfort 1, trenches at Fort Hill within the ancient Chinese ramparts, army trenches at Mt Herschell and Gurkha Hill, a concrete army bunker in the upper Bawdwin village and gun emplacements on a side ridge off Meingtha Ridge.

Although these modern-period defence sites are not within the date-range of protected sites as stipulated in the Myanmar heritage legislation (i.e., they are not more than 100 years old), they are a continuity of the human occupation at Bawdwin and some of these defence sites are situated within the ancient Chinese forts. The significance of the modern defence sites is not assessed.

Areas of high chance accidental discoveries

A key feature of the Bawdwin landscape is the large number of graveyards known and likely to occur across the area. While there is an apparent preference for ridge locations (especially the ends of ridges), additional graveyards are likely to occur within the area encompassed by the Chinese hillforts (see Figure 5.46) and may occur in the lower valley. Graveyards at Bawdwin therefore may be encountered during future earthworks and excavation in such areas.

The areas between Chinese hillforts are likely to be hot spots for evidence of Chinese occupation, as these hillforts were previously likely connected along ridgelines.

The areas where communities in the Bawdwin concession area reside may contain subsurface archaeological evidence of earlier Chinese occupation. The areas most likely to contain such archaeological evidence are on either side of the open pit, particularly in the area of the Mine Office and Post Office all the way upstream to the Goldhole Valley area.

5.8.5 Sensitivity of cultural heritage values

This section builds upon discussion of cultural heritage features in Section 5.4 and describes the sensitivity for each of the identified cultural heritage features and values. Sensitivity in this context is a quantification of how sensitive the cultural heritage feature or value is to change as a result of the project. Sensitivity is based on the importance of the value, the vulnerability of the value to change, and the resilience of the value in terms of its ability to overcome changes and maintain its inherent value.

Applicable guidelines and standards

Myanmar has two laws related to the protection and preservation of cultural heritage; the Protection and Preservation of Ancient Monuments Law (2015) and the Protection and Preservation of Antique Objects Law 2015. There are no Myanmar guidelines for cultural heritage assessment or determination of significance or sensitivity, so the following international charters, guidelines and methods have been used for guidance:

- The Burra Charter, established by the International Council on Monuments and Sites (ICOMOS) and the Australian Burra Charter Practice Note on Understanding and Assessing Cultural Significance (ICOMOS, 2013a).
- The International Committee for the Conservation of the Industrial Heritage (TICCIH) TICCIH's Nizhny Tagil Charter for the Industrial Heritage (TICCIH, 2003).
- IFC Performance Standard 8 (Cultural Heritage) and guidance notes (IFC, 2012).

The definitions used for assigning significance of a value are based on the Australian Burra Charter Practice Note (ICOMOS, 2013a), which provides five significance criteria: aesthetic, historic, scientific, social and spiritual. An additional significance criterion relevant to Bawdwin is technological significance, given that machinery, equipment and constructed structures are all features of significant heritage value at Bawdwin. The technological significance criteria are taken from the Nizhny Tagil Charter for the Industrial Heritage (TICCIH, 2003).

In accordance with the Myanmar Technical Guidance Environmental Impact Assessment Guidelines for the Mining Sector, this assessment has considered the importance of the value, which has the suggested definition in the guidelines of “The value that is attached to a specific environmental component in its current condition.” This aligns with definition of cultural heritage significance, which is the aesthetic, historic, scientific, social or spiritual value for past, present or future generations and which is embodied in the place itself, its fabric, setting, use, associations, meanings, records, related places and related objects (ICOMOS, 2013b).

Table 5.72 presents the definitions of these factors of significance along with the criteria for their assigned ratings.

International Finance Corporation (IFC) Performance Standard 8 recognises the importance of cultural heritage and aims to ensure clients protect cultural heritage values. The objectives of IFC Performance Standard 8 are:

- To protect cultural heritage from the adverse impacts of project activities and support its preservation.
- To promote the equitable sharing of benefits from the use of cultural heritage.

The IFC Performance Standard 8 Guidance Note 8 states that ‘critical heritage’ is not to be significantly altered, damaged, or removed except under exceptional circumstances. The definition for critical heritage in IFC Performance Standard 8 Guidance Note 8 is ‘*(i) the internationally recognized heritage of communities who use, or have used within living memory the cultural heritage for long-standing cultural purposes; and (ii) legally protected cultural heritage areas, including those proposed by host governments for such designation*’. As the Bawdwin site has been recognised internationally in terms of its heritage (mainly for key features such as the railway and Marmion Shaft winding house as well as the complex history of the mine itself) and many of the features at the mine are protected by Myanmar law, such features are considered critical heritage based on the IFC definition. The likelihood of a feature being classified as critical heritage under the IFC Performance Standard 8 has been incorporated into the assessment of importance (i.e., with features likely to be critical heritage having a higher importance).

The vulnerability of each value is defined by considering its location with respect to the project; its size, distribution or extent; its current condition; and its setting. This approach is consistent with the Burra Charter Australia ICOMOS Charter for Places of Cultural Significance (ICOMOS, 2013b), which states that cultural heritage conservation requires retention of associated features such as the visual and sensory setting, its location (particularly if based on historic event or importance) and its co-existence with other cultural values. The latter aspect is particularly important at Bawdwin where areas or ‘precincts’ have collective significant values that are higher than the value of individual places within that precinct, or where areas contain multiple cultural heritage sites or values.

The resilience of each value is defined by considering the extent to which its original value would be retained after some degree of change. In many cases this is essentially the reverse of vulnerability. An example of resilience is the degree to which a structure or building could have its original parts replaced without losing its heritage value. This is a particularly relevant consideration for the assessment and conservation of industrial heritage. TICCIH is the international society which focuses on the study, protection, promotion and interpretation of industrial heritage around the world. TICCIH's Nizhny Tagil Charter for the Industrial Heritage (TICCIH, 2003) is the international guidance document for the management and conservation of industrial heritage. A key maintenance and conservation philosophy under the charter is that preservation of the functional integrity of the industrial heritage feature is important in successful conservation of its heritage value. In other words, the heritage value of an industrial site or feature could greatly reduce if, for example, machinery or components are removed or replaced with modern elements.

An important caveat associated with the assessment of sensitivity herein (and particularly the assessments of ‘importance’) is that the significance of the value may vary widely depending on different people and perspectives. For example, an Asian temple that has been highly modified over the years may still hold its cultural heritage value for local people whereas from a Western perspective modernisation of the temple may appear to detract from its original cultural heritage value. This assessment of sensitivity provides justification that supports the ratings; however, it should be noted that additional public consultation may result in some changes to the ratings depending on what the communities say they value about each of the features. The specialist study upon which this section draws its information only undertook very limited public consultation in relation to cultural heritage values.

Assessment of sensitivity of cultural heritage values

Table 5.73 outlines the importance, vulnerability, resilience and overall sensitivity for each known cultural heritage site or value, based on low, medium and high scale. Supporting justification for the ratings is given in the table. Appendix H provides a more detailed assessment of importance (significance) across six criteria: aesthetic, historic, scientific, technological, social and spiritual. It is noted that additional currently unknown cultural heritage sites are highly likely to be present in the project area. Preliminary assessments of the importance (significance), vulnerability, and resilience of these features are made, based on the corresponding known features; however, the actual significance of unknown sites cannot be confirmed until the features are encountered and further investigations are completed.

Table 5.72 Significance definitions and ratings criteria

	Definition	Ratings criteria[c]		
		Low	**Medium**	**High**
Significance/ importance	**Aesthetic[a]:** Refers to the sensory and perceptual experience of a place—that is, how we respond to visual and non-visual aspects such as sounds, smells and other factors having a strong impact on human thoughts, feelings and attitudes.	The place/site and/or its setting has little or no visual appeal	Moderate visual appeal	High visual appeal
	Historic[a]: Intended to encompass all aspects of history—for example, the history of aesthetics, art and architecture, science, spirituality and society. A place may have historic value because it has influenced, or has been influenced by, an historic event, phase, movement or activity, person or group of people. It may be the site of an important event.	Sites/places not associated with any known historical event, person or theme.	Associated with moderately significant historical event/person/theme at either local and/or provincial and/or national level.	Associated with highly significant event/person/theme at either local and/or national and/or international level.
	Scientific (archaeological)[a]: Refers to the information content of a place, or its ability to reveal something about the past using scientific techniques such as archaeology. The relative scientific value of a place is likely to depend on the importance of the information or data involved, on its rarity, quality or representativeness, and its potential to contribute further important information about the place itself or a type or class of place or to address important research questions.	Little or no visible or suspected archaeological information. Extensively damaged. Very common site types.	Visible and/or highly likely presence of archaeological information. Little to light damage. Rare or uncommon site types.	Extensive visible and suspected sub-surface archaeological information. Very rare or rare site types nationally/internationally.
	Technological[b]: The industrial heritage is the evidence of activities which had and continue to have profound historical consequences. The motives for protecting the industrial heritage are based on the universal value of this evidence, rather than on the singularity of unique sites.	Place/site/items of very common type in moderate to poor condition. Better examples exist locally/nationally.	Place/site/items of moderately common to uncommon type in moderate to good condition. Comparable examples exist nationally or internationally.	Places/sites/items of uncommon type in moderate to good condition. Rare nationally or internationally. Very complete or original condition will add to significance.
	Social[a]: Refers to the associations that a place has for a particular community or cultural group and the social or cultural meanings that it holds for them.	Places/sites that do not appear to have clear social connection at either local/provincial/national level.	Places/sites that have moderately significant social connection for a cultural group at either local/provincial/national level.	Places/sites that have highly significant social connection for cultural group at either local/provincial/national/international level.
	Spiritual[a]: Refers to the intangible values and meanings embodied in or evoked by a place which give it importance in the spiritual identity, or the traditional knowledge, art and practices of a cultural group.	Places/sites that do not appear to have any clear spiritual connection with a cultural	Places/sites which have a moderately significant spiritual connection for a cultural group	Places/sites that have a highly significant spiritual connection for a cultural group at either the

	Definition	Ratings criteria[c]		
		Low	**Medium**	**High**
		group at either local/provincial/national level.	at either local/provincial/national level.	local/provincial/national/ international level.
	Critical heritage – Likelihood of feature being classified as critical heritage under IFC Performance Standard 8	Low likelihood of being critical heritage under IFC PS8.	Medium likelihood of being critical heritage under IFC PS8.	High likelihood/almost certain to be determined critical heritage under IFC PS8.
Vulnerability		The site is already degraded or diminished and has little vulnerability to further changes.	The site is moderately intact and somewhat vulnerable to further changes.	The site is intact and highly vulnerable to changes.
Resilience		Limited or no capacity to adapt to change and little or no heritage value can be retained.	Some limited resilience to change. Some of the heritage value can be retained.	Easily adaptable to change and most or all of the heritage value can be retained.

a Source for definition: ICOMOS (2013a)
b Source for definition: TICCIH (2003)
c Criteria based on professional judgement as outlined in Appendix H

Table 5.73 Importance, vulnerability, resilience of the cultural heritage values

Cultural heritage value	Importance	Vulnerability	Resilience	Sensitivity
Chinese mining period features				
Chinese hillforts and defended ridges system	**High** The hillforts served as a collective defence (and probably administrative) system for the mine. The remnants of the hillforts are largely intact which is unusual for features older than 500 years in a monsoon climate. The hillforts and defended ridges are unlike any features found elsewhere in Myanmar. These features have high aesthetic, historic, scientific (archaeological) and technological importance and are highly likely to be classified as critical heritage under IFC Performance Standard 8.	**High** These features are located in prominent positions of the landscape and are highly vulnerable to changes to both the feature and surrounding landscape. Hillfort 4, however, is considered to have **medium** vulnerability as it is already highly damaged.	**Medium** The hillfort and defended ridges system would be able to withstand some localised changes to the surrounding landscape, but cultural heritage values would be difficult to re-establish if damaged. Some of the hillforts, e.g., Hillfort 4 and the hills at Hillfort 1 have been extensively modified from their original condition by twentieth century mining activities, and have some resilience to further disturbance.	**High** (Hillfort 4 Medium) The hillfort and defended ridges system would be able to withstand some localised changes to the surrounding landscape, but cultural heritage values would be difficult to re-establish if damaged. Some of the hillforts, e.g., Hillfort 4 and the hills at Hillfort 1 have been extensively modified from their original condition by twentieth century mining activities, and have some resilience to further disturbance.
Artefacts and evidence of Chinese occupation in Nam Pangyun valley	**High** These features allow for an understanding of the Chinese occupation and the historic operation of the mine and hillfort system, and have high historic, scientific (archaeological) and technological importance. While the known artefacts and evidence of Chinese occupation have been assigned a high importance, this rating is also conservatively applied to as yet unencountered artefacts and evidence. Since it is likely that archaeological evidence from the initial Chinese occupation and earlier periods (especially if from the Bronze Age) would have high historic, archaeological and technological importance. However, further assessment would be needed to confirm the	**High** These features are vulnerable to being disturbed or destroyed due to the widespread location of features and likely presence of unknown features. Artefacts and other evidence generally hold higher significance if they can remain intact (including when in situ or when excavated) and their heritage context is understood.	**Medium** The artefacts and evidence of Chinese occupation are expected to be widespread throughout the Nam Pangyun valley but concentrated in the valley floors. This material has already been subjected to substantial impact by historic mining and occupation with direct disturbance, placement of waste, mining and placement of buildings. Identification of features and artefact material may allow for its relocation, conservation and use in scientific research. The success of regaining the value of the features will be dependent on appropriate archaeological recording, analysis and reporting.	**High**

Cultural heritage value	Importance	Vulnerability	Resilience	Sensitivity
	actual importance of currently unknown features once discovered. It is unlikely these features would be classified as critical heritage under IFC Performance Standard 8.			
Chinese bridge remains	**High** This feature (despite have some changes from 20th and 21st century development) has high historical and scientific (archaeological) significance as the bridge foundation is a rare remaining feature of the ancient Chinese occupation from the early settlements at Bawdwin.	**High** This is the last known feature of its type in this setting, and its removal would constitute a complete loss of the bridge foundation from the mining setting.	**Low** This feature would lose most of its heritage value if dismantled and removed, even if portions of it were preserved in museums.	**High**
Mining and smelting evidence (Chinese era)	**High** These sites have high potential archaeological and technological research value, particularly as little is known about the early minerals exchange network throughout southeast Asia and the mining methods at the centre of it. Such features provide important archaeological and technological evidence of early mining activity and also aid in the overall interpretation of the Chinese occupation at Bawdwin. The collective evidence of mining and smelting during Chinese occupation was assessed as having high historic, scientific (archaeological) and technological importance. While the known mining and smelting evidence of from the Chinese era have been assigned a high importance, this rating is also conservatively applied to as yet unencountered Chinese mining and smelting evidence. However, further assessment would be needed to confirm the actual importance of such features once discovered. Low likelihood of being classified as critical heritage under IFC Performance Standard 8.	**High** Two furnaces that are of possible Chinese original have been located to date (on the hillside adjacent to the open pit and on the hills more than 1.5 km north of the open pit), but more may exist. These sites are vulnerable to project disturbance as they are typically located on valley slopes and any direct disturbance or alteration to the slopes will cause damage. Ancient Chinese underground workings are highly vulnerable to project disturbance as these are concentrated mostly around the current open pit and mineral resource.	**Low** Damage to or loss of ancient furnaces or mine workings cannot be reversed. It is unlikely that if significantly damaged that any heritage value associated with these features would be retained.	**High**

Cultural heritage value	Importance	Vulnerability	Resilience	Sensitivity
Graveyards (all periods)	**High** All graveyards have been considered to have social and spiritual value. The modern graveyards are likely to have high social and spiritual value to existing communities. The older graveyards are likely to have less social value but higher bioarchaeological and historical value. They could provide a range of information about the ancient Chinese and colonial period populations (e.g., ethnic/racial origins, health, quality of life, working conditions). Overall, a high importance is assigned to all graveyards, with sites assessed as having high historic, scientific (archaeological), social and spiritual importance. The graveyards have a low likelihood of being classified as critical heritage under IFC Performance Standard 8. While the known graveyards have been assigned a high importance, this rating is also conservatively applied to as yet unencountered graveyards and burials. However, further assessment would be needed to confirm the actual importance of such features once discovered.	**High** Graveyards are highly vulnerable to disturbance, particularly the graveyards that are not known or clearly marked as these are more likely to be accidentally encountered or damaged.	**Low to Medium** Damage to, or loss of graveyards cannot be reversed and if relocated the original heritage value may be lost or reduced. Many of these graveyards are located in prominent positions in the landscape. As such, they have little or no resilience to being relocated without losing some aesthetic (and potential spiritual) value but would likely retain their social, and potentially archaeological, value with appropriate measures put in place.	**High**
Colonial period mining heritage				
Marmion shaft and winding house	**High** The Marmion shaft and winding house is a rare example of a complete British 20th-century winding plant located in its original context in the remote Myanmar mountains that is largely in its original condition. This site was assessed as having high aesthetic, historic, scientific (archaeological) and technological importance and has a high likelihood of being classified as critical heritage under IFC Performance Standard 8.	**Medium** Heritage value is vulnerable to degradation, loss or replacement of the building, equipment or their elements and also loss of the functional integrity of the winding house. Given that the Marmion shaft and winding house are complete features that are almost entirely in their original condition, their value is vulnerable to change.	**Medium** Would likely still retain some of its heritage value if relocated and refurbished however, key to its current value is its current functionality and surrounding context in the Bawdwin mining landscape and with other key mining heritage features.	**Medium to high**

Cultural heritage value	Importance	Vulnerability	Resilience	Sensitivity
Independence monument	**Medium** This feature represents an important moment in Myanmar's history but probably has medium archaeological, social and cultural value given its degraded condition and its low prominence in the overall landscape.	**Low** The monument is already degraded (weathered, discoloured, weeds growing at the base)	**High** The monument would likely still retain its heritage value if relocated.	**Low**
Central Bawdwin precinct	**High** This precinct contains key structures (e.g., mine office, clubhouse, Dead Chinaman Tunnel, Bawdwin timberyard, compressor house) relating to historic mine operation and key buildings of importance to the wider community (e.g., post office, company store, railway station). This precinct has been a key area of social importance throughout Bawdwin's history, from the early Chinese, through to the Colonial period, to the current day. While the significance of each building or structure within this precinct may vary in its specific values and attributes, it is important to recognise the heritage value of this area as a whole. This precinct was assessed as having high historic, scientific (archaeological), technological and social importance.	**Medium** This precinct has some vulnerability to loss of heritage value as it is in a fixed location and setting that cannot be moved. This is relevant to both changes to the visual setting (i.e., if additional buildings are to be constructed nearby in the future), or if they may be impacted directly to make way for more modern infrastructure for development of the project. While wooden and metal buildings and structures have been, and will continue to be, exposed to weathering and degradation (i.e., corrosion, rotting, erosion of adjacent ground, etc.), ongoing natural degradation of these is not expected to materially influence the vulnerability of their heritage value over the project timescale.	**Medium** The area would be able to withstand some localised changes in terms of additional buildings and changes to the landscape without materially affecting the aesthetic, historic and social appeal of the area as a whole.	**Medium**
Tiger Camp precinct	**High** This precinct contains a key industrial structures and buildings associated with historic mine operation (e.g., Tiger Tunnel and electric railway, railway yards, tippler and ore bins). It is an important industrial archaeological precinct, containing evidence for the development of the mine and the use of electric motive power. Overall the precinct was assessed to have high historic and technological significance.	**Medium** This precinct has some vulnerability to loss of heritage value as it is in a fixed location and setting that cannot be moved. This is relevant to both changes to the visual setting (i.e., if additional buildings are to be constructed nearby in the future), or if they may be impacted directly to make way for more modern infrastructure for development of the project.	**Medium** The area would be able to withstand some localised changes in terms of additional buildings and changes to the landscape without materially affecting the aesthetic, historic and social appeal of the area as a whole.	**Medium**

Cultural heritage value	Importance	Vulnerability	Resilience	Sensitivity
	The precinct is not likely to be classified as critical heritage under IFC Performance Standard 8.	While wooden and metal buildings and structures have been, and will continue to be, exposed to weathering and degradation (i.e., corrosion, rotting, erosion of adjacent ground, etc.), ongoing natural degradation of these is not expected to materially influence the vulnerability of their heritage value over the project timescale.		
Namtu to Bawdwin railway	**High** The railway is a prominent feature of the Pangyun Valley and an important example of early twentieth century British engineering in a mountainous location. Its significance comes from its engineering, unique setting and that it is still largely intact (apart from some sections that need repair) and a complete system. Similar railways around the world are recognised by UNESCO as world heritage sites and as such it is expected that the railway would be of high international importance and potential future heritage tourism potential. The railway also has importance to the local community as it is key representation of the link between the Bawdwin mine and the Namtu communities over the last 100 years. The Namtu to Bawdwin railway was assessed as having high aesthetic, historic, scientific (archaeological) and technological importance. It is highly likely to be classified as critical heritage under IFC Performance Standard 8.	**Medium** The railway is heavily reliant on its location and setting for its cultural heritage value and these two aspects cannot be changed. Therefore, changes to the setting (particularly visual aesthetics) within the Nam Pangyun valley could detract from the heritage value of the railway itself. The condition and integrity of the railway is also vulnerable to change and deterioration if not maintained and this would detract from its aesthetic, historic and technological significance. While wooden and metal structures have been, and will continue to be, exposed to weathering and degradation (i.e., corrosion, rotting, erosion of adjacent ground, etc.), ongoing natural degradation of these is not expected to materially influence the vulnerability of their heritage value over the project timescale.	**Medium** As fixed infrastructure, the railway has limited resilience to change, particularly considering its location and the importance of this setting to its value.. The age of the railway also makes it susceptible to further degradation and deterioration. Preservation of the rail infrastructure or sections of the rail would provide some resilience to maintaining the heritage value of the site. As fixed infrastructure, the railway has limited resilience to change, particularly considering its location and the importance of this setting to its value, which provides access to the Nam Pangyun and Tiger Camp. The age of the railway also makes it susceptible to further degradation and deterioration by natural processes. Preservation of the rail infrastructure or sections of the rail would provide some resilience to maintaining the heritage value of the site.	**Medium**
Religious sites				

Cultural heritage value	Importance	Vulnerability	Resilience	Sensitivity
Bawdwin and Tiger Camp religious sites	**Medium to High** Many of the religious site at Bawdwin and Tiger Camp areas are still in use and further consultation with communities is required to better understand the significance of these sites to them. The religious sites are assessed to have high social and spiritual significance, medium to high aesthetic and historic significance, and low scientific or technological significance and have been given an overall ranking of high importance. The sites are unlikely to be considered critical heritage under IFC Performance Standard 8.	**Low to Medium** Many of the religious sites are located on prominent locations on hillsides and are susceptible to loss of aesthetic value.	**Medium to High** Most sites are likely to retain their heritage value after some degree of change (i.e., replacing components of, or upgrading of, the buildings). If relocated they are likely to lose aesthetic (and potential spiritual) value but would likely retain their social value with appropriate measures put in place.	**Medium**
Village buildings				
Bawdwin village buildings (including Chinese Bazaar buildings)	**Medium** The buildings of key cultural heritage significance include the remaining stone buildings in the Chinese Bazaar area and the remains of ancient Chinese bridges in the Goldhole Valley area. These buildings have medium historical and scientific significance as remaining evidence of the early colonial-period Chinese community at Bawdwin. The Bawdwin village buildings are unlikely to be considered critical heritage under IFC Performance Standard 8.	**Medium** The Bawdwin village buildings are vulnerable to loss of aesthetic value from landscape changes in proximity to these sites and vulnerable to direct disturbance as they are in a fixed location close to existing mining operations. While wooden and metal buildings and structures have been, and will continue to be, exposed to weathering and degradation this does not materially influence the vulnerability of their heritage value over the project timescale.	**Medium** The area would be able to withstand some localised changes in terms of additional buildings and changes to the landscape without materially affecting the aesthetic, historic and social appeal of the area as a whole.	**Medium**
Tiger Camp buildings	**Medium** The buildings include the stone stores at Tiger Camp which have medium historical significance as they are an example of the development of permanent community resources in early Bawdwin.	**Medium** The sites are vulnerable to some loss of aesthetic value from landscape changes or if other buildings are constructed in proximity to these sites. They are also vulnerable to direct disturbance as they are in a fixed location.	**Medium** The precinct would likely still retain most or all of its heritage value after change, provided the key characteristics (i.e., key buildings and any important contents) were not lost or materially altered. As this feature is	**Medium**

Cultural heritage value	Importance	Vulnerability	Resilience	Sensitivity
	The buildings are unlikely to be considered critical heritage under IFC Performance Standard 8.	While wooden and metal buildings and structures have been, and will continue to be, exposed to weathering and degradation (i.e., corrosion, rotting, erosion of adjacent ground, etc.), ongoing natural degradation of these is not expected to materially influence the vulnerability of their heritage value over the project timescale.	a collection on buildings, it does provide some resilience to localised changes.	

5.8.6 Summary

The cultural heritage of the study area can be summarised as follows:

- The Bawdwin region has a rich mining history extending over six centuries. The cultural heritage and associated values are complex and widespread around the Bawdwin area.
- Existing tangible cultural heritage features include Chinese heritage features, graveyards, colonial-period mining and infrastructure heritage features, religious sites, Bawdwin and Tiger Camp village buildings, modern defences. Additionally, there are areas of high chances of accidental discovery of additional cultural heritage features, such as graveyards and evidence of Chinese occupation.
- The features of high cultural heritage importance include:
  - Chinese hillforts and defended ridges, as these are unique features, unlike any found elsewhere in Myanmar.
    - Artefacts and evidence of Chinese occupation in Nam Pangyun valley including the remains of the Chinese bridge, these features allow for an understanding of the Chinese occupation and the historic operation of the mine and hillfort system, and have high historic, scientific (archaeological) and technological importance.
    - Mining and smelting evidence from the Chinese era, these sites have high potential archaeological and technological research value, particularly as little is known about the early minerals exchange network throughout southeast Asia and the mining methods at the centre of it. Such features provide important archaeological and technological evidence of early mining activity and also aid in the overall interpretation of the Chinese occupation at Bawdwin.
  - Marmion shaft and winding house, as these have high aesthetic, historic, scientific (archaeological) and technological importance and are likely to have high social importance and symbolism to communities in the Bawdwin concession area.
  - Mining infrastructure in the Tiger Camp precinct, which as high historic and technological importance.
    - Central Bawdwin precinct which has been a key area of social importance throughout Bawdwin’s history, and has high historic, scientific (archaeological), technological and social importance.
    - All graveyards have been considered to have social and spiritual value. The modern graveyards are likely to have high social and spiritual value to existing communities. The older graveyards are likely to have less social value but higher bioarchaeological and historical value.
  - Namtu to Bawdwin railway, as it has high aesthetic, historic, scientific (archaeological) and technological importance and it is expected that the site has potential commercial/tourism value and international value.

5.8.7 Uncertainties and limitations

The key uncertainties and limitations of this section are:

- The cultural heritage field survey relied on opportunistic consultation with local people during the field survey. As a result, the significance and sensitivities of cultural heritage values do not yet factor in the specific views of the local community or the broader scientific community. The assessment of significance and importance is based on the professional judgement of the archaeologist, Dr Peter Petchey.

- The field survey was limited to surface observations only from a single site visit. It is highly likely that further information on cultural heritage features at the study area would be found by conducting detailed archaeological excavation surveys combined with consultation with local communities.
- There is high uncertainty in the location of many subsurface heritage features and artefacts, which cannot be confirmed until excavation works are conducted. In such cases, the locations of subsurface features can only be interpreted from observations of landform, surface expressions or features, and knowledge of past activities and events.
- In many cases, the exact age of the cultural heritage feature cannot be confirmed but only interpreted from available evidence. In such cases, best estimates are made of the associated time periods and may be in some cases incorrect.

5.9 Socio-economic environment

5.9.1 Context

The project is located within the Shan Plateau in northern Shan State, Myanmar, approximately 170 km northeast of Mandalay and 160 km west of the Chinese border.

Northern Shan State has six districts. The districts are split into townships, with each township consisting of several village tracts, which in turn are made of villages. Typically, villages are also differentiated into separate wards. Groups of adjacent villages are known as village-tracts.

The project is located in Namtu township in Kyaukme District. The neighbouring townships of Manton and Namsan townships to the northwest and southwest respectively are known as the Pa Laung Self-Administered Zone (SAZ).

Namtu township comprises 24 village tracts including Bawdwin (also known as Baw Twin) and Namtu Town. The administrative basis of Bawdwin and Namtu are outlined in Table 5.74 and shown in Figure 5.52. The Bawdwin village tract borders the following village tracts based on data from the Myanmar Information Management Unit (MIMU, 2020a):

- The Hu Hsar village tract to the west (population 914)
- The Hin Poke village tract to the north-west (population 1,086)
- The Kyu Hsawt village tract to the north-east (population 926)
- Namtu Town to the east (population 13,300) and
- The Hko Mo village tract to the south-east (population 940).

Table 5.74 Administrative basis of Bawdwin Village Tract and Namtu Urban Village Tract

Entity	Namtu Town	Bawdwin Village
State	Shan (North) State	
District	Kyaukme District	
Township	Namtu township	
Village Tracts	Namtu Urban Village Tract	Bawdwin Village Tract

The Bawdwin village tract consists of Bawdwin upper and lower villages and Tiger Camp. It comprises the following wards:

- Wards to the north of the existing mine pit: Aung Chan Thar Ward, Thiri Mingalar Ward and Yadanar Myay Ward.
- Wards to the south of the existing mine pit: Pyi Taw Aye Ward, Aung Tha Pyay Ward, Mingalar Kwe Ward and Aung Theikdhi Ward.
- Wards to the east of the existing mine pit: Tiger Camp 1 and Tiger Camp 2.

Namtu Town contains the Pang Hai Ward and the Tha Ta La Wards, which means 'mining enterprise'. Tha Ta La Ward is made-up of seven wards, termed wards one to seven (within this EIA). Tha Ta La Ward was originally established to accommodate Bawdwin mine workers and government officers involved in the mine operations.

The substantial population in Namtu Town, including business and service infrastructure, has a major influence on the dynamics of social and business relationships across the region.

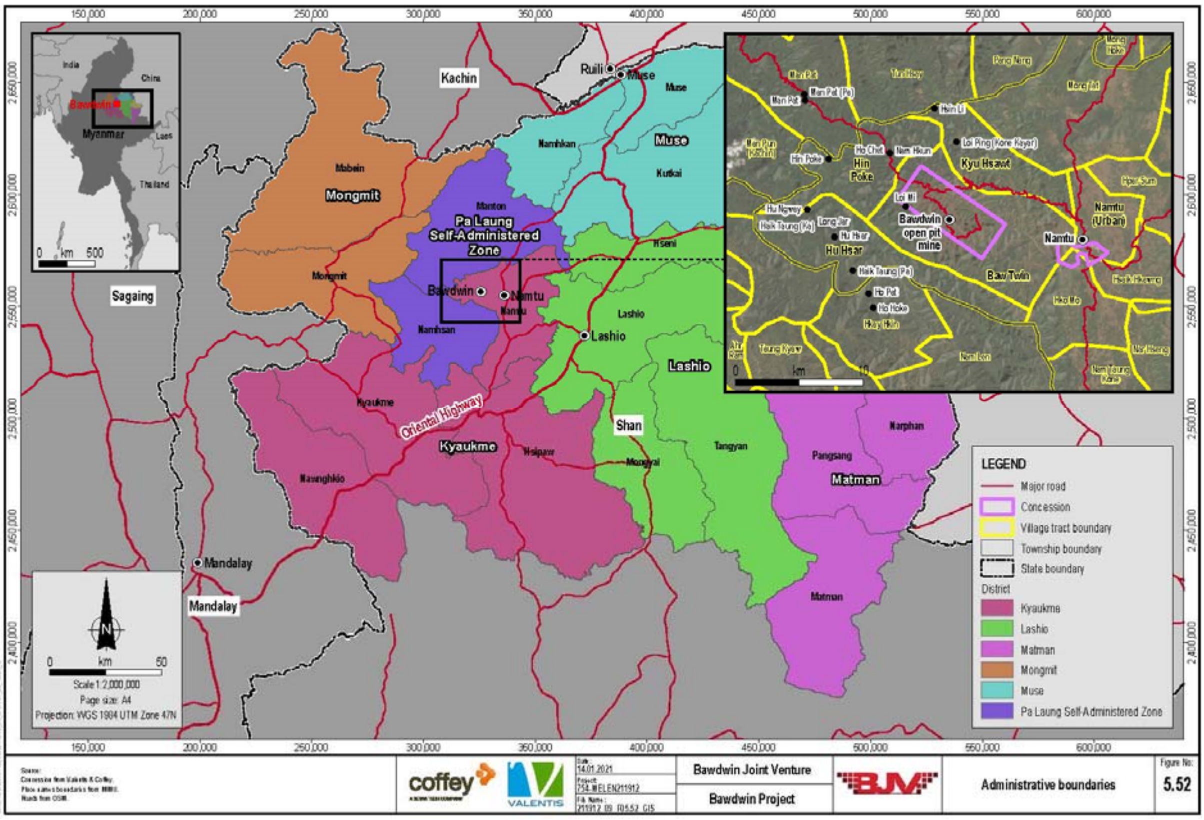

Figure 5.52 Administrative boundaries

Surrounding the Bawdwin concession area, there are several dozen villages lying within the Hu Hsar, Hin Poke, Kyu Hsawt, Man Pun, Man Pat 2, Hko Mo, Tun Hsay and Hkay Hkin village tracts, which have a combined population of approximately 9,000 people (excluding the Bawdwin village tract). Many of these villages interact with Bawdwin and Namtu to varying degrees, for example to access schools and for religious purposes.

The Bawdwin upper and lower villages are primarily accessed by a gravel road running along the Nam Pangyun valley south from the Namtu – Manton Road. The villages largely consist of weatherboard houses with corrugated iron roofs situated on terraces along the hillside.

Bawdwin upper village contains the main Pagoda and Monastery, a number of small shops attached to houses, and a primary and post-primary school. It is located in a narrow part of the valley, so only contains one or two terraces of houses.

Bawdwin lower village is more spread-out and located in a more open area of the valley with three or four terraces of housing. It contains a second Pagoda and Monastery, Mosque, Baptist Church and Nepalese temple. It has the original Bawdwin railway station, post office, a post-primary school and a secondary school, central market, free standing shops, medical clinic, cinema, village hall, playgrounds and carpenter’s workshop.

Within the Bawdwin village areas there are a number of areas of small cropping fields where village residents grow vegetables for local consumption. There is also extensive infrastructure used for the former mining operations, which includes the open pit to the northeast of Bawdwin lower village, the Marmion Shaft headframe and winding house, floatation and concentrator plant, mine offices, workshops, power station, railway lines and yards and rail loading facility.

Tiger Camp contains historical mineral handling infrastructure and a small collection of settlements situated around the confluence of the Nam Pangyun and Wallah streams. Infrastructure in the Tiger Camp area was a critical part of the mine’s operation during the colonial period and includes the ore tippler, ore bins, railyards, the Tiger Tunnel portal, electric substation, office, clubhouse, stone store and police station. Most of these infrastructure items are still in service or functioning to some degree. The railway line from Namtu to Bawdwin has a station at Tiger Camp.

Tiger Camp is the collective name applied to two residential areas. Tiger Camp village proper is situated in the Nam Pangyun valley and at the confluence of the two streams, while the Wallah Gorge village sits in the valley of the Wallah stream. It contains small shops, two Pagodas, one primary and one middle school and a Christian church. Tiger Camp has no roads suitable for cars; access is by motorbike or walking, either from the Bawdwin Villages via the football field, or from Namtu via the railway line. In addition, WMM normally operates a weekly rail service between Tiger Camp and Namtu, which residents of both Bawdwin and Tiger Camp use to shop in Namtu. Additional journeys are arranged as required.

The Nam Pangyun valley hosts the railway corridor and is a relatively narrow valley at Tiger Camp before broadening into a wider valley at lower elevations towards the junction with the Myitnge River (known locally as the Namtu River). The narrow gauge railway runs from the Bawdwin Mine offices to the Tiger Camp rail loading facilities, via the lower village and Wallah Gorge. From the loading facilities the line runs down the Nam Pangyun valley to the Namtu Railway Station, which is located on the edge of the Myitnge River, on the south-eastern side of Namtu township.

The valley between Tiger Camp and the Myitnge River junction is home to a artisanal miners who fossick for the lead-zinc slag which was discarded during the historical smelting in the Chinese period of occupation and has washed into the Nam Pangyun. The numbers of miners present in the valley varies substantially both with seasons and also based on the regional security climate (there is generally more miners present in the dry season)) and can range from a few hundred to a few thousand. Most accommodate themselves in self-constructed timber, temporary bamboo and tarpaulin shelters. There are also a number of permanent houses on slightly higher ground along the riverbanks where inhabitants have small agricultural plots.

Namtu township is centred on the Myitnge River, which bisects the town. Namtu is a large regional town and hub for several dozen surrounding villages and farm tracts, providing commercial supplies, fuel, schooling, banking, local employment and medical services. Namtu was originally established as the base for the Bawdwin smelter and 32 Mile concentrator and tailings facilities. As such, the town does not have a large commercial sector, and most of the industrial sector supports the WMM operations. The main industrial operation in the town not associated with WMM is a zinc fuming plant operated by a Chinese company. Namtu has a network of sealed and unsealed roads in reasonable condition.

Beyond Namtu township along the road to Lashio there are two villages of roughly 3,000 people (Man Sam and Ei Naing), and numerous smaller villages. The two large villages are located on the main road and have medical clinics and limited shops. The road between Namtu and Lashio varies between low to moderate elevation ranges and low-lying areas. The lower elevation lands are farmed with relatively broad-acre plantation crops such as corn and bananas, with some rubber plantations. Rice fields occupy higher level locations which are closer to water sources. The predominant limestone of the Shan Plateau underlies much of the landscape between Namtu and Lashio, and is quarried for cement production.

The following sections describe the existing socio-economic components in relation to the project including social, economic, health as well as land use and infrastructure.

5.9.2 Study area and method

This section describes the existing socio-economic and health environment in relation to the Bawdwin project.

The information in this section draws from the Bawdwin Project Socio-economic Baseline conducted by Coffey-Valentis (2019) (Appendix E). That study characterised socio-economic conditions focussing on the Bawdwin and Namtu communities and surrounding areas. The socio-economic baseline study involved a review of available data, field survey and community consultation. Additional surveys of farms and villages surrounding Bawdwin were undertaken by BJV.

The information in this section also draws from the health baseline report conducted by Coffey-Valentis (2019) (Appendix G), a baseline investigation of blood lead levels in existing workforce by BJV on behalf of WMM, and an initial desktop study completed by Vantage Health. Vantage Health is a specialised Myanmar-based consultancy comprised of healthcare professionals with diverse expertise in public health, health policy, health administration , and evaluation. This study assessed the existing health conditions of residents of Bawdwin and select Namtu villages, including aspects related to mortality and morbidity, occurrence of diseases, nutrition, accidents and injuries, and other social health determinants. The study also investigated current human exposures to contaminants (such as lead and zinc) that may be present in the environment from previous operations and/or with the potential to be released from project activities. The health baseline study focusses on the people that may be affected rather than a defined/physical area. The health study areas group people and communities living in similar geographic regions who may experience comparable project impacts.

Descriptions of road and traffic conditions in the Bawdwin area and along the main proposed export route between Namtu and Lashio are drawn from the road and traffic characterisation study by Valentis (2020) (Appendix F).

Study areas

Study areas for social, economic and health aspects were defined in order to group communities living in similar geographic locations and with the potential to be impacted by the project by varying degrees. The main study areas are the Bawdwin study area and the Namtu study area. Two additional socio-economic study areas encompass communities outside Bawdwin which may be affected by project activities.

- **Bawdwin study area** (Figure 5.53): is located within the Bawdwin mining concession area and is approximately 27 km from Namtu Town. The study area comprises eight wards along the Nam Pangyun that surround the existing mine and make up what is known as upper and lower Bawdwin villages. These wards are Aung Chan Thar, Yan Naing Kwe, Thiri Mingalar, Yadanar Myay, Pyi Taw Aye, Aung Tha Pyay, Mingalar Kwe and Aung Theikdhi. This study area also includes two wards located at Tiger Camp; Tiger Camp 1 and Tiger Camp 2 wards. Plate 5.87 and Plate 5.88 show a portion of Bawdwin and Tiger Camp villages.

- **Namtu study area** (Figure 5.54): comprises seven wards (Tha Ta La Wards 1-7) and the Hseik Khaung Village Tract, Har Lin Village as part of the Tha Ta La area of Namtu Town, within the Namtu concession area. Tha Ta La can be translated to ‘mining enterprise’, as these wards were originally established to accommodate Bawdwin mine workers and government officers. The eight wards within the Namtu study area were selected for the study due to their strong associations with the mine in the past. Pang Hai ward, which is located north of the Myitnge River, was not included in the Namtu socio-economic study area due to access constraints, however, was included in the Namtu health study area.

- **Regional study area:** includes villages in eight village tracts outside the Bawdwin concession (Table 5.77) that have the potential to be affected by the project. This study area also includes the area between Tiger Camp and Namtu along the Nam Pangyun valley which is inhabited by artisanal miners and several other landholders. These villages are shown on Figure 5.55. Plate 5.89 shows a typical community of artisanal miners in the Nam Pangyun valley. Along roads to the south, west, and north of Bawdwin which are not part of the export corridor there are four nearby village tracts in Namtu township, three village tracts in Manton township, and one village tract in Namhsan Township. There are several villages within these village tracts that are close to the Bawdwin concession (Figure 5.55).
- **Shan State regional study area**: comprises regional communities between Namtu and Lashio in proximity to the proposed export and logistics corridor that have the potential to be affected by the project (Figure 5.56). Other roads from Bawdwin extend north to Manton, south to Hko Mo and west to Hu Hsar. On the export route from Namtu to Lashio there are seven village tracts in Namtu township, and three village tracts in Lashio township (Figure 5.56).

Socio-economic and health statistics regarding the Bawdwin and Namtu study areas have been compared to Shan State and Myanmar statistics where possible to provide regional and national context.

Study methods

Socio-economic baseline study

The socio-economic baseline study comprised both desktop review of available data and field surveys and was conducted between November 2018 and March 2019. The socio-economic baseline study was informed from primary data obtained through household surveys, focus group interviews and primary sources, as well as secondary data such as relevant analytical reports and articles, where available.

Field surveys were conducted between 21 February 2019 and 1 March 2019 by a survey team comprising six Myanmar nationals with tertiary education and prior survey experience. The team was led by a stakeholder engagement specialist, Ms Thet Htar Myint, who provided training to the interviewers on the research methodology and the survey material. Once the surveys were completed, the survey leader reviewed each survey sheet with the appropriate interviewer as part of the data verification process. Plate 5.90 and Plate 5.91 show socio-economic surveys being undertaken.

Between 20 February and 25 February 2019, approximately 27% of the population (837 people) within the Bawdwin study area was interviewed, representing 36% of the households (192 households). Between 25 February and 1 March 2019, one representative from 172 households within the Namtu study area (17% of the households) was interviewed, representing the 725 people that live in these 172 households (13% of the population in the study area). Together, approximately 20% of the total population was interviewed, representing 27% of the households across the two study areas.

Plate 5.87 Bawdwin village

Plate 5.88 Tiger Camp

Plate 5.89 Artisanal miners in the Nam Pangyun valley

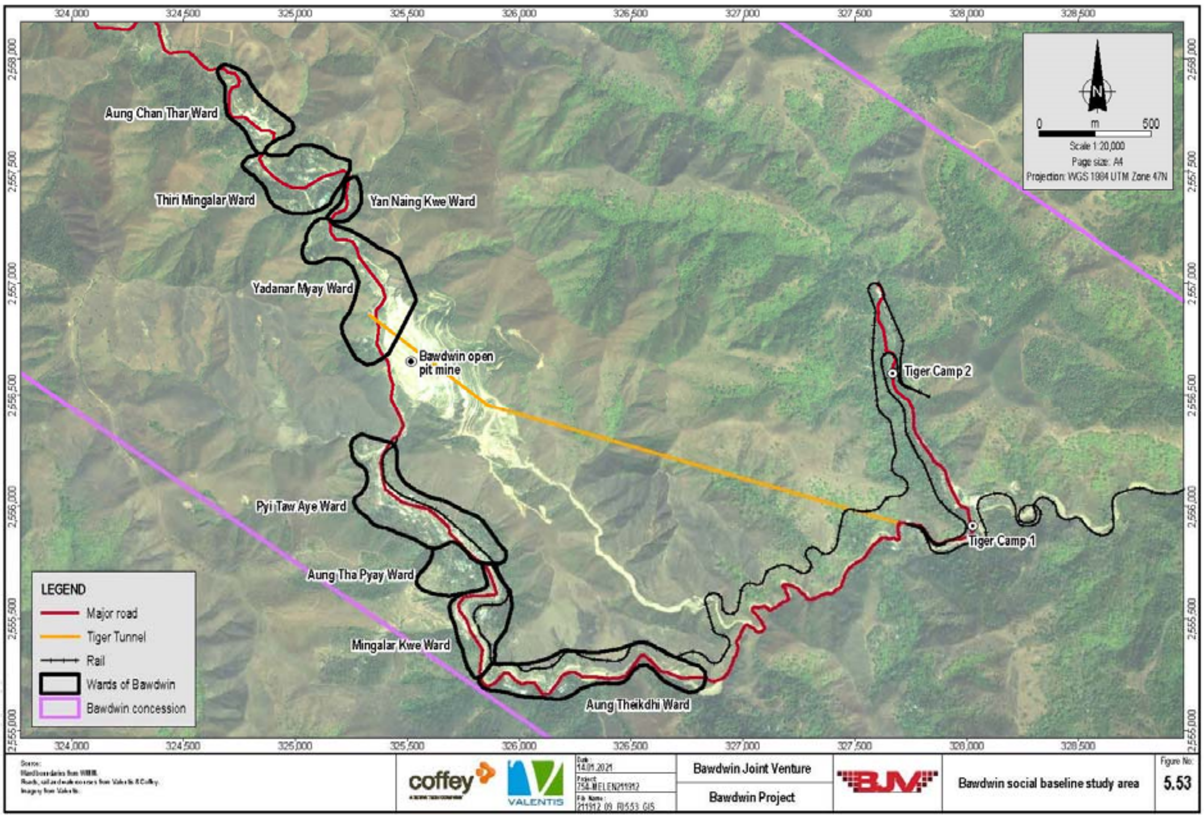

Figure 5.53 Bawdwin social baseline study area

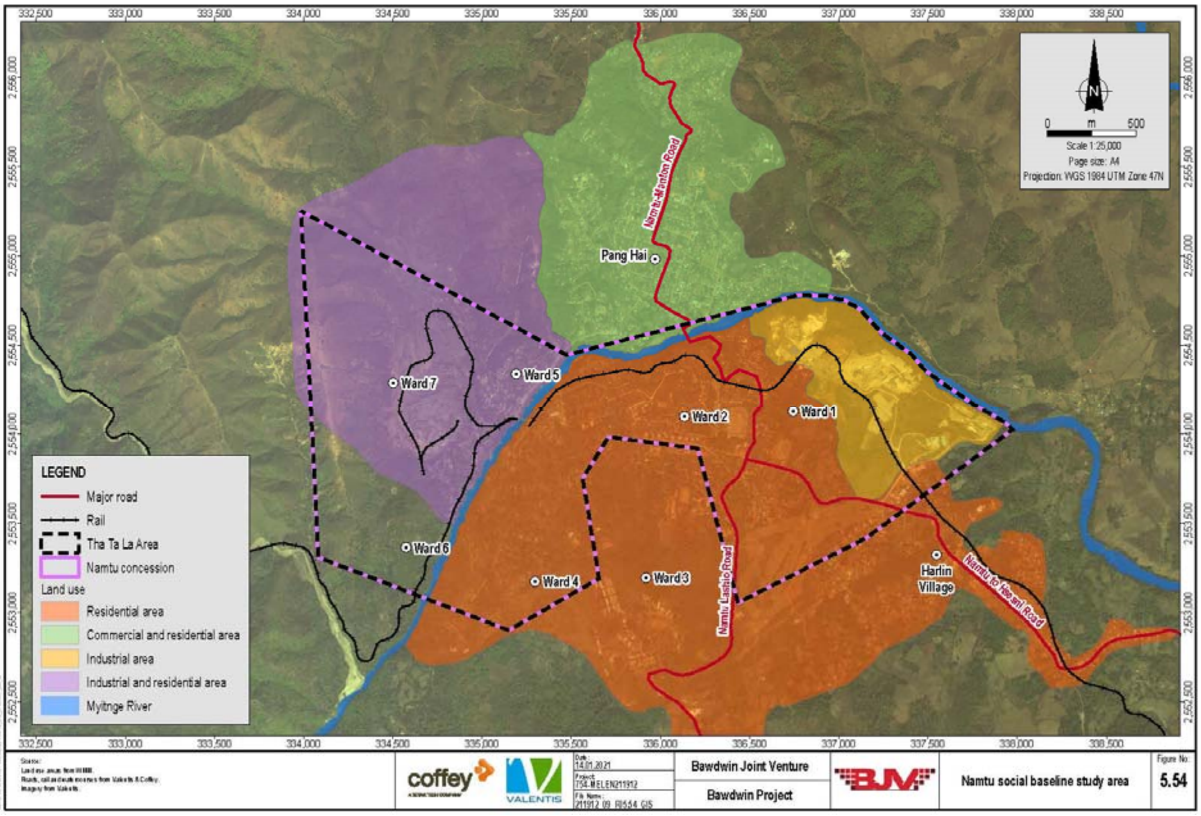

Figure 5.54 Namtu social baseline study area

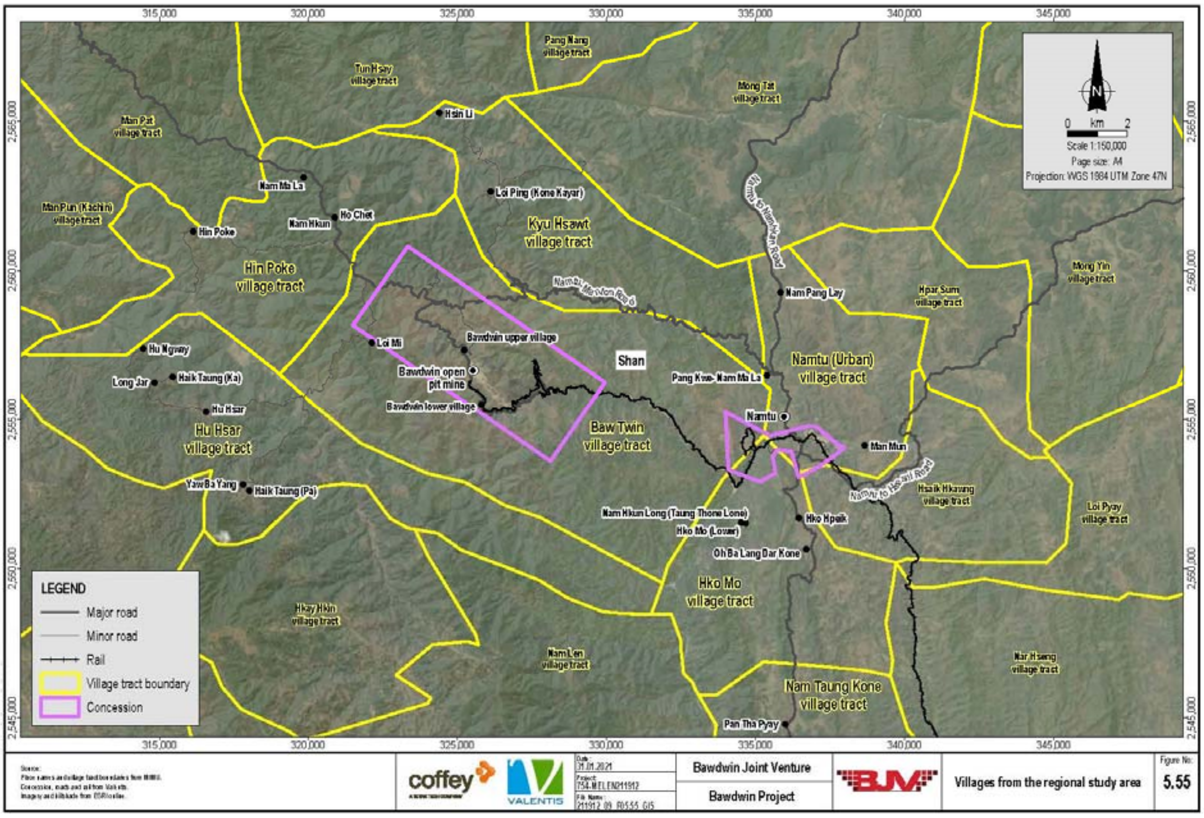

Figure 5.55 Villages from the regional study area

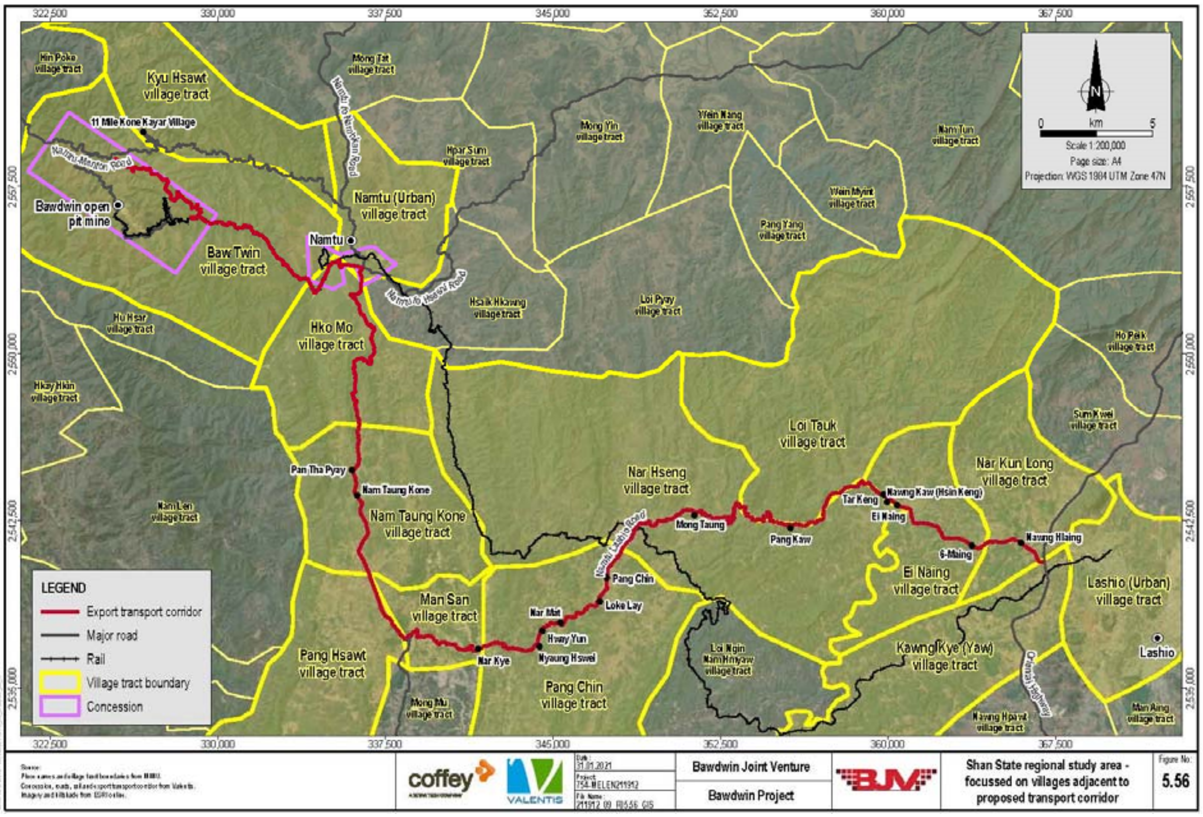

Figure 5.56 **Shan State regional study area - focussed on villages adjacent to proposed transport corridor**

Methods used for the socio-economic baseline study are summarised in Table 5.75.

Table 5.75 Socio-economic characterisation study methods

Method	Description
Primary data sources	Primary sources included the statistical and economic reports from relevant Government administrative offices, available historical economic surveys, and national statistics and censuses prepared by governmental offices or international organisations. The Bawdwin General Administration Department (GAD) 2018 and 2019 reports provide demographic data for 2017 and 2018, respectively. The Namtu General Administration Department (GAD) 2018 report provides demographic data for 2017.
Household surveys	Household level surveys were conducted using questionnaires in Myanmar language. They collected data on age and gender of household members, education levels, religious practices, employment, household income and expenditure, water and sanitation matters, infrastructure (physical and social), health matters, and land ownership and use. Households are defined as groups of people living together and sharing resources. Absent individuals (for example, children attending boarding school) were included as household members if they relied on household support but were not included if residing elsewhere or financially independent. The distribution of household surveys conducted in the Bawdwin and Namtu study areas are presented in Figure 5.57 and Figure 5.58 respectively.
Focus group interviews	Focus group interviews were conducted in all 18 wards of the study areas. Ward administrators, household leaders (those who represent 10 households and those of higher rank who represent 100 households who are elected by the lower rank household leaders), village elders, key informants and other community members were among those interviewed from each ward. All survey respondents were able to communicate in Myanmar language. A total of 232 people were interviewed in the Bawdwin study area between 21 February and 25 February 2019, and 213 people were interviewed in the Namtu study area between 27 February and 1 March 2019. Another questionnaire was distributed at the focus group interviews which collected the following information for each ward: list of participants; social profile; vulnerable groups in the community; ethnic minority groups; religion; gender roles; community organisation; employment and wages; land holding and land use; livestock; access to health services; and community infrastructure facilities (e.g., school, health care centre, water use and water supply, road transportation, power supply, visual components). A series of focus group interviews were conducted with village leaders of surrounding villages in proximity to the Bawdwin concession area. This included interviews from Hin Poke, and Hu Hsar village tract.

Health baseline study

The health baseline assessment included both primary (field) and secondary (desktop research) data collection. Relevant data from the other EIA studies was also considered as part of the health baseline. `

Prior to the commencement of the field survey, the study team sought approval from the Ethics Review Committee who are associated with the Medical Research Centre under the Ministry of Defence. The study had a moral obligation to ensure research was conducted in such a way that human rights were upheld and that study participants and communities were respected, protected and treated fairly. The qualified field team that conducted the survey included ten medical graduates trained by Jack Dempsey and Karen Teague of Coffey, and a Myanmar supervising medical doctor, Dr. Myo Set Thwe. Written consent was obtained from all study participants.

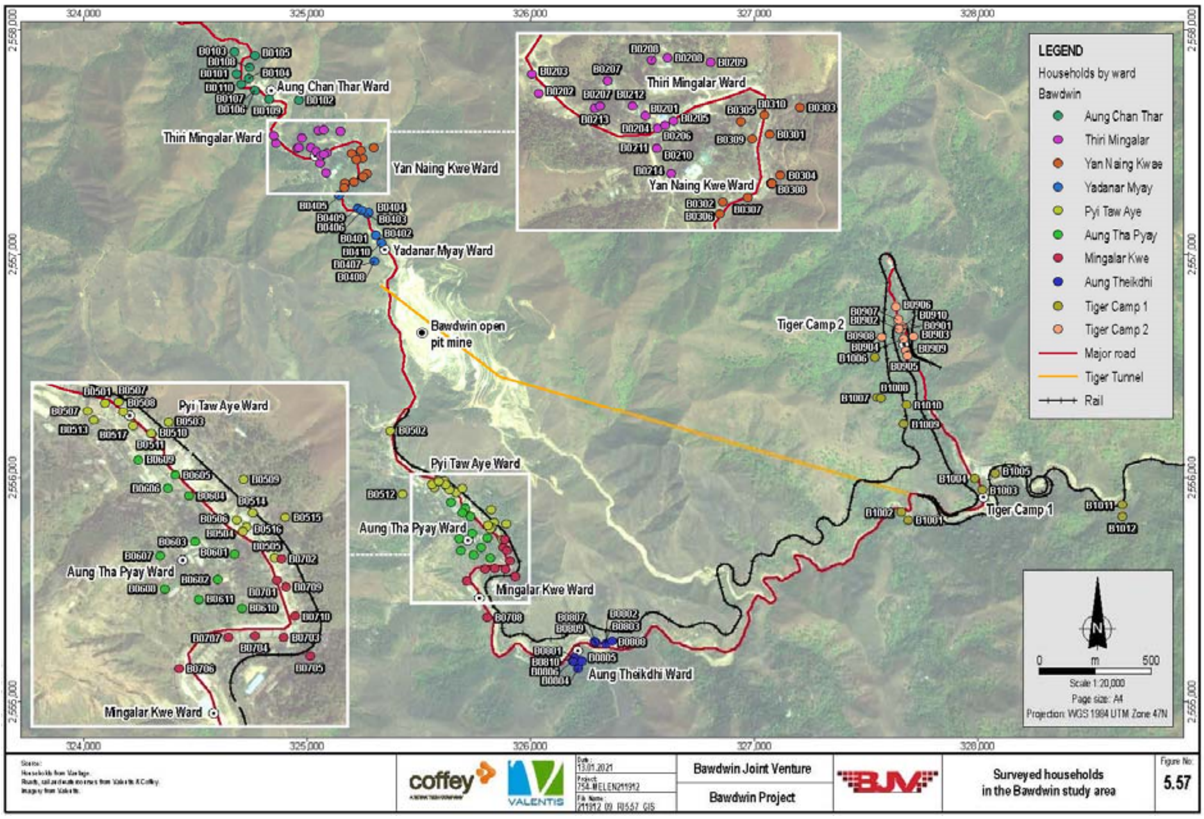

Figure 5.57 Surveyed households in the Bawdwin study area

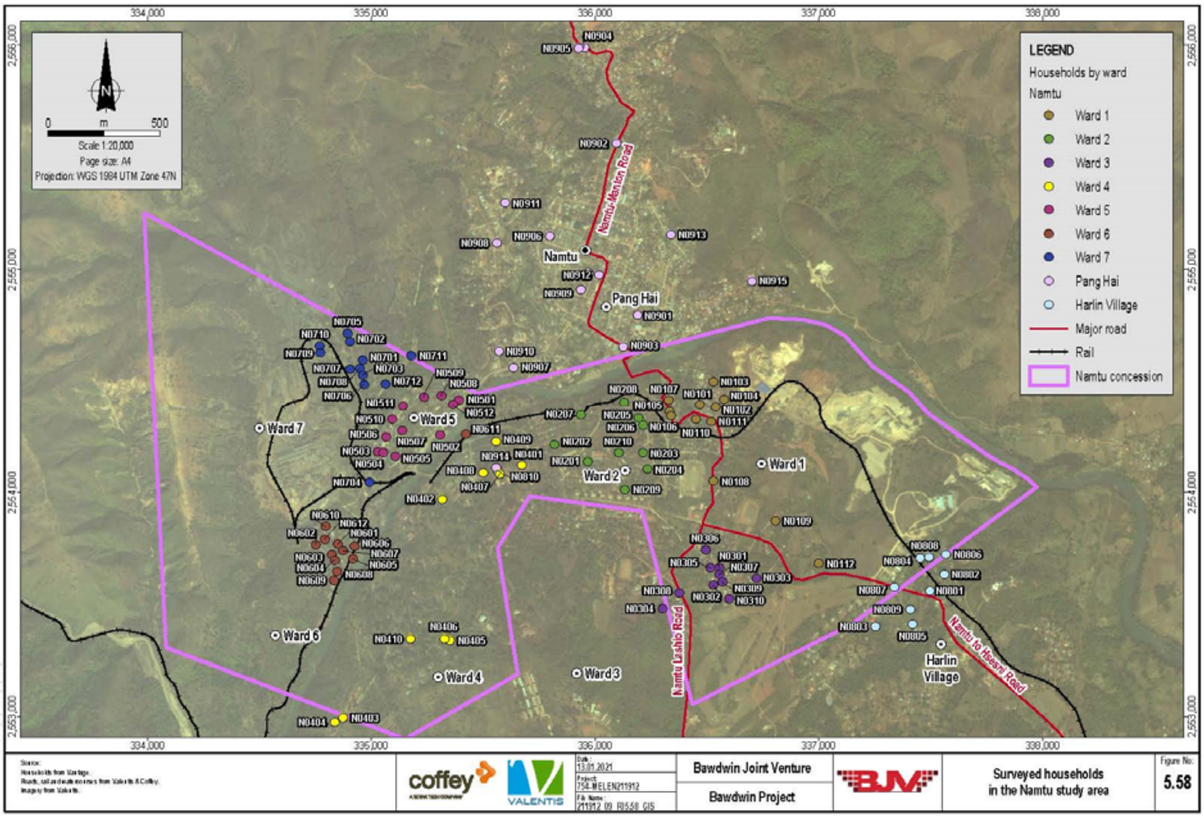

Figure 5.58 Surveyed households in the Namtu study area

A baseline health, diet and nutrition survey was conducted to obtain information related to household demographics, health indicators, nutritional status, environmental health conditions and communities. Non-invasive clinical examinations were also conducted as well as gathering local health data. Drinking water, cooking water, food and household garden soil samples were collected and sent for analysis at the PT Intertek Ultama Services, KAN accredited laboratory in Jakarta, Indonesia.

At least 10 households from each ward within the study areas participated in the survey. A total of 217 households were surveyed across the study areas (114 households surveyed in the Bawdwin study area and 103 households surveyed in the Namtu study area). The locations of the surveyed households in the Bawdwin and Namtu study areas are presented in Figure 5.57 and Figure 5.58. All surveys were administered by native Burmese speakers. Plate 5.92 shows a household health survey being undertaken.

Methods used for the health baseline study are summarised in Table 5.76.

Table 5.76 Health characterisation study methods

Method	Description
Secondary data collection	A desktop health study was conducted by Vantage which included reviewing secondary data such as censuses and organisational records and recording observations during a visit of the Namtu township area. A range of sources provided information on the local population, local health status, disease burden estimates, available health facilities and infrastructure, and the existing health workforce.
Primary data collection	Four questionnaires were used in the surveys, including a household survey questionnaire, medical and clinical examination form, 24-hour dietary recall questionnaire, and seasonal availability of food questionnaire.
Household and medical questionnaires	The focus of the household surveys was on demographic characteristics, environmental health circumstances, household economic details and healthy behaviour and lifestyles. Environmental health parameters that are the main determinants of population health included those related to drinking water supply, sanitation, overcrowding, ventilation and control of vector-borne diseases. The head of household or other responsible adult (when head of household was unavailable) was the target of the questionnaire. The medical and clinical form targeted the individual's perception of their health and any medical treatment in the previous year, focussing on clinic conditions included in the Myanmar Ministry of Health national report (MoH, 2014). Physical examinations were also conducted as part of the household and medical survey which included: taking blood pressure; checking patients' spleen, kidneys and liver; examining eyes, teeth and skin; and conducting anthropometric measurements such as height and weight.
Food consumption and food contamination studies	Food consumption and food contamination studies were undertaken which gathered information on an individuals' food intake through 24-hour dietary recall and seasonal availability of food questionnaires. The study also included measuring current food intake via the duplicate meal method, which involved setting aside duplicate portions of all foods and beverages consumed in a specific time period and sending these 'duplicate meals' to the Queensland Government (Australia), Forensic and Scientific Services Laboratory (NATA Accredited) for analysis of heavy metal content.

Blood lead level baseline investigation

To investigate the levels of lead within the current workforce at Bawdwin, BJV on behalf of WMM undertook an investigation of the blood lead levels in workers at Bawdwin between April and June 2020. This investigation was conducted for occupational health and safety purposes, not for this EIA. However, it has been referenced as it provides valuable baseline information.

Plate 5.90 Socio-economic survey at Yadanar Myay ward

Plate 5.91 Socio-economic survey at Thiri Mingalar ward

Plate 5.92 Health survey

The investigation involved the use of a portable lead analysis instrument (LeadCare II) to measure the concentration of lead in blood from a finger prick, and a survey to collect social and employment demographic information. Qualified medical personnel undertook the calibration of the analyser, sample collection and preparation, and sample analysis. A total of 85 workers from the permanent workforce and 61 recently engaged contract workers were surveyed and tested on one to three occasions. Contract workers were not residents locally and were therefore considered a control group. The permanent workers tested account for 20% of the current Bawdwin workforce.

Road and traffic baseline study

The road and traffic characterisation study by Valentis investigates the existing road and traffic conditions in the Bawdwin-Namtu area and along the main proposed export route to National Highway 3 between Namtu and Lashio. This assessment involved a field survey that monitored traffic at six sites in Bawdwin, five sites in and around Namtu and three sites in Man Sam village. Monitoring times and days varied to ensure temporal variation in traffic was recorded. The road between Bawdwin and Namtu was surveyed in November 2018 to identify and characterise the general features.

In November 2018, a survey was made of the road conditions on the Namtu-Manton public road between the junction with the existing Bawdwin Mine access road and Namtu, to examine the general features of the road for inclusion in a preliminary engineering review. This survey included surveying, measurement and photography of the road and relevant features. It also included identification and measurement of all bridges, floodways, landslides, obstacles, passing bays and waterways.

Surrounding farm and village surveys

Surveys at several farms and at the nearby Hin Poke and Kone Kayar village tracts were undertaken by BJV to obtain socio-economic information and determine the use of Bawdwin facilities and services by these groups, such as schools, medical centres, religious facilities, markets. The villages surveyed within the Hin Poke village tracts were Loi Mi, Hsai Gaung, Kone Kayar, Nam Hkun and Nam La. The villages surveyed within the Hu Hsar village tract were Hu Hsar, Haik Taung (Pa), Yaw Ba Gang, Haik Taung (Ka), Long Jar and Haik Taung.

5.9.3 Public administration

The Region or State Government Law (2010) established the General Administrative Department (GAD) as the administration for all State or Region governments. The Head of the GAD is the Executive Secretary of the Region or State. Below the state and regions, District Administrators and Township Administrators are both GAD Officers. The Township Administrator provides direction to the Village Tract and Ward Administrators. These arrangements ensure that the GAD is central to all efforts to coordinate, communicate among and convene other government actors in subnational governance.

In accordance with the administrative structure, the Namtu township GAD Officer is the focal contact person to coordinate and communicate with Namtu and Bawdwin Administrations, including Tiger Camp. The GAD has various key roles, including population registration, land registration, and many forms of tax collection.

At village level, the Ward or Village Tract Administration Law, first passed in 2012, introduced elections for the appointment of Ward or Village Tract Administrators (W/VTAs). Previously, no elections were held, and GAD township administrators directly appointed W/VTAs. Since the first round of elections in late 2012, the law has been amended twice (in January 2016 and December 2016), altering the election process. Under the current system, representatives from each household elect a Household Leader which represents 10 households, who in turn elect a Household Leader to represent 100 households. If there is only one elected Household Leader representing 100 households, he/she will automatically become the W/VTA. Where there are multiple Household Leaders representing 100-households, household representatives vote again to elect a W/VTA. The process is overseen by a Supervisory Board of five elders, appointed by the Township Administrator.

An overview of the Myanmar administrative structure is presented in Figure 2.4.

5.9.4 Security

Northern Shan State hosts various non-government armed groups. The groups predominately fight for autonomy, resources and territory. The major groups are:

- Ta'ang National Liberation Army (TNLA), established in 1992 and an ally of the Kachin Independence Army (KIA).
- Shan State Army (SSA), which includes Shan State Army-South (SSA-S) and Shan State Army-North (SSA-N).
- Restoration Council of Shan State (RCSS).
- Myanmar National Democratic Alliance Army (MNDAA).
- United Wa State Army (UWSA).

To curb tensions, the Union Government of Myanmar designated certain areas of Shan State as Self-Administered Zones. A law relating to the administration of these zones was issued in October 2010. A Self-Administered Zone is a form of public administration in Myanmar, which is run by a 'Leading Body' consisting of at least ten members made up of State or Regional Parliamentary (Hluttaw) members elected from the SAZ and other members nominated by the relevant ethnic group (refer Article 283 of the Constitution of the Republic of the Union of Myanmar (2008)). The Leading Body has both executive and legislative powers. They are a part of Myanmar government, but are self-administered.

As part of the peace process, a Nationwide Ceasefire Agreement (NCA) was initiated by former President of the Republic of the Union of Myanmar, U Thein Sein, on 31 March 2015 and 15 Ethnic Armed Organizations were invited to take part. This agreement allows ethnic insurgent groups to participate in the peace negotiation process.

The SSA-S signed the NCA; however, SSA-N declined to enter the agreement. The other groups in Shan state, UWSA and KIA are still in discussion with the Union Government and are not yet signatories to the agreement. The KIA formed and led the Northern Alliance (Burma), which includes the Arakan Army, MNDAA and Shan State Army. At the time the Myanmar Government were in active conflict with TNLA, the MNDAA and the Northern Alliance (Burma) were not invited to join the NCA. Despite the NCA, the groups continue to instigate skirmishes between each other and Myanmar Government forces. In December 2017, the SSA and TNLA clashed in Namtu Township (Mine Yin Village Tract) and since that time there have been several other clashes in the local region

The current Union Government places peace and order as a high priority for the country and continues to hold talks with these groups. There were 12 peace talks with various groups in 2017. The Union Government has formed the Federal Political Negotiations and Consultative Committee (FPNCC) to progress the peace discussions.

While some of these groups form alliances (under the umbrella Northern Alliance organisation or in the form of bilateral relationships), the links between the organisations are not clearly defined. For example, clashes over land control between TNLA and RCSS (aided by their armed wing, SSA-S) reportedly took place in August, 2018 (The Irrawaddy, 2018). In turn, RCSS and SSPP have been involved in land disputes for a prolonged period of time, however in March 2019 RCSS/SSA-S proposed a ceasefire with SSPP/SSA-N (but did not involve TNLA in negotiations) (The Irrawaddy, 2019a, 2019b). Given the recent nature of these developments and yet incomplete process of signing the truce, the security dynamics are a significant influence over the area. According to media and other formal news agencies, the key trigger of tensions is uncertainty about land ownership.

Members of both the TNLA and the SSA live in the villages surrounding Bawdwin. Infantry Battalion No. 66 of the Myanmar Government military is also deployed near Bawdwin and Namtu, with a post at the Military Base within the Bawdwin concession.

5.9.5 Social profile

Myanmar is one of the world's most culturally diverse countries, with over a hundred ethnicities, a rich history and a wealth of cultural and religious traditions. Myanmar is divided into 21 subdivisions: seven States (Chin, Kachin, Kayah, Kayin, Mon, Rakhine and Shan), seven Regions (Ayeyarwady, Bago, Magway, Mandalay, Sagaing, Tanintharyi and Yangon), five self-administered zones (SAZ), one self-administered division and one Union territory (Naypitaw is located here). The States are mostly upland, mountainous areas, largely populated by ethnic communities besides the Bamar majority. The Regions are located mainly in the valleys with a largely Bamar population. The landscape of Myanmar is diverse and defines the agricultural and mineral resources potential and largely determines other socio-economic parameters in the study area.

Shan State is the largest state of the administrative divisions in Myanmar, covering 155,801.38 square kilometres (DOP, 2015b), almost a quarter of the country's total area. It is bordered by Kachin State in the north, the People's Republic of China in the north and east, the Lao People's Democratic Republic in the east, Thailand and Kayah and Kayin States in the south and Mandalay and Sagaing Divisions in the west.

Shan State consists of 54 townships and 193 wards and village-tracts. Four of the five SAZs in Myanmar (Pa'O SAZ, Danu SAZ, Pa Laung SAZ and Kokang SAZ) as well as the Wa Self-Administered Division are located in Shan State. Shan State's population is approximately 5.824 million people with a population density of approximately 34.4. persons per square kilometre, one of the lowest state densities in Myanmar. Population is less dense in hilly regions where there are fewer employment opportunities and where transport and communications are constrained.

Generally speaking, people of Shan origin reside in valleys throughout the state while Danu, Taungyoe, Inn-than (Inn-hsa) and Bamar peoples predominantly live in the west of Shan State. Pa Laung (alternatively known as Ta-aung) people live in the northern part of the state, Pa-O ethnic group reside in the south of the state, Kachin and Lisu (Lishaw) in the north, Kokang in Kokang region, Wa (Lwela) in Hopang Township on the east of Thanlwin River and Eikaw (Arkha) and Lahu in the Kengtung region.

Most of the residents of Shan State identify as Buddhists, but Islam, Christianity and Hinduism are also practised. Myanmar is the predominant language used in the region, but multiple ethnicities also speak different languages.

National Highway 3 runs approximately 450 km from Mandalay to Muse town on the border with China (approximately 250 km away from the Project Area by road)[2], where several border trade gates are situated. The border-crossing is used for exports of raw materials from Myanmar to China and imports of finished goods (e.g., electronics and processed food). National Highway 3 crosses the Kyaukme, Lashio and Muse Districts of Northern Shan State, passing close to Kyaukme, Hsipaw and Lashio.

Demography

Demographic data were collected from the Bawdwin Administration Office and the Namtu Administration Office records, last updated in 2018, as well as from field studies. The Bawdwin study area field survey was undertaken between 15 and 21 February 2019 and the Namtu study area field survey was conducted between 27 February and 1 March 2019. Households from the Hin Poke, Hu Hsar and Loi Mi village tracts were interviewed in 2020.

Demographic and education data for the broader communities that may be affected by mining activities were collected by using public available demographic data from the 2014 Myanmar census (DOP, 2015a; DOP, 2015b; DOP, 2016a; DOP, 2016b).

Communities

The population of Myanmar in 2019 was approximately 53 million people (World Bank, 2019). Close to 70 percent of the population lives in rural areas.

Population data for the Bawdwin study area was obtained from the Bawdwin GAD reports (BGAD, 2018; BGAD, 2019). The Bawdwin 2019 GAD statistics (containing 2018 data) for the wards within the Bawdwin show a total population of 3,499 across 8 wards and Tiger Camp (Figure 5.59), comprised of 810 families in 534 households. There is a record of an increase in population but decrease in families between 2017 and 2018, likely a result of an increase in dependents in existing families rather than the start of new families, or inconsistencies in reporting.

[2]Google Earth imagery, 2019

Outside the main Bawdwin villages there are several farming hamlets, including Tiger Camp farms located above Tiger Camp and Wallah Gorge near the plant access road, farms associated with lower Bawdwin village, including a hamlet associated with Aung Theikdhi Di Ward, Loi Mi farms located west of Bawdwin associated with Loi Mi Village, and Nam La farms located near Manton Road in the northeast corner of the Bawdwin concession. Additional isolated farming households may be present within the concession. Surveys were undertaken at some of the farms, with the household and population breakdown of these groups outlined in Table 5.77. Farms on Chin Hill which were surveyed were largely associated with Tiger Camp and are included in the Tiger Camp survey results. The lower Bawdwin village farms surveyed were primarily those associated Aung Theikdhi Di Ward, with one additional farm outside the concession also surveyed.

Table 5.77 Households and residents of farming hamlets in and surrounding Bawdwin

	Households	Permanently inhabited households	Number of residents
Loi Mi farms	10	10	50
Tiger Camp farms +Chin Hill	14 +4	11 +4	51 +14
Bawdwin lower farms	6	3	14
Nam La farms	7	4	18

Namtu Town comprises the Tha Ta La and Pang Hai wards, with a total population of around 13,500. The seven Tha Ta La wards were established to accommodate people involved in mining operations. The Namtu GAD 2018 statistics (containing 2017 data) for the Tha Ta La wards show a total population of 5,699 across 7 wards and Har Lin village (Figure 5.59) made up of 1,439 families in 988 households (NGAD, 2018). The population information for Har Lin village came from the Har Lin village head. Pang Hai ward is located north of the Namtu concession area, with the main ethnic groups being Shan, Kachin and Pa Laung, along with other migrants. According to the 2014 census, Pang Hai had a population of 7,634 (DOP, 2015c)

There are eight village tracts in proximity to the Bawdwin concession area surrounding the Baw Twin village tract, with a total population of 8,913. The breakdown of this population by village tract is provided in Table 5.78. Within the eight village tracts, there are approximately 23 villages of interest in the Hu Hsar, Hin Poke, Hko Mo, Man Pun, Man Pat 2 and Hkay Hkin Village Tracts. These villages are those closest to the Bawdwin concession.

Table 5.78 Population of village tracts in the regional study area

Village Tract	Villages near Bawdwin[3]	Village tract population[1]
Namtu township		
Hu Hsar The Hu Hsar village tract is approximately 9 km to the west and southwest of the Bawdwin concession area. It comprises six villages in vicinity of the Bawdwin concession (villages of interest), each with a population of between one and two hundred persons, with the main ethnic groups being Kachin and Pa Laung. All villages, except for Yaw Ba Gang, are accessible to Namtu by road, and none have connection to grid electricity or a major market.	Hu Ngway Long Jar Haik Taung (Ka) Hu Husar Haik Taung (Pa) Yaw Ba Gang	914
Hin Poke The Hin Poke village tract is between 5 to 10 km to the west and northwest of the Bawdwin Mine. It comprises six villages in vicinity of the Bawdwin concession (villages of interest), with one village, Kone Kyar, accounting for close to half the total population. Ethnicities of the residents include Kachin, Pa Laung, Bamar, with Nam La village including a small population of Nepalese. All villages, except for Nam La, have access to Namtu by road and/or motorbike track, and none have connection to grid electricity or a major market.	Hin Poke Loi Mi[4] Nam Hkun Nam Ma La Loi Ping (Kone Kayar)[5] Hsin Li[5] Hsai Gaung[2]	1,086
Kyu Hsawt Kyu Hsawt village tract is located to the east of the Bawdwin village tract. It is sparsely populated with less than 1,000 people.	No villages of interest	926
Hko Mo Hko Mo village tract borders the Bawdwin village track to the southeast and also Namtu Town to the south. It is sparsely populated with less than 1,000 people.	Hko Hpeik Oh Ba Leng Dar Kone	940
Manton Township		
Man Pun (Kachin)	Man Pun	1,317
Man Pat 2	Da Bang Kya Htan Man Pat Man Pat (Pa)	1,447
Tun Hsay	No villages of interest	337
Namhsan Township		
Hkay Hkin	Ho Pat Ho Hoke Pang Wat Man Wea	1,946

[1]Village tract population data is from the 2014 Census (DOP, 2015c).
[2]These villages were surveyed by BJV and identified with the village tract as presented in the table above, however, are not listed in the 2020 MIMU Place Code list (MIMU, 2020b) or MIMU March 2020 spatial data.
[3]Village names sources from MIMU 2020b. Note that only villages of interest near Bawdwin are listed. This is not an exhaustive list of villages in each village tract.
[4] Listed in the 2020 MIMU Place Code list (MIMU, 2020b) as within Hin Poke village tract however depicted in MIMU March 2020 spatial data as within Baw Twin village tract. [5] Listed in the 2020 MIMU Place Code list (MIMU, 2020b) as within Hin Poke village tract however depicted in MIMU March 2020 spatial data as within Kyu Hsawt village tract.

There are 23 villages within seven village tracts along the approximately 66 km export route between Namtu and Lashio. These village tracts have a total population of 16,483 people (excluding the Namtu village tract as this is included in the Namtu study area and the Hko Mo village tract as this is included in the regional study area). The breakdown of this population by village tract is provided in Table 5.79.

Table 5.79 Population of villages along the export route to Lashio

Village Tract	Villages near the export route[2]	Village tract population[1]
Namtu township		
Nam Taung Kone	Pan Tha Pyay Nam Taung Kone Ho Kat Loi Wein	1,359
Man San	Man San Man Hawng	3,937
Pang Chin	Kun Kyawng Ping Long Nyaung Hswei Hway Yun Nar Mat Loke Lay Pang Chin	2,036
Nar Hseng	Nar Hseng Mong Taung	2,645
Lashio township		
Loi Tauk	Pang Huong	1,114
Ei Naing	Nawng Kaw (Hsin Keng) Ei Naing Tar Shwe Han 6-Maing	3,527
Nar Kun Long	Nawng Hlaing	1,865

[1]Village tract population data is from the 2014 Census (DOP, 2015c).
[2]Village names sources from MIMU 2020b. Note that only villages of interest near Bawdwin are listed. This is not an exhaustive list of villages in each village tract.

Household composition

The household composition of Shan State as recorded in the 2014 census indicates the median household size is 4 people and the average household size is 4.7 people (DOP, 2015b). According to the Bawdwin GAD data, the average household size is 6 people in the eight Bawdwin wards and 5 people in the two Tiger Camp wards. The social baseline field survey data shows that the average household size of survey respondents in the Bawdwin study area is four people, two less than determined by analysis of the GAD data. This may be explained by the observation that often the extended family of an individual family unit live together in the same dwelling. The Namtu study area average household size was 6 people according to Namtu GAD (2018) data, whereas the field survey data indicates an average household size of 4 people.

The most frequent household size of households surveyed by the social baseline team in Bawdwin is 4 people, and 5 people in Namtu. The distribution of household sizes in Namtu and Bawdwin is similar to Shan State and Myanmar household sizes (Figure 5.59).

Surveys of Hu Hsar and Yaw Ba Gang villages in the Hu Hsar village tract indicated the average household size is between 4 and 5 people, whereas villages in the Hin Poke village tract had an average village size ranging between 5 and 12 people. Households in farming hamlets surrounding Bawdwin varied in size, averaging between 4 and 6 people in the Tiger Camp, lower Bawdwin, Loi Mi and Nam La farms.

Age groups

The age profile of the population of Myanmar and Shan State shows an expansive pyramid type population distribution with the largest age categories from younger age groups. The 0 to 10 years and 10 to 20 year categories dominate the profile (Figure 5.60). This type of age distribution indicates a high birth rate. In comparison, the age profile for the Bawdwin and Namtu study areas were more stable or constrictive, with the 10 to 20 year category being largest, but other age categories having a greater proportion of people. The Bawdwin and Namtu age distribution is more consistent with a population experiencing a lower birth rate and potential emigration of younger people.

Age data provided by the Bawdwin GAD (2018) is separated into two categories: those under 18 (youth) and those 18 and over (adults). Tiger Camp is not considered here as youths are defined as those under 15 which may have led to some statistical distortion. The youth were found to represent 31.9% of the Bawdwin study area population, according to the GAD data. The field survey data for the eight Bawdwin wards is generally consistent with the GAD with 26.2% youths and 73.8% adults (Figure 5.60).

Age data provided by the Namtu GAD (2018) shows that the youth (under 18 years) represent 28.5%, and adults (18 and older) represent 71.5% of the population in the Namtu study area, with the majority of youth being female (50.6%). According to the age group data of the field survey respondents, 28.5% of the population are youths, 71.5% of the population are adults. Overall, the age distribution is similar to that of the Bawdwin study area (Figure 5.60).

Gender

The gender composition in the Myanmar population is slightly skewed towards females with a ratio of 51.8% female to 48.2% male. In Shan State the composition is equal with 50.0% of the population female, and 50.0% male (DOP, 2015a; DOP, 2015b).

The official Bawdwin GAD data (2018) of the gender composition of the population shows that in 2017 approximately 53.6% of the population in the Bawdwin and Tiger Camp wards were female and 46.4% were male. Of the respondents in the field survey in early 2019, 52.1% were female and 47.9% were male. None of the individual wards had a population with more males than females. The Pyi Taw Aye ward has the highest ratio of females to males with approximately 70% female and 30% male according to the field survey data.

According to the Namtu GAD data (2018), the Namtu study area population comprises 47.2% males and 52.8% females. The gender composition of participants in the field survey is largely consistent with the Namtu GAD statistics, with 47.5% male and 52.5% female.

The gender ratios within the Bawdwin and Namtu study areas as well as the Shan State and Myanmar populations are presented in Figure 5.60.

The gender composition of the village tracts outside Bawdwin that may be affected is similar to that of Shan State. The eight village tracts along the export corridor to Lashio have an average composition of 50% male and female. Individual village tracts vary, ranging from 48% male and 52% female to 52% male and 48% female. The eight village tracts on the roads to the north, south and west of Bawdwin have an overall composition of 48% male and 52% female.

Education

There are two main categories of education in Myanmar: basic education (primary, middle, secondary and high school) and higher education (college diploma and university level degrees). Other education includes informal monastery education and vocational training.

Shan State’s socio-economic indicators sit in the mid-range of Myanmar’s statistics, compared to other states. However, it has the lowest literacy level and school enrolment rates in Myanmar.

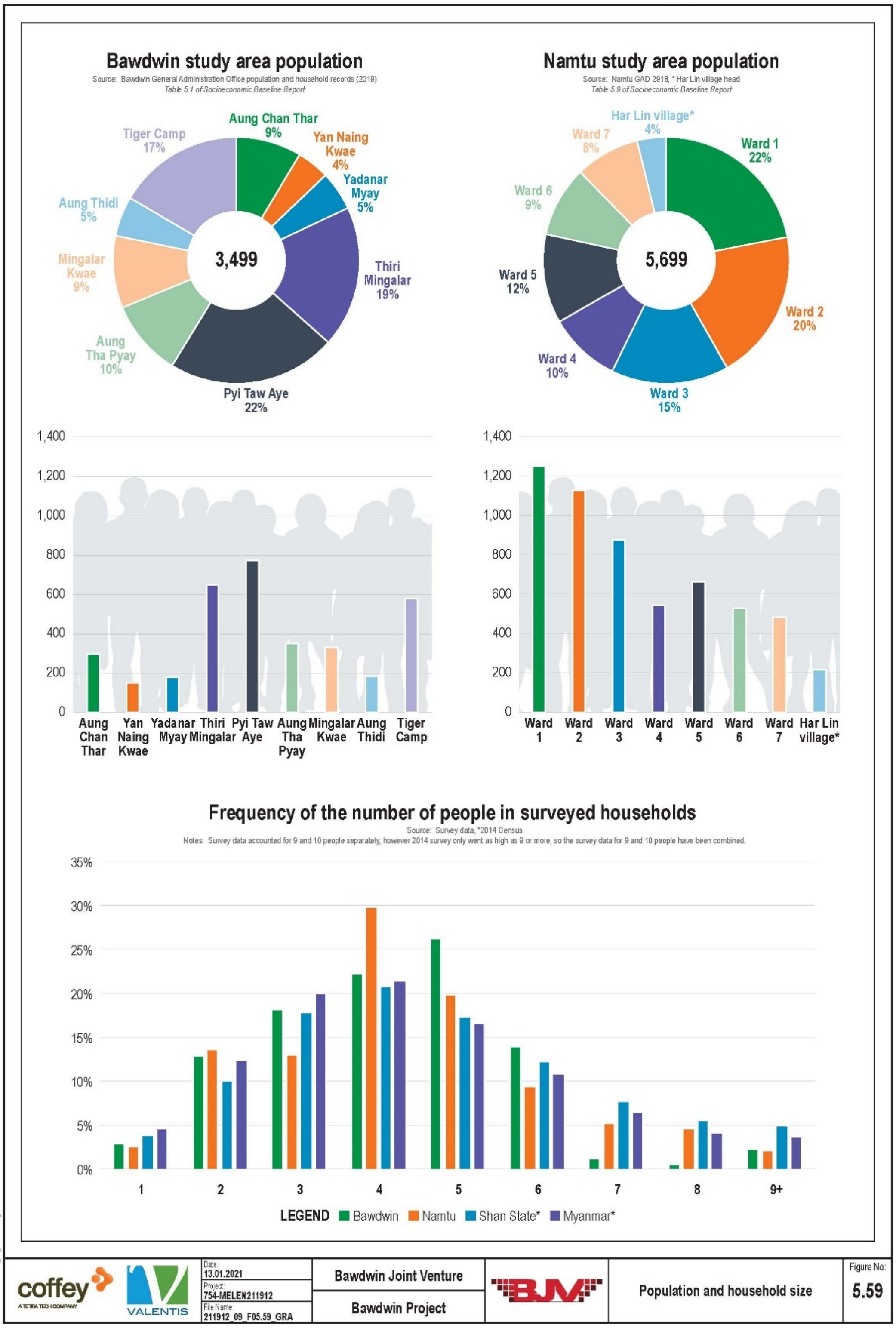

Figure 5.59 Population and household size

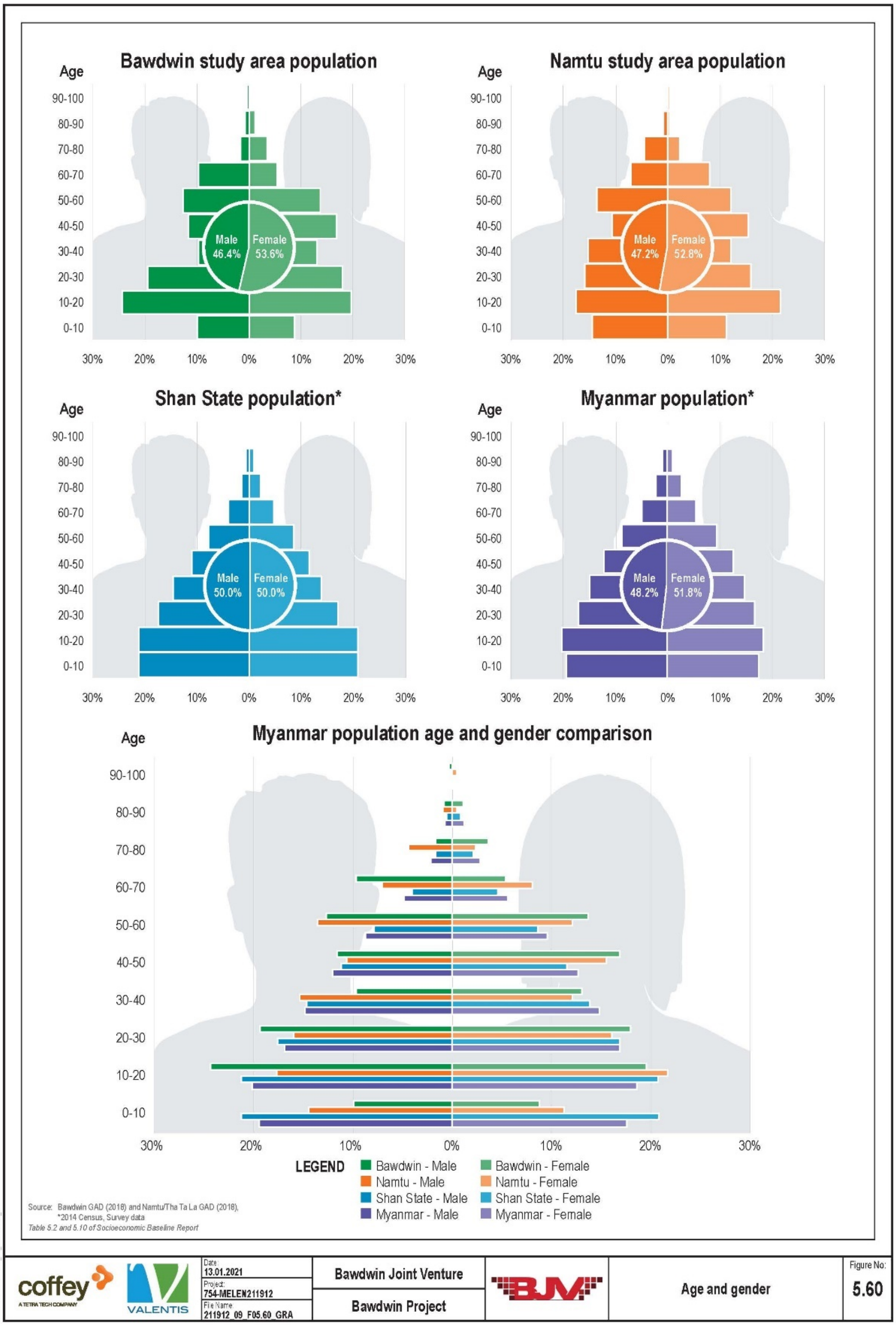

Figure 5.60 Age and gender

According to field survey data from the Bawdwin and Namtu study areas, the proportion of people who have completed some form of higher education in these areas is relatively high compared with Shan State overall. Levels of higher education were 12% in Bawdwin and 8% in Namtu, compared to 5% in Shan State (DOP, 2015b). The Bawdwin and Namtu study areas also have higher proportions of people with who have completed some form of basic education and less people with no education, compared to Shan State overall. Levels of basic education were 79% for Bawdwin, 76% for Namtu compared to Shan State overall in which 49% of people have basic education (DOP, 2015b). The proportion of people with no education was 6% in Bawdwin and 8% in Namtu, compared to 45% of people in Shan State overall.

Higher education facilities are generally only available in major population centres and cities such as Mandalay and Yangon. Lashio contains two universities: the Lashio University, which focuses on liberal arts, humanities and science, and the Technical University of Lashio, which focuses on engineering and technology.

Within the Bawdwin and Namtu study areas, some elders only received an informal rudimentary education from temple monks. The majority of people graduating from primary or post-primary schools from these areas were reported to most commonly go on to work as labourers or in factories. Figure 5.61 shows education levels in the study areas compared to Myanmar and Shan State.

Myanmar's student to teacher ratio is 27:1 at secondary schools and 24:1 at primary schools (World Bank, 2020). The average student to teacher ratio is 5:1 at the Tiger Camp middle school and primary school, 16:1 at the three primary schools in Bawdwin and 19:1 at the high school (Figure 5.61). It has been reported that the Tiger Camp middle school is operating at considerably below its capacity for students.

Survey data indicated that 786 students attended schools in Bawdwin and Tiger Camp. Follow up surveying of school headmistresses by WMM in early 2020 indicated that of these students, 157 students (around 20% of the total students attending school in Bawdwin and Tiger Camp) travel from 22 villages outside Bawdwin to attend school.

Most of the students who travel from villages outside Bawdwin to attend school attend the high school (68%), with the remainder attending No.2 Primary (14%) and No.3 Primary (18%) (Figure 5.61). Of the students travelling from outside Bawdwin, 69% come from villages in Namtu township and 23% from villages in Manton township. Of the 22 villages students travel from, students from five villages (Lon Jar, Hai Taung, Hu Ngwe and Hu Hsar villages in Namtu and the Man Pat village in Manton) make up 60% of the total number of students travelling to Bawdwin.

Students may travel to Bawdwin for education for several reasons including:

- Proximity to facilities (in particular high school facilities), e.g. those from the Ho Hoke and Ho Pat villages in the Hkay Hkin village tract in Namhsan township may attend as their villages are closer to Bawdwin schools than alternative facilities.
- Parents may be seasonal workers in Bawdwin.
- WMM provides affordable housing to village students.

Students who travel to Bawdwin for school either commute daily, usually by walking, or stay in Bawdwin during the week, returning to their villages for the weekend. The accommodation options available to students who attend school in Bawdwin include housing provided by WMM, monasteries and private guest houses.

Surveys of the surrounding village tracts and farms indicate some students from the villages in Hu Hsar village tract and Hsai Gaung village board in Bawdwin, while some students from Nam Hkun village and the Nam La and Loi Mi farms board in Bawdwin or commute by walking or motorbike.

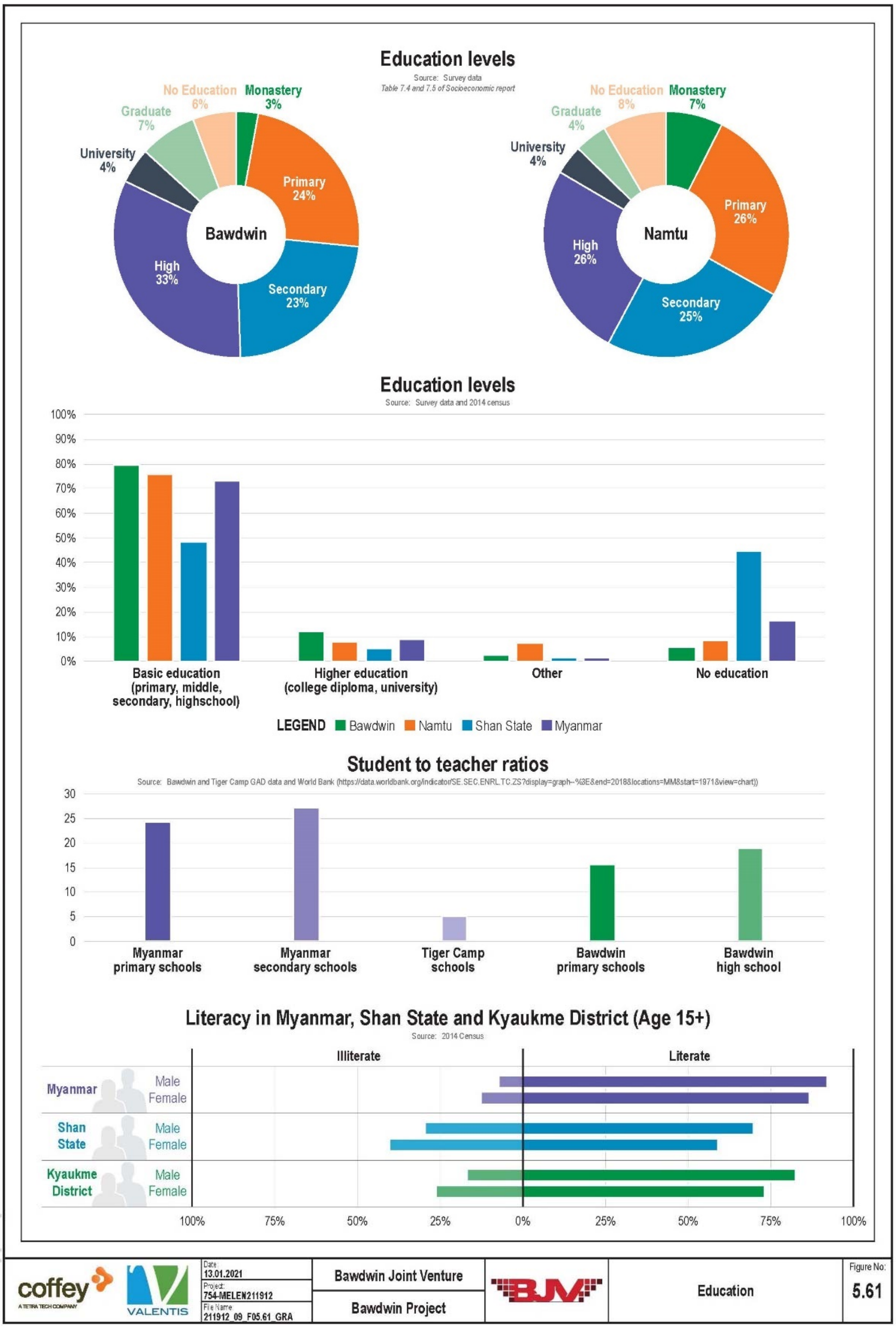

Figure 5.61 Education

The number of students attending Bawdwin schools from neighbouring villages in 2019/2020 is shown in Table 5.80.

Table 5.80 Number of Bawdwin school pupils from neighbouring villages in 2019-2020

Township/village	School			Total
	High School	No. 2 Post Primary	No.3 Post Primary	
Namtu Township				
Lon Jar	19	8		27
Loi Myae		8		8
Hai Taung	12		9	21
Hin Boke	7			7
Hu Hsar	16			16
Hu Ngwe	1		15	16
Kone Kaya	1	1	1	3
Hsin Li	3		2	5
Nam Khun	4	2		6
Manton Township				
Loi Kan	1	2		3
Tong Maw	4	1		5
Man Pat	12		1	13
Ho Chet	2			2
Raw Brang	8			8
Nam Sar	1			1
Ho Nam	1			1
Man Loi	1			1
Loi Khun	1			1
Lan Pan Kye	1			1
Nam Hsan Township				
Ho Hoke	3			3
Ho Pat	8		1	9
Total	**106**	**22**	**29**	**157**

Source: Win Myint Mo Industrial Co. Ltd, March 2019.

Literacy and language

Myanmar is the predominant language used in the region. However, many ethnic groups, particularly families who are ethnic minorities, speak different languages (including Kachin, Chin, Shan Palung) amongst themselves.

The 2014 census found that 65% of the Shan State population aged 15 years and older was literate (DOP, 2015b). Literacy rates were 70% among men and 59% among women in Shan State. Kyaukme District, where Namtu township is located, had a higher literacy rate of 78% for those aged 15 and older compared to the national average of 90%. The literacy rate in urban areas of Namtu township was 87%, compared to a rate of 60% in rural areas of the Township. Literacy levels in Myanmar, Shan State and Kyaukme District are shown in Figure 5.61.

A small proportion of respondents to the household surveys in the Bawdwin study area above age 10 are illiterate, with approximately 4% of females illiterate in Aung Chan Thar ward, 10% of females and 2.5% of males in Aung Tha Pyay ward, 16.5% of females in Aung Theikdhi ward and 7% of females in Mingalar Kwe ward. The remaining six wards within the Bawdwin study area have no known records of people who are illiterate. However, in Tiger Camp, according to interviews with ward leaders and previous administrative office records, approximately 10% of the population is illiterate.

Results from the household surveys show that all wards across the Namtu study area have a percentage of the female population that is illiterate, ranging from approximately 2.5% at Tha Ta La ward 1 to 17.5% at Har Lin. Four wards (Har Lin and Tha Ta La wards 2, 3 and 6) have a percentage of the male population that is illiterate, ranging from approximately 2.5% at Tha Ta La ward 3 and 10.5% at Har Lin. Har Lin is a rural village where education has been historically difficult to access, and given the majority of respondents from this area were elderly people, that is probably the explanation for the larger percentage of the population that are illiterate in that area. It is unclear why illiteracy rates are generally higher for females, but it may be connected to traditional concepts of gender roles.

Ethnicity

There are 8 major ethnicities in Myanmar: Kachin, Kayah, Kayin, Chin, Bamar, Mon, Rakhine, and Shan with 135 ethnic groups. The distribution of these ethnicities is largely geographical, with the Shan people primarily residing in Shan State.

Most of the community members in the Bawdwin study area are Bamar (90%) followed by Chin (3.8%) and Shan (3.2%). Palung (1.4%), Kayin (0.6%), Kachin (0.5%) and Chinese (0.5%) make up the other ethnicities in the area (BGAD, 2019).

In the Namtu study area, most of the community members are Bamar (69.6%), with the next highest ethnicities identifying as Shan (16.3%) and Kachin (8.3%). Seven other ethnicities were reported in the Namtu study area including Nepalese (1.8%), Kayin (1.5%), Palung (1.1%), Hindu (0.7%), Chinese (0.3%), Chin (0.3%) and Wa (0.1%) (NGAD, 2018).

The Namtu study area is more diverse than the Bawdwin study area due to higher commercial and industrial activity in the area, which attracted workers from within Myanmar and abroad. The population in the Bawdwin concession area is also more tightly controlled by GAD and ME-1 due to their relationship (i.e., employment and housing) linked to the mine. It cannot be confirmed whether those identifying as Chinese, Nepalese or Hindu are first generation or second and third generation.

The populations of both the Bawdwin and Namtu study areas are not considered to meet the definition of indigenous people (e.g., IFC, 2012), or in other words social groups that identify themselves as distinct from mainstream groups in national societies. People that are defined as indigenous are often more vulnerable to adverse impacts associated with project developments than non-indigenous communities. This vulnerability may include loss of identity, culture, and natural resource-based livelihoods, as well as exposure to impoverishment and diseases.

In the Hu Hsar and Hin Poke village tracts, the main ethnicity in most villages is Kachin (Hu Hsar, Yaw Ba Gang, Haik Taung (Ka) and Hsai Gaung villages). The main ethnicity in the other villages in these tracts include Palung (Haik Taung (Pa) and Kone Kayar villages), Li Hsu/Kachin (Lone Jar village) Kachin/Bamar (Nam Hkun village) and Nepalese/Gurkha (Nam La village). Surveys of households in the Loi Mi farms indicated the main ethnicities are Gurkha and Kachin.

Religion

Myanmar has no constitutionally established state religion and many different religions are practiced, although 87.9% of the population identify themselves as Buddhist. Other religions in Myanmar include Christianity (6.2%), Islam (4.3%), Hinduism (0.5%) and Animism (0.8%) and other (0.2%) (DOP, 2016b). Most Shan States residence identify as Buddhists (81.7%), but Islam (1.0%), Christianity (9.8%), Animism (6.6%) and Hinduism (<0.1%) are also practiced (DOP, 2016b).

According to the Bawdwin GAD (2018), a majority of the Bawdwin study area community members identify themselves as Buddhist (94.7%), followed by 4% identifying as Christian and 0.9% identifying themselves as Muslim. In the Bawdwin villages there are seven monasteries, three Sikh temples and two churches.

In the Namtu study area, according to the Namtu GAD (2018), an even greater majority of community members identify themselves as Buddhist (99%) with the remaining members identifying themselves as Christian (0.6%) and Hindu (0.3%). In Namtu there are five monasteries, two Hindu temples, two Mosque temples and two churches.

The religious identifications within the Bawdwin and Namtu study areas and at the national level are shown on Figure 5.62.

Vulnerable people

Vulnerable people include those who:

- have disabilities (blind, deaf, hearing impairments, have had polio, or suffer from mental illness),
- live in a female led household,
- live alone; and,
- are over 85 years old.

As discussed above indigenous people and ethnic minorities can also be considered vulnerable groups.

In Shan State, 3.9% of the population is disabled, 21.7% of households are female led, 3.8% live alone and 0.3% of the population are over the age of 85 (DOP, 2015b).

In the Bawdwin study area 1.7% of people are disabled, 20.3% of households are female led (with 15.8% of the population occupying these households), 4.1% live alone and 0.83% are over 85 years old. In the Namtu study area, 4.3% of people are disabled, 15.7% of households are female led (with 29.9% of the population occupying these households), 2.4% live alone and 3.7% are over the age of 85. People over 85 years old in both Bawdwin and Namtu are entitled to social welfare support.

In Myanmar the retirement age is 60, but there are no mandatory pension obligations and the population do not have access to a government pension, except for civil servants. A retired employee who has paid contributions to the Health and Social Care fund for at least 180 months is entitled to medical treatment provided by a specified clinic. Approximately 4% of the Myanmar population over age 15 are government employees, which similar to the proportion of government from the Namtu township (3.2%).

Social organisations

A range of for-profit and not-for-profit organisations and social services are present in the study areas. The organisations and social services within the Bawdwin study area (35 known) and Namtu study area (29 known) that mostly focus on youth, education and the elderly (Table 5.81).

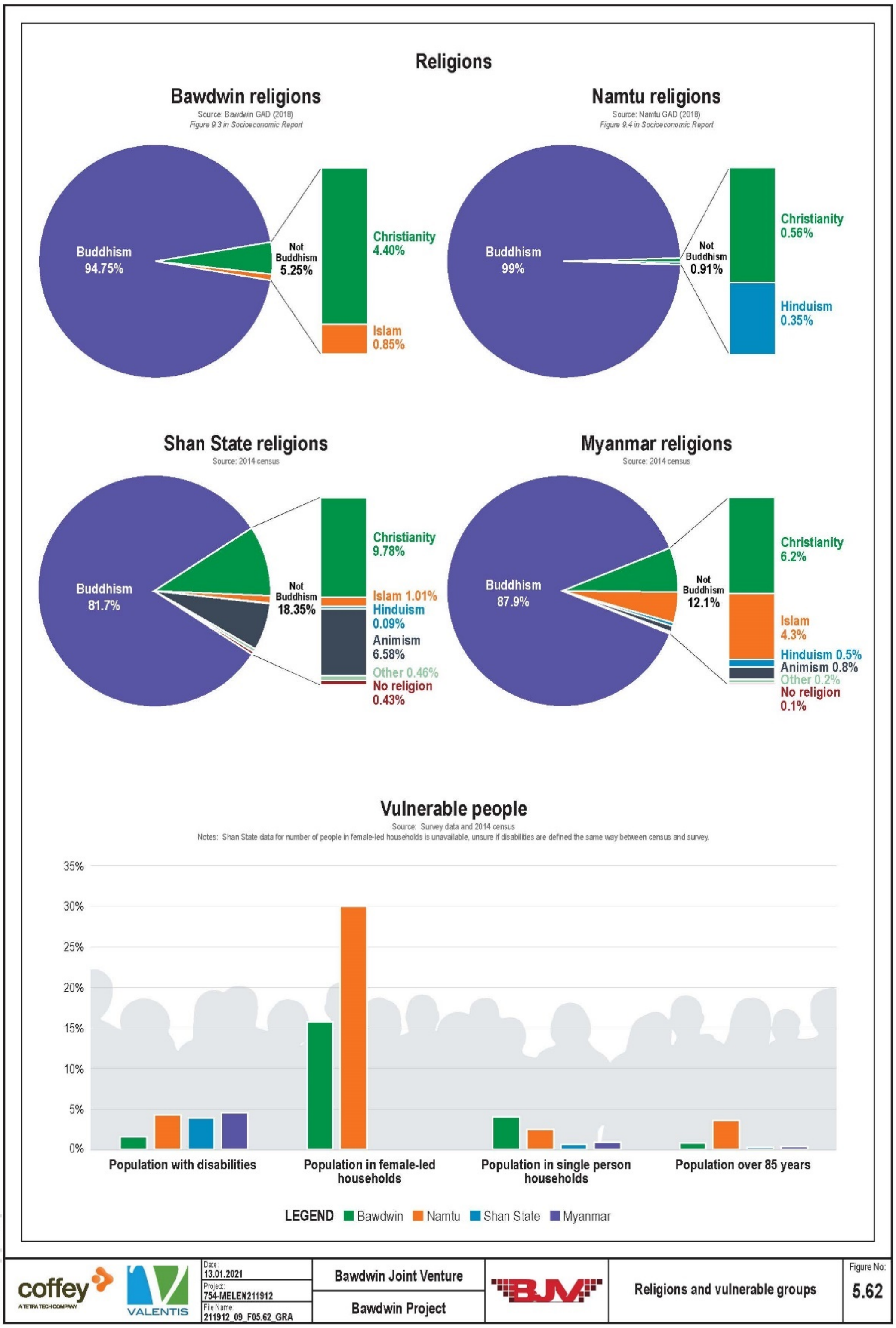

Figure 5.62 Religions and vulnerable groups

Table 5.81 Organisations and societies in the Bawdwin and Namtu study areas

Ward	Organisations/Groups
Bawdwin study area	
Aung Chan Thar	Youth group
Yadanar Myay	Women’s group
	Youth group
Pyi Taw Aye	Youth group
	Anar Gat A Lin Tane Educational Foundation
	Computer Training
	Religious group
Aung Tha Pyay	Youth group
	Workers' Committee
	Anar Gat A Lin Tane Educational Foundation
	Twel Lat Myar
Mingalar Kwe	Workers' Committee
	Myit Tar Phyu
	97/98 Student Team
	Anar Gat A Lin Tane Educational Foundation
	Twel Lat Myar
	Youth group
Aung Theikdhi	97/98 Student Team
	Twel Lat Myar
	Youth group
Tiger Camp 1	Pyin Nyar Yaung Chi Educational Foundation
	Youth group
Tiger Camp 2	Pyin Nyar Yaung Chi Educational Foundation
All wards	Mining Workers Federation Myanmar
Namtu study area	
Ward 1	Tha Ta La Youth Group
Ward 2	Myanmar conservation Team
	Youth group
	Phyu Sin Myit Tar blood donation
	Wards' committee
Ward 3	Phyu Sin Kyal
	Lu Mhu Yae
Ward 4	Youth group
Ward 5	Youth group
Ward 6	Youth group
Ward 7	Women’s group
	Religious group
Har Lin	Tha Ta La Youth Group
	Religious group

Immigration and emigration

Up until the late 1950s, Namtu was one of the British empire’s most important mining centres, with its own airfield, hospitals, recreational facilities and other infrastructure. The town’s development probably caused inflow of labour to the Bawdwin and Namtu areas from central parts of Myanmar. As determined through the household surveys and focus group interviews, residents are second or third generation in-migrants and consider the study area their ‘homeland’. Retired workers for the old Bawdwin mine say they do not have a home to return to and therefore have stayed in the area in subsidised accommodation provided by WMM. There has been no significant recent inflow of labour to the study area as there have been no mining operations in the area since 2009, but the commencement of oxide mining at Bawdwin in June 2020 (which is not in the scope of this EIA) may change this situation.

The majority of emigrants from the Bawdwin study area are employed in Namtu, Lashio and Muse as unskilled labour, with few employed as skilled workers in other parts of Myanmar or overseas. Results from the household survey show that approximately 350 family members of the respondents (equivalent to 43% of the field survey population or 10% of the total Bawdwin population (BGAD, 2019)), most under 40 years old, have left the Bawdwin study area in search of work. Approximately 700 family members of the respondents (equivalent to 98% of the field survey population or 12% of the total Namtu population (NGAD, 2018)) in the Namtu study area have left the area in search of work.

5.9.6 Economic profile

Myanmar’s economy is one of the least developed of southeast Asia. Much of the population is engaged directly in agricultural livelihoods, with rice being the most common, which covers about 60% of the country's total cultivated land area. Other key industries in the country include forestry, manufacturing, mining, oil and gas and tourism. The main exports for the country are natural gas, timber, pulses, beans and rice, clothing and gems.

Myanmar is a nation in transition. In 2011, when new President Thein Sein's government came to power, the country embarked on a major policy of reforms including anti-corruption, currency exchange rate regulation, foreign investment laws and taxation. This policy reform continued following democratic elections in 2015 and has resulted in rapid economic growth and measurable improvements in social welfare.

Notwithstanding improvements in social welfare it is estimated that a quarter of the population are considered poor with poverty being more prevalent in rural areas (FAO, 2016).

On a regional scale, rates of poverty in Shan state are relatively high compared to other areas of Myanmar. Agriculture is the largest economic sector in the state, even in urban areas, followed by mining and by tourism in the south of the state.

Employment

The economy and livelihoods of people in the Bawdwin and Namtu study areas centre on persons working in the mining sector or those retired. Nearly all community members have a regular income from either a Government paid pension or a monthly salary from WMM for mining activities. When the Bawdwin mine was operating, at least two generations of family members from the Bawdwin and Namtu study areas were employed at the mine. After WMM took over the mining license in 2009, the workforce gradually decreased from approximately 2,000 to 600, leading to people having to work outside the Bawdwin mine area as labourers.

The main sources of income for people in the Bawdwin and Namtu study areas are employment in mining operations, casual labour and seasonal jobs. Mining jobs are important not only for income, but also for subsidised housing. Of the respondents from the surveys and focus group interviews in the Bawdwin study area, the majority remain working in the mining sector (56%) or are retired (18%). In Namtu, the majority of the survey respondents either work in the mining sector (46%) or are retired from the mining sector (11%). Formal employment opportunities for women are often available in office work in the mining sector. Aside from working in formal employment in the mining sector, artisanal and opportunistic mining of slag on hillsides and downstream of the mine and in ER Valley is a source of income and livelihood for both residents of Bawdwin and Tiger Camp communities and a population of artisanal miners beyond the Bawdwin mining concession area. The population varies seasonally with the largest during the dry period.

Employment in Myanmar and Shan State is typically in the agriculture, forestry and fishing sectors, with 72.7% of people working in these sectors in Shan State and 52.4% of people in Myanmar (DOP, 2016a). Contrastingly, very few survey respondents reported the head of household working in these sectors in Bawdwin (1.2%) and Namtu (4.4%).

Crop farming in Bawdwin is primarily for subsistence, but some agriculture products are sold in local markets and some also sold in Namtu and Lashio. Jengkol or dogfruit, is a key cash crop of the study areas, which believed to have medicinal properties, such as purifying blood, easing dysentery and preventing diabetes).

It is not possible to determine the exact unemployment rate across both study areas due to seasonal employment of unskilled workers in smaller occupations (small-scale sales). Many respondents to the surveys stated that there are few job opportunities for the younger generation, including university graduates.

Employment by sector for the Bawdwin and Namtu study areas, along with Shan State and Myanmar more generally is presented in Figure 5.63.

Livelihoods for villages and farms surrounding the Bawdwin concession area are primarily based on agriculture. In Hu Hsar village tract, the principal staple crops are paddy and vegetables, while tea is the principal cash crop. In the Hin Poke village tract, the principal staple crops are corn, paddy and vegetables, with tea and jengkol being the principal cash crops. In Loi Mi farm households, the staple crops are maize, tea leaf and jengkol, while the principal cash crops are seasonal vegetables. Generally, residents of surrounding villages and farms are not employed in Bawdwin, with the exception of some mine workers from Nam La village in the Hin Poke village tract.

Villages surrounding the Bawdwin concession area access the Bawdwin villages for commerce (use of the market or retail shopping), with the purchase of fuel or mechanical repairs being most frequently mentioned.

Domestic work

The survey study found that household responsibilities, such as cooking, washing, fetching water and childcare, were shared between males and females. The labour division is also shared, although some interviewed females have more household duties as they also head their households. Minoletti (2016) reports that cultural norms still play a strong role in household division of labour in Myanmar and there is an uneven division of labour in the household with men typically being resistant to domestic chores seen as a woman's responsibility. Most families in Myanmar have the father listed as the household head, according to the GAD family registration records (BGAD, 2019). Men and women participate together in social activities, but men generally take the lead responsibility in decision-making and governance roles in society.

Household Income

The average annual GDP per capita in Myanmar is 1,694,219 MMK or roughly 1,200 USD (approximately 141,185 MMK per month) (CEICData, 2020). The mean monthly household income in Bawdwin is 263,923 MMK, with the average income of individual wards ranging from 190,750 MMK to 387,615 MMK. The mean monthly household income in Namtu is 246,187 MMK with the average income of individual wards ranging between 110,909 MMK to 360,206 MMK.

Household income and expenditure for the Bawdwin and Namtu study areas is presented in Figure 5.63.

There is no material wage difference between male and female labourers in the Bawdwin area, however there is a difference in income between skilled and unskilled labourers in the Bawdwin and Namtu areas (Table 5.82).

Table 5.82 Daily income of skilled and unskilled labour in Bawdwin and Namtu

	Bawdwin	Namtu
Skilled labour	6,000 – 9,000 MMK per day	7,000 – 11,500 MMK per day
Unskilled labour	5,000 – 6,000 MMK per day	5,000 – 6,000 MMK per day

Expenditure

As shown in Figure 5.63, household expenses are almost the same as earnings in both Bawdwin and Namtu study areas. The main expenditure items are food and housing, followed by education, health and social activities. The lack of job opportunities in the areas force people to send their children to work elsewhere and remit funds home, otherwise older generations are unable to sustain themselves on their own pensions and salaries.

Debt is defined as the gap between expenditure and income and an inability to pay for goods and services in the absence of physical cash. There are no known debt mechanisms reported during the field survey, such as credit card debts or mortgage loans, that are available in the study areas, although informal systems are widespread in Myanmar and known to be important elsewhere. In Bawdwin and Namtu respectively, 54% and 50% of survey respondents have debt. The percentage of survey respondents in each ward in Bawdwin with debt ranges between 20% and 73%. In each ward in Namtu this ranges between 32% and 71%. A lower number of dependents, higher skill levels, proximity of the ward to commercial activities and employment opportunities may explain why households in certain wards accumulate surpluses and do not have debt.

Assets

Most household assets in both study areas are non-luxurious items (electric cookers, water heaters and television sets). Most households have access to a mobile phone. Some people own motorbikes for commuting to and from school and work.

Land ownership

Myanmar's current land-administration system retains many features of the one established during British colonial rule. At present, land administration in Myanmar is characterised by multiple and overlapping institutional mandates, laws and regulatory frameworks, and indeterminate land classification (FAO, 2016).

The GAD of the Ministry of Home Affairs is responsible for administering and managing all non-forest and non-farm land in the country. This includes town, village, religious and common land, riverbanks, ponds, cemeteries, grazing pastures and disposable state land. The GAD has branches at township and state/region levels and acts as the representative of the central government at these levels.

The Settlement and Land Records Department under the Ministry of Agriculture and Irrigation is responsible for maintaining land registry and cadastral maps and has branches at state, district and township levels. Each township is further divided into a number of circles, each headed by a land inspector (assistant staff officer) who is responsible for, among other things, validating and checking land records (FAO, 2016).

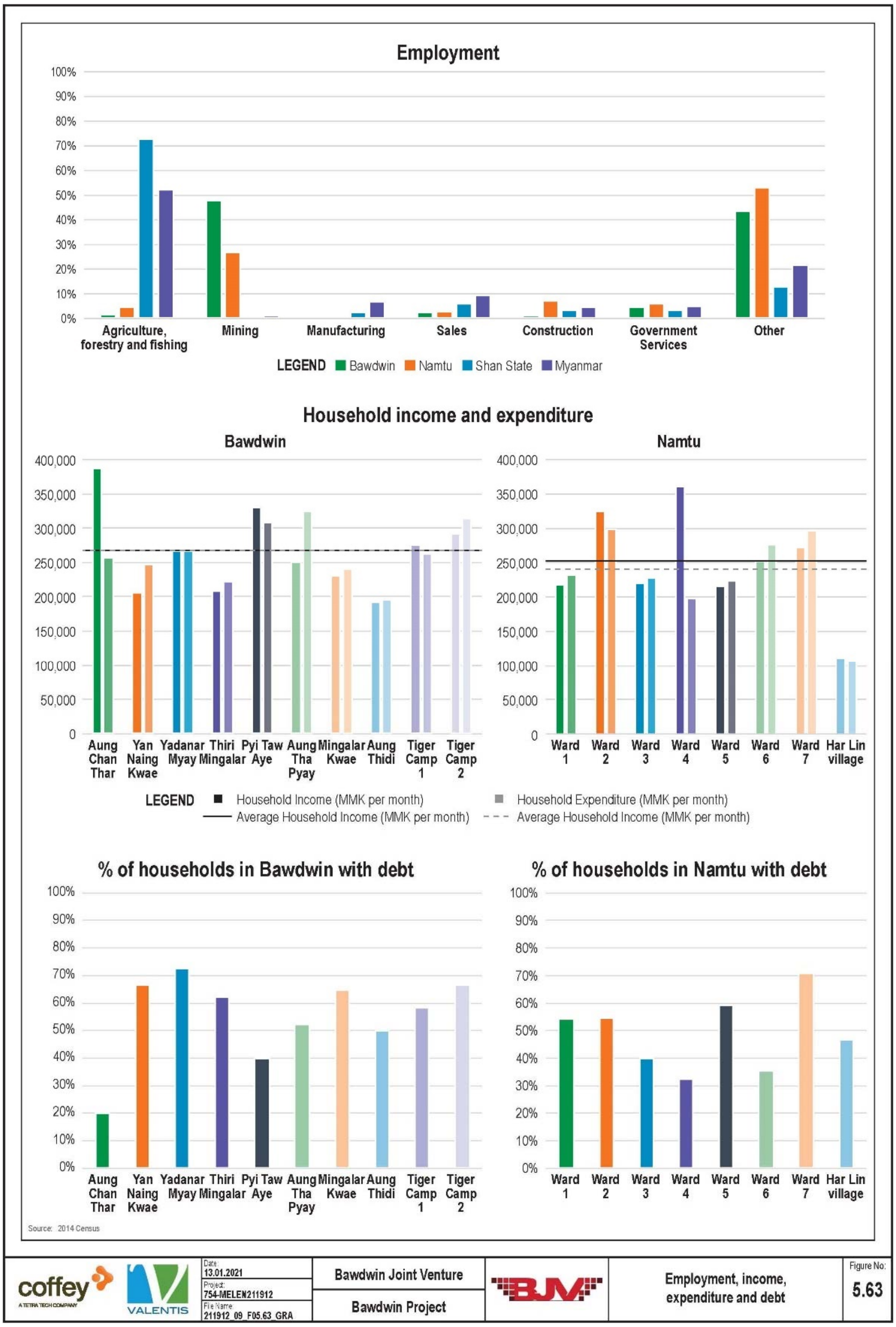

Figure 5.63 Employment, income, expenditure and debt

There are eleven different classes of land in Myanmar, as follows:

- Freehold Land
- Grant Land
- Agricultural Land
- Garden Land
- Grazing Land
- Vacant, Virgin and Fallow Land
- Forest Land
- Town Land
- Village Land
- Cantonments
- Monastery Land

Each land type has its own rights and obligations for Myanmar citizens. Depending on the type of land, the owner/lessor will need to obtain certain approvals or follow certain procedures before a lease can be legally concluded and registered on the land in question, or before a company can apply for a construction permit.

Myanmar nationals (individuals and companies) are able to sell, lease, mortgage and transfer their rights to land, whether it is a freehold, leasehold or Government lease, to other Myanmar nationals. However, the Transfer of Immovable Properties Act sets out the key restrictions for foreign ownership of real property in Myanmar.

In essence, the restrictions mean that foreigners cannot be transferred property from a Myanmar national. The exception to this restriction is where foreign companies established in Myanmar are issued a permit by the Myanmar Investment Commission (MIC). In this case, obtaining land rights involves first negotiating with individual land rights holders on a case-by-case basis. Then, approval for the arrangement must be sought from either the local, state or regional authorities. Finally, the MIC must approve the land right acquisition arrangement.

Depending on the particular type of land, the lessor will have to apply for a change of purpose of the land before he can lease the land to a foreign-owned company. Common types of land are Garden Land and Agricultural Land.

In the legal context the term ‘Garden Land’ is inclusive of the broader definition of the term ‘Agricultural Land’. However, the type of crop(s) grown on it may differ from those usually grown on agricultural land. Besides, the amount of revenue payable to the government with regard to garden land is much higher. Garden land is also not transferable although in practice transfers by sale take place frequently in practice.

Agricultural land is specifically designated for paddy or crop cultivation. Agricultural land cannot be used for any purpose other than paddy or crop cultivation, unless the purpose of the land is changed. The Farmland Law and Farmland Rules set forth the procedures that are required to obtain permission to use Agricultural land, as well as permission to change the purpose of such land. To obtain legal permission to use Agricultural land, a farmer must apply to the relevant village or tract farmland management committee for a Farmer’s Certificate (also called Form 7). If the farmer then wishes to change the purpose of the land, then the farmer must apply to the township department office for permission to change the purpose of the land. The farmer must specify the purpose for which he wishes to use the land.

The granting of large-scale state land leases was commenced by the military government in 1991 and accelerated after the adoption of the Wastelands Instructions that year (FAO, 2016).

For state land leases, a contract (often called a permit or concession agreement) is prepared, allowing the investor to carry on a specific kind of commercial or development activity in an area. This could be developing land/natural resources, exploring for minerals or operating a concession stand. Such an understanding generally covers agribusiness ventures, mining concessions, oil and gas exploratory permits and logging in forest areas.

WMM lease rights

Under the Myanmar Mines Law (1994), all minerals and mineral products, whether in situ or extracted from the ground, are owned by the State. MONREC is responsible for mineral concession rights in Myanmar and there are various mining enterprises under MONREC which are responsible for policy, exploration, and taxation. Mining Enterprise 1 (ME-1) is the contracting department for Bawdwin/Namtu.

The right to explore or mine minerals in Myanmar does not come with land ownership rights. Rather permits are granted by MONREC that allow the holder of the permit to undertake exploration and mining activities on the land. The exploration or mining company is required to negotiate a right of access to the land to explore or mine. Usually at the mining stage this involves purchase of the land if it is owned privately, however this is not required if it is Government owned.

The rights to conduct work and produce ore in the study area are governed by the Production Sharing Contract (PSC) on Production and Processing of Lead and Zinc in Namtu-Bawdwin Mine between ME-1 and WMM. Under the contract, ME-1 transferred all fixed property at Bawdwin and Namtu to WMM as well as the responsibility for ME-1 staff employed at those locations. The Bawdwin concession area and Namtu concession area transferred to WMM are located in Namtu township, covering an area of approximately 2,458 ha and 491 ha, respectively.

Community land rights

Due to the lease agreements between ME-1 and WMM, the community is prohibited from trading land and housing within the concession areas. WMM provides housing and accommodation to the majority of its employees. Rentals are subsidised for persons employed by WMM in the Bawdwin and Namtu concession areas, and residents not employed by WMM pay an unsubsidised rate. Unsubsidised rental rates are between 4,000 and 8,000 MMK per month.

Housing extensions and new dwellings have been erected by some residents, at their own cost, to allow for family growth. These structures usually do not have electrical connection.

5.9.7 Health profile

The Department of Health (DOH), one of seven departments under the Ministry of Health, is responsible for the management of public health activities through various national programmes in collaboration with development partners, civil service organizations and community-based organizations. Public health services in Myanmar are delivered to the communities by rural health centres (RHCs) and sub-rural health centres (sub RHCs) through corresponding township, district, and region and state health departments that provide technical assistance and support.

The DOH plays a major role in providing comprehensive health care throughout the country including remote and hard-to-reach border areas. Some government ministries also provide health care for their employees and their families. These include Ministries of Defence, Railways, Mines, Industry, Labour, Energy, Home and Transport. National Health NGOs such as Myanmar Maternal, Child Welfare Association and Myanmar Red Cross Society also provide some health-related services to communities. Smaller private, not-for-profit, Community Based Organizations (CBOs) and religious-based societies also provide a range of health services including ambulatory care, emergency medicine, institutional care and social health protection in some large cities and townships.

In terms of key health issues in Myanmar, malaria is one of the most prevalent diseases. It is endemic in 284 out of 330 townships. Malaria represents an enduring public health problem due to climatic and ecological changes, population migration to rural economic frontier areas (to seek employment in such sectors as forestry, mining, plantations and roadbuilding) and the evolution of the multi-drug resistant (MDR) Plasmodium falciparum parasite. Tuberculosis (TB) is another major health problem. In global terms, Myanmar has the 22nd highest rate of TB, the 27th highest MDR-TB prevalence rate and the 41st highest HIV prevalence rate. HIV/AIDS prevention and care initiatives have been promoted in Myanmar at a state level since 1989.

Health and medical infrastructure and access

In Myanmar there are public and private hospitals. Private hospitals are accessible to all, provided that the patients are able to pay for their healthcare.

There is a small government hospital within the Bawdwin study area. This hospital is staffed by two nurses and does not have a doctor. The facility is not well equipped or supplied and lacks essential prescription drugs. Accordingly, the facility does not fully meet the needs of the community, especially in emergency situations. In Tiger Camp, there is one sub health care centre and one health assistant who is supported by community volunteers.

The private clinic in Bawdwin (operated by BJV) is available for mining company employees only. The clinic has up to three doctors on roster at any given date and is well-equipped with basic essential medicines and medical devices. A well-equipped ambulance with assigned drivers is available for emergency transportation. The clinic is designed and equipped to stabilise and maintain life in case of emergencies prior to evacuation to an external medical facility with greater capability.

Diagnostic facilities for common illnesses and occupational diseases are poor in both the public hospital and the private clinic. People in the Bawdwin community not employed directly by the mine need to go to Namtu to buy required medicines. Many Tiger Camp residents travel to the public hospital in Bawdwin as the Tiger Camp Health Sub-Centre is in very poor condition and is only run five days per week.

Namtu has a public hospital (150 beds) that is in overall good condition compared to other township hospitals in Myanmar. The hospital’s laboratory and imaging services are not tailored to the occupational hazards more commonly seen in the mining industry, or mining occupation-related disease, which are not easily detected with current equipment. There are only four doctors in the public sector in Namtu, with an extreme shortage of other health workforce colleagues (nurses and public health supervisors). In Namtu township there is an overall doctor-to-population ratio of 1:7,260. The national average doctor-to-population ratio is 1:1,640, and the WHO recommended ratio is 1:1,000. Participants in household interviews and focus groups believe that medical equipment in the Namtu hospital is outdated, not well maintained and often out-of-order.

Lashio General Hospital is the only tertiary public hospital in the region that delivers multi-specialty services, and is located approximately 50 km from Bawdwin. Although limited in terms of emergency care, it remains the only option for life (or limb) threatening conditions. There is also a private Aung hospital in Lashio, which has limited services. Bawdwin and Namtu residents rely heavily on Lashio General Hospital and private hospitals for their major health problems.

There is one national program relating to employer-liability, which dictates mandatory risk pooling, for child and family, maternal, sickness and employment injury. Legislation has not yet entered into force for unemployment benefits, disability benefits, survivor pension (deceased's dependent widow(er), children, or parents) and old age pension. Disability benefits mainly come from social insurance, but in 2015 its effective coverage was only 0.4% of the population.

The average number of patients per doctor for the Bawdwin and Tiger Camp villages, Namtu and the Myanmar average is presented in Figure 5.64. Plates 5.93, 5.94 and 5.95 show three healthcare facilities in the region.

Questionnaires completed at the focus group interviews in the Hu Hsar village tract reported a significant level of dependence on services available in Bawdwin village. Health services accessed by questionnaire respondents included trauma treatment, obstetrics, supply of medicine and referrals to higher order centres. While all respondents considered the level of services provided was mediocre, the only alternative for these health services was in Namtu, which is significantly further and costlier. Similarly, questionnaire respondents from the focus group at Hin Poke village tract and Loi Mi farm also used the Bawdwin health services and had similar concerns about accessing healthcare at Namtu.

Community health profile

General physical and mental health

The health baseline survey of 217 households across Bawdwin and Namtu was used to inform the general physical and mental health profile of Bawdwin and Namtu communities. This involved a household survey questionnaire, medical and clinical examination form, 24-hour dietary recall questionnaire, and seasonal availability of food questionnaire as described in Table 5.76.

Overall, the population of Bawdwin and Namtu seems to be in good health with low numbers of chronic disease, infectious disease and vector-borne disease. Figure 5.64 presents the types of medical conditions Bawdwin and Namtu respondents recorded in 2018. The high incidence of gastritis in comparison with other reported medical conditions is likely due to the prevalence of *H. Pylori* in Asian countries (50 to 90%). Approximately 87% of Bawdwin respondents and 80% Namtu respondents considered their health in the last year (either their own or their children's) as good or very good. Only 3.2% reported themselves to be in poor health and 13.8% reported that they were in fair health. Approximately 90% of Bawdwin respondents reported their mental health over the last year as good or very good with only one individual reporting poor mental health. In Namtu, 77% of respondents reported their mental health over the last year to be good or very good, with no-one reporting poor mental health.

Physical examinations

Blood pressure measurements

Blood pressure was measured in a total of 390 individuals (225 females and 165 males) which included only four infants. Hypertension/high blood pressure (systolic blood pressure greater than 140 mm Hg) was found in (15.1% of females, and 14.6% of males), but severe hypertension (greater than 180 mm Hg) was found in only 1.3% of females and 0.6% of males. The reported prevalence of high blood pressure in Myanmar is approximately 30% for both sexes. The collected data reflects the generally good state of health of the participants and corresponds with the low levels of obesity and other metabolic disorders.

Anthropometry measurements

Anthropometric measurements were taken to develop estimates of under-nutrition (including stunting and wasting) and over-nutrition (over-weight and obesity) in infants, children, adolescents and adults in the surveyed Bawdwin and Namtu households.

Body mass index (BMI) is the internationally recommended indicator of over-weight and obesity in children, adolescents and adults (WHO, 1995). Of the 39 children aged six to 18 years, 46% were underweight, 8% were within the overweight and obese range, and 46% were within the normal BMI range. Of the 353 adults aged 19 to 60, only 13% were underweight and 29% were overweight or obese, with the remaining 59% within the normal BMI range (Figure 5.64). This is consistent with approximately 23% of adult males and 39% of adult females having a high waist circumference.

BMI values above the acceptable range can be indicative of potential for several lifestyle-related conditions including high blood pressure, heart disease, type 2 diabetes and increased mortality. High waist circumferences are associated with increased risk of cardiovascular disease. Of the respondents in the Bawdwin and Namtu study areas, respectively, only 3.0% and 4.7% suffered from diabetes in the previous year (Figure 5.64), and approximately 15% of individuals have high blood pressure (Figure 5.64).

Acute, chronic and severe chronic malnutrition (lack of proper nutrition) prevalence in infants (aged 5 years or less) can be determined using weight-for-age, weight-for-height and height-for-age as indicators. Severe wasting and obesity are indicated by a weight-for-height value three standard deviations below or above the WHO median value (growth standard), respectively (WHO, 1995). Of the 24 infants measured, three males (13%) showed evidence of severe wasting and one male and one female (9%) recorded weight-for-height values indicating obesity. All other values (78%) were within the normal range (within two standard deviations above and below the median). No reliable estimate can be made of the incidence of malnutrition. The quantity and nutritional value of the available food is adequate in these populations. The causes of stunting in infants is unclear but may be due to disease or illness or a lack of protein rich food (less likely).

Reproductive health and support

Survey questions regarding reproductive health were asked to women between 17 and 45 years of age; however, the total number of responses varies between questions, possibly due to respondents choosing to not answer some questions and the nature of the questionnaire. There were no significant differences between the Bawdwin and Namtu communities.

Only three of the 188 interviewed married women were pregnant at the time of the survey. Approximately 77% of respondents reported access to prenatal care and 77% reported giving birth (on at least occasion) at a health service institution. Of the respondents, 76% received tetanus vaccination, 76% took iron supplements and 69% took Vitamin A supplements.

Only 9% of respondents reported difficulty in getting pregnant for more than one year, implying generally good reproductive success. The reported total number of pregnancies per woman ranged from 0 to 10. Only six of the 165 respondents did not have children.

The median number of children for those with children was three, with 454 children in total. Difficulties carrying to term was reported by some respondents, with one woman reporting seven pregnancies and five miscarriages or stillbirths and another reporting five pregnancies and four miscarriages or stillbirths.

Rates of early miscarriage and foetal wastage were well within normal ranges. The total number of early miscarriages and late miscarriages plus stillbirths (59) equates to 13% of living children (although the numbers are inconsistent with the total exceeding the individual categories). Miscarriage in the early stages of pregnancy is common. Studies show that approximately 15% to 20% of women who know they are pregnant have a miscarriage at some point before 20 weeks of pregnancy, with 80% occurring in the first 12 weeks. Another 38 children (8% of living children) died before the age of 5 years.

Overall, the surveyed women reported an overall healthy reproductive status, as most had successfully borne several children and few reported difficulties getting pregnant.

The rate of infant and child death (less than 5 years old) in Myanmar is high at 49 deaths per 1,000 live births in 2018 (approximately 5% mortality) (WHO, 2019) compared to more developed countries in the region. There is no apparent trend in cause of death. However, infectious disease accounts for approximately 30% of cases. The rate of annual childhood mortality based on data from Namtu Town hospital varied between 6 and 20 deaths per 1,000 live births (between 0.6% and 2.0% mortality), lower than the national rate.

The crude birth rate, crude death rate, infant mortality rate and maternal mortality rate in Namtu township, Shan State and nationally is presented in Figure 5.64.

Plate 5.93 Sub healthcare centre (Lower Tiger Camp)

Plate 5.94 No. 7 Hospital (Pyi Taw Aye)

Plate 5.95 No 5. Hospital (Tha Ta La ward 4)

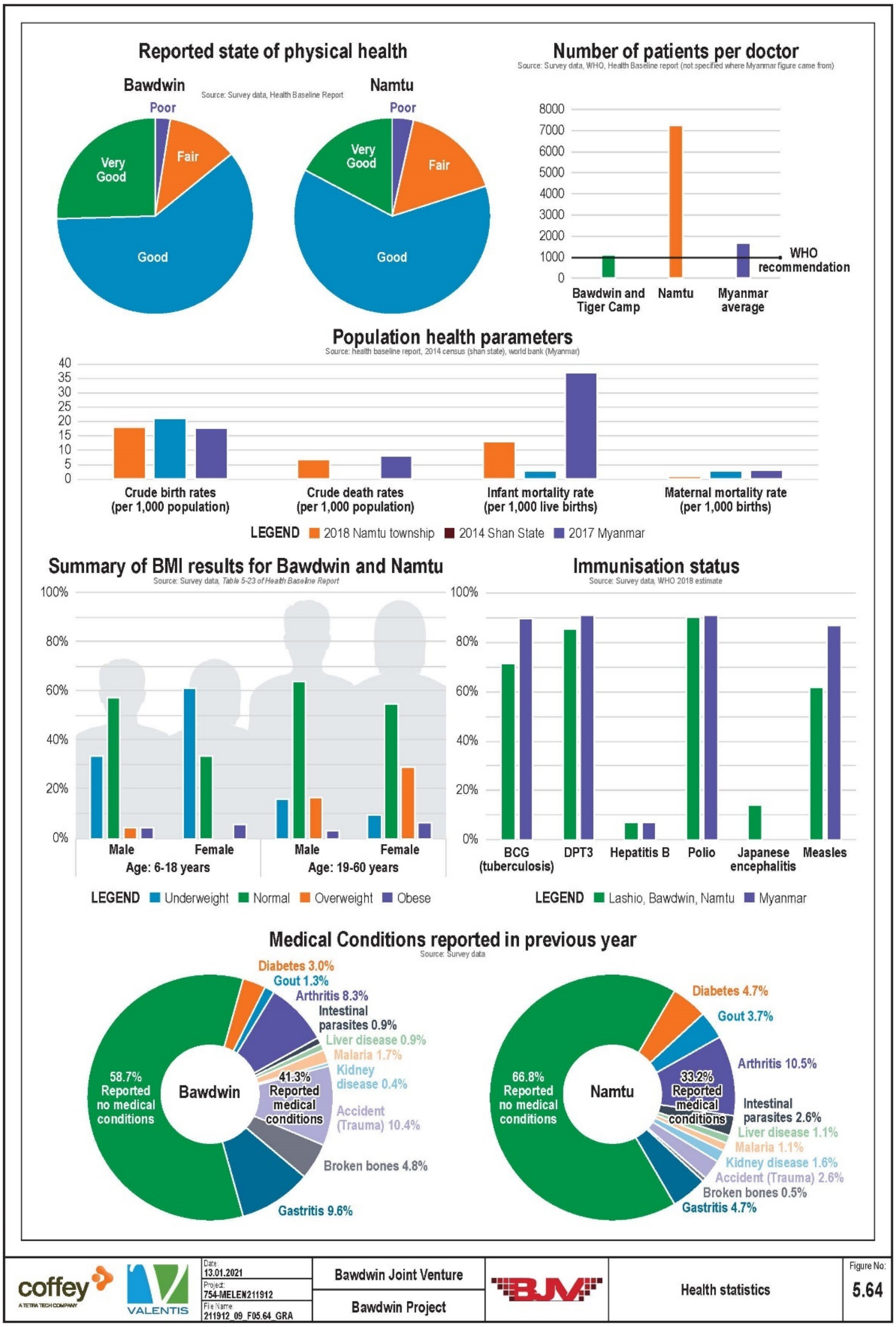

Figure 5.64 Health statistics

Immunization status

The 2018 WHO immunisation schedule for Myanmar recommendations vaccination against the Bacillus Calmette Guérin, hepatitis B, diptheria, haemophilius influenzae type b, polio, rubella, measles, tetanus, pneumococcal conjugate and Japanese encephalitis (WHO, 2019).

Immunization information was provided for 42 infants ranging in age from 1 to 55 months. Not all mothers were able to produce a health care card. Coverage for measles was 26 infants (62%), BCG (Bacillus Calmette-Guérin) 30 infants (71%), polio 38 infants (81%), DPT3 (diphtheria, pertussis and polio) 36 infants (75%), hepatitis B 34 infants (81%), and Japanese encephalitis 6 infants (14%).

The achieved immunization rates in the surveyed communities compare reasonably well with the 2018 WHO and UNICEF (2020) estimates for Myanmar as a whole (BCG 90%, DTP3 91%, polio 91%, measles 87%). Approximately only 50% of all children in Myanmar 12 to 18 years old will complete the full recommended immunization schedules, as there are difficulties in achieving full immunization such as geographical isolation, low economic status, younger maternal age, fewer antenatal care visits, and no maternal tetanus vaccination.

Immunisation rates in study areas compared to the national average is shown in Figure 5.64.

Mortality and morbidity

Morbidity refers to the rate of disease in a population and mortality refers to the number of deaths in a given time or place. Table 5.83 summarises the most prevalent health problems in Bawdwin and Namtu in 2018 (according to health records from the Namtu township Health Department), and Table 5.84 summarises the leading causes of mortality in Namtu township over 2016, 2017 and 2018.

Table 5.83 Leading causes of morbidity in Bawdwin and Namtu township in 2018

Rank	Bawdwin and Tiger Camp	Namtu township
1	Acute viral infection	Acute respiratory tract infection
2	Injury (not specified whether work related or not)	Gastritis
3	Acute respiratory tract infection	Acute gastroenteritis
4	Gastritis	Acute viral infection
5	Skin diseases	Hypertension

Table 5.84 Leading causes of mortality in the Namtu township

Rank	Cause of mortality		
	2016	2017	2018
1	Acute gastroenteritis	Cardiovascular accident	Cardiovascular accident
2	Acute respiratory tract infection	Koch’s Lung (tuberculosis)	Narcotic abuse
3	Cardiovascular accident	Retroviral infection	Koch’s Lung (tuberculosis)
4	Acute viral infection	Narcotic abuse	Preterm/low birth weight
5	Koch’s Lung (tuberculosis)	Gastrointestinal tract bleeding	Hepatic encephalopathy

Health problems occurring in Namtu and Bawdwin communities are similar to those commonly seen across northern Shan State, where gastritis, acute viral infection and respiratory tract infection were also the leading causes of morbidity. However, skin diseases (such as allergic dermatitis or fungal skin infections) were more common in the Bawdwin area and narcotic-related deaths (mainly drug overdoses) were significant in Namtu township in 2017 and 2018. The high rates of narcotic abuse do not correspond with the low rates of narcotic use reported by survey respondents (only two respondents at Namtu admitted to the use of illicit substances). Smoking, betel nut and alcohol were reported as being commonly used/consumed in Bawdwin and Namtu. Smoking cigarettes and alcohol use were higher in the Namtu communities than at Bawdwin but betel nut use was slightly lower than at Bawdwin.

Hospital records from 2016 to 2018 show no evidence of occupational diseases in Namtu township, although, some staff in Namtu Hospital mentioned lead poisoning cases in 2003 in Namtu. Hospital records of the lead cases were not available.

Communicable diseases

Of the 430,056 total deaths in Myanmar in 2016, 18% are estimated to be due to communicable diseases (13.3% to infectious and parasitic diseases and 4.7% to respiratory infections) (WHO, 2020). Of the deaths caused by infectious and parasitic diseases, tuberculosis (43.3%), diarrhoeal diseases (20.9%), and HIV/AIDS (13.6%) were the most common (WHO, 2020). Of the deaths caused by respiratory infections, 99.8% were estimated to be caused by lower respiratory infections. This is comparable to trends elsewhere in South East Asia, where 18.1% of deaths in 2016 are estimated to be due to communicable diseases (12.4% infectious and parasitic diseases and 5.7% respiratory diseases). Of the deaths caused by infectious and parasitic diseases, 38.0% were by tuberculosis. Globally, 14.9% of deaths were estimated to be caused by communicable disease in 2016. Of the infectious and parasitic diseases (9.7% of total deaths), 23.5% of these could be attributed to tuberculosis.

Nutrition

Food and nutrition play a vital role influencing health. Food consumption and food contamination studies were undertaken to understand the nutritional health of individuals within the Bawdwin and Namtu communities.

Food sources and seasonal availability of foods

Food sources are similar between Bawdwin and Namtu communities. Fresh food is bought from the local market three to six days per week by 44% of households in Bawdwin and 73% of the households in Namtu, with these foods generally available year-round. Namtu households purchase packaged food from the local market more frequently that the Bawdwin community (41% vs 22%). Wild sourced or hunted food is rarely reported in either community. In both communities about 25% of all fresh food is locally grown by friends and neighbours seasonally, with availabilities ranging from two to eight months. The reported seasonal availability of foodstuffs (either grown or hunted locally or bought from markets) varied depending on the respondents (nineteen households were asked about seasonal availability) and the source of the food, therefore it is assumed for the food frequency questionnaire that all foodstuffs are available all year.

24-hour dietary recall and nutrition at survey communities

Households were asked to report the main ingredients or dish names that were consumed in the previous day. In the 1,700 meals recalled, the two most commonly reported main ingredients in meals were rice (515 meals) and green vegetables (383 meals) with fish (179 meals), chicken (108 meals) and eggs (93 meals) as the main protein sources. This is consistent with the findings of the survey of nutrition, with the same dominant carbohydrate and protein sources. There were only small differences in the consumption frequencies between Bawdwin and Namtu, with dietary recall and survey of nutrition both indicating that the diets in Bawdwin and Namtu are very similar.

Consumption of green vegetables was high in the Bawdwin and Namtu study areas, with mean consumption varying between 4 to 6 times a week and daily. Fresh fruit was reported to be consumed at an average of two to three times a week. These results may be a consequence of the timing of the survey (May 2019), but direct observation implied availability of garden produce all year. The nutritional status of communities is directly influenced by access to an adequate quantity and quality of food. Food selection is greatly influenced by household income and other economic factors (particularly family size) and seasonal food availability.

Metal concentrations in food

Two to three meals (considered to be representative of food eaten over a 24-hour period) were collected from selected households, combined, blended, frozen and shipped to the Queensland Health Forensic Science Services laboratory for analysis of metals and metalloids.

A number of metals such as arsenic, cadmium, lead and mercury are naturally occurring in food. Metals can also occur as residues in food because of their presence in the environment (soil, water or the atmosphere), as a result of human activities such as artisanal mining, farming, industry or car exhausts, or from contamination during food processing and storage.

Food standards have been determined by World Health Organization (WHO) and the Food and Agriculture Organisation of the United Nations (FAO) in the Codex Alimentarius Commission (WHO, 2019) for a number of contaminants and toxins in foods. Similarly, the European Commission (EC, 2010) and Food Standards Australia and New Zealand (FSANZ, 2016) also provide food standards.

Both regulatory authorities generally focussed on additives to foods (e.g., pesticides) and on those foods that can contribute significantly to the total dietary intake of a particular chemical (such as mercury in shellfish). Therefore, guidelines have only been established for cadmium; lead in plant foods; and arsenic, cadmium, lead and mercury in aquatic biota.

In both Bawdwin and Namtu, the maximum concentrations of arsenic, cadmium and lead exceeded the screening criteria as defined in the health baseline study (Appendix G). In most wards, the average concentration of lead in foods also exceeded the screening criteria (0.05 mg/kg). The concentrations of lead in the blended meals in six wards was more than double the screening criteria. The average lead level in food in Mingalar Kwe ward (Bawdwin lower village) was more than six times the screening criteria and in Yan Naing Kwe ward (Bawdwin upper village) the lead level was more than 10 times the screening criteria. Data indicates the intake of lead in food in the selected Bawdwin wards (less so in the Namtu wards) is a significant exposure pathway for residents in these areas.

Living conditions

Most residents have lived in the same dwelling since before the handover to WMM in 2009 and most heads of households have been resident for over four decades. Houses are generally made of wood or bamboo with tin roofing. Plates 5.96, 5.97 and 5.98 show examples of houses in the study area, and Plate 5.99 shows the kitchen of a house in Bawdwin.

Most of the surveyed houses have floor areas less than 50 m^2 with generally larger dwellings in Namtu compared to Bawdwin. The floor areas of surveyed houses are shown in Figure 5.65. The majority of houses were considered to have satisfactory ventilation (59% in Bawdwin and 49% in Namtu), and less than 3% of houses in Bawdwin and 17% of houses in Namtu were considered to be poorly ventilated. Most households reported that they do not cook inside the house or use an open fire inside the house where people sleep (72% in Bawdwin and 83% in Namtu).

Access to potable water

Households who participated in the health baseline survey were asked to report their normal source of potable water. Drinking water and domestic water samples were collected from households and communities and analysed in June and August 2019. Results of the drinking water sample analysis are presented in Section 5.3.3.

Drinking water in the Bawdwin study area mostly comes from streams, channels and pipes, followed by public tap and house connection. The location of key drinking water sources for Bawdwin and Tiger Camp villages is shown in Figure 5.66. Nam Pangyun cannot be used as a water source as several public toilets are located along the stream bank making it a wastewater stream.

Most water source infrastructure was reported by interviewees as satisfactory (drinking water from uncovered tanks and undeveloped sources (e.g., springs and wells) with some attention paid to hygiene), a smaller number were described as good (potable water from covered tanks or other protected sources) and very few were unsatisfactory (unprotected sources with evidence of water pooling, mosquito larvae present and area contaminated with household wastes). Breakdown of the condition of drinking water infrastructure (as reported by interview respondents) is presented in Figure 5.67.

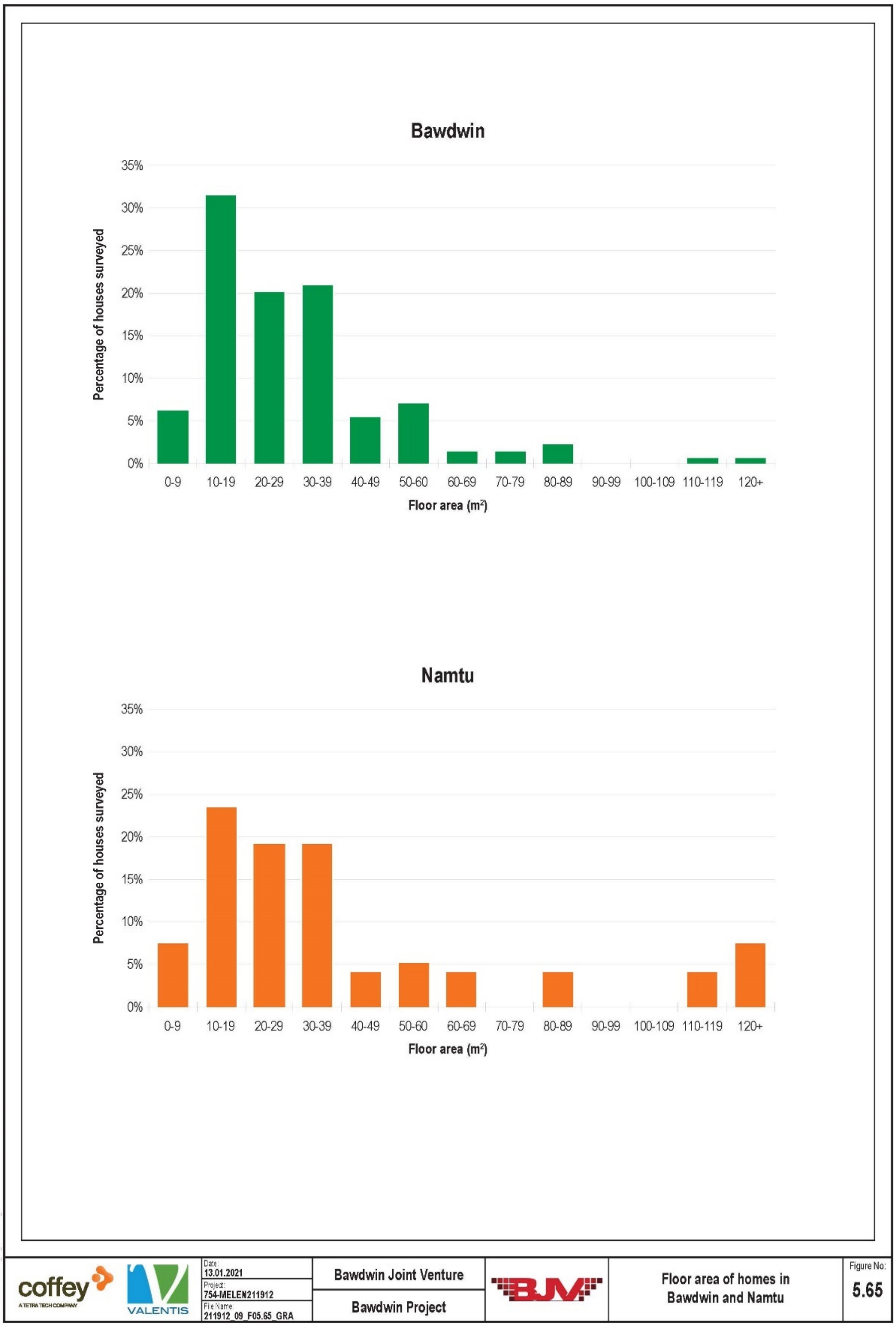

Figure 5.65 Floor area of homes in Bawdwin and Namtu

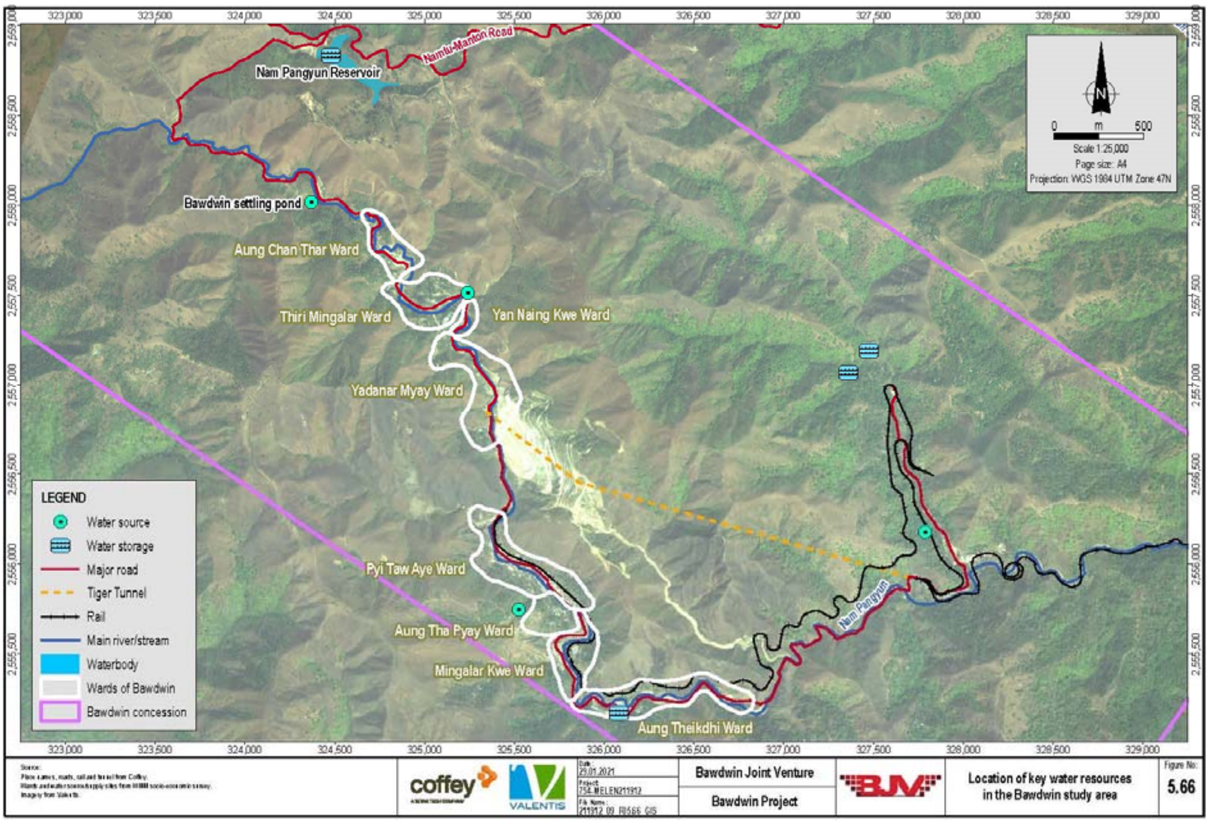

Figure 5.66 Location of key water resources in the Bawdwin study area

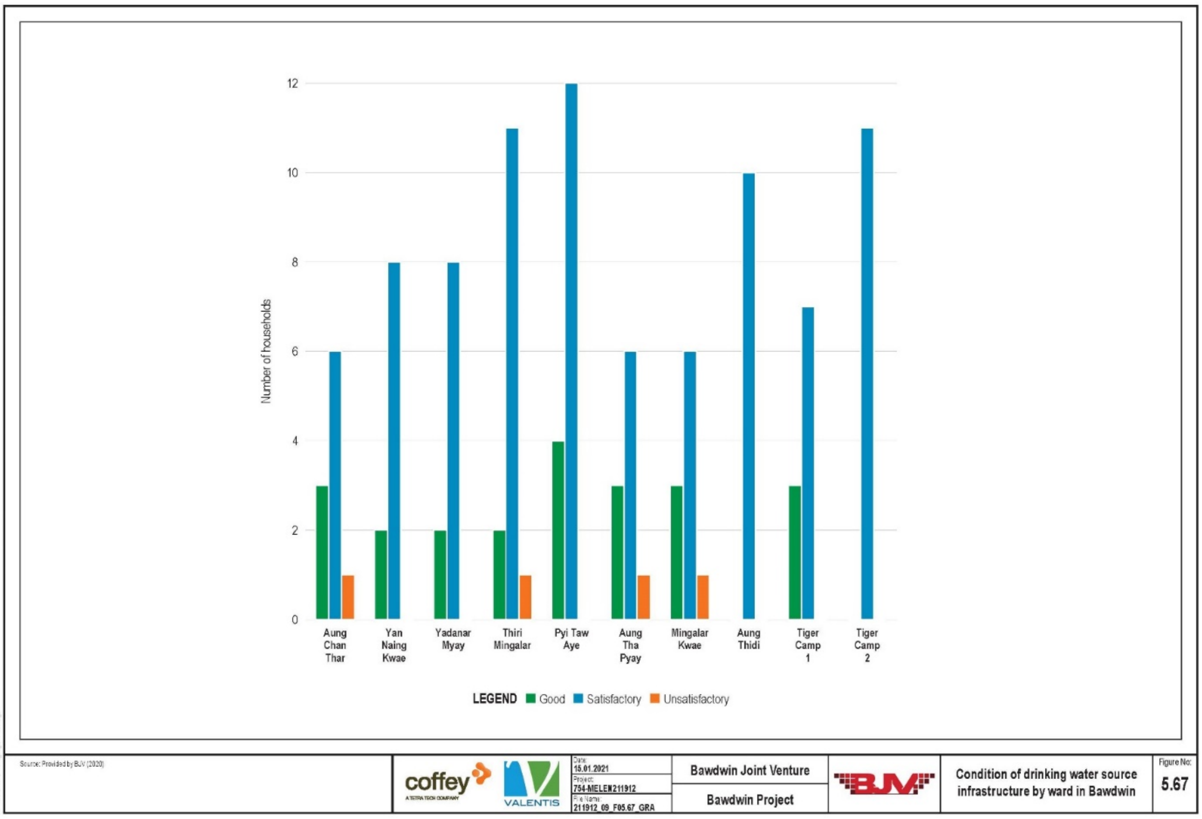

Figure 5.67 Condition of drinking water source infrastructure by ward in Bawdwin

In all Namtu Tha Ta La wards the Kho Mo Reservoir, located approximately 2 km south of the Myitnge River at Namtu, is the main source of drinking water. WMM built tube wells in some wards as the reservoir does not have sufficient water for the whole Namtu area during the dry periods. Most water source infrastructure is considered satisfactory, followed by a smaller number described as good and very few described as unsatisfactory. The location of key drinking water sources for Namtu is shown in Figure 5.68. Breakdown of the condition of drinking water infrastructure (as reported by interview respondents) is presented in Figure 5.69.

The majority of the households in Bawdwin and Namtu (79% and 75%, respectively) treat their water in some way (about 25% of households use filters and about 50% of households boil the water). Some households drink untreated water for reasons that are unspecified. During the rainy season, some households in both study areas switch to collecting rainwater or sourcing water from a nearby well, due to the high turbidity in the streams. During dry periods, some households purchase bottled water.

Sanitation and waste management

In the Bawdwin study area, almost all toilets are located along the Nam Pangyun bank and discharge directly to the stream (with no treatment) (87%), with the remaining toilets discharging into the ground (12%) or to a septic tank (0.8%) (Figure 5.70). Most toilets are common and public (66%) and few houses have private toilets (34%). Soap and water are available to wash hands at most toilets.

Namtu has a higher percentage of households with their own toilet compared to Bawdwin (71%). Two households in Namtu reported having no toilet implying they use a yard, bush, local river or stream. The primary sewage disposal method in Namtu is for sewage to drain to the ground (67%) or a septic tank (27%) (Figure 5.70). Soap and water are available to wash hands at the majority of toilets in the area. Common toilets are located throughout Namtu and typically shared between four and five households. The only exception is in Tha Ta La ward 7 which has limited space for a common toilet. A few senior and officer houses have separate toilets that drain to a stream or river. Plate 5.100 is an example of a toilet in Namtu.

Solid waste management is an issue in the Bawdwin and Namtu study areas which negatively impacts the environment. Whilst 74% of households in Bawdwin and 97% of households in Namtu reported having waste management systems in the field survey, this primarily involved burning or other disposal methods including dumping into nearby streams. Uncontrolled dumping and burning of rubbish are commonly practiced and result in land, water and air pollution. Due to limited space, financial limitations, lack of enforcement and social awareness issues, there are no designated dump sites for solid waste. Plate 5.101 shows an unofficial waste dumping site.

5.9.8 Environmental health exposure pathways

Environmental exposure pathways and impacts for people living and working near mining operations have been widely studied around the world. Understanding the characteristics of contaminants that may be exposed and the behaviour of people in these areas, determine the likelihood exposure and absorption of such contaminants.

The substances and hazards identified as likely contaminants of potential concern for the baseline health assessment of Bawdwin and Namtu included:

- Metals either naturally occurring or elevated due to historical mining or processing activities.
- Particulates and gases as a result of dust generation and combustion of fossil fuels.
- Microbial presence due to inadequate sanitary or hygiene practices.
- Excessive noise that may negatively impact health.

Since the Bawdwin project will be occurring in a ‘brownfields environment’ that has had a long history of lead-silver-zinc mining and smelting, metals and in particular lead are deemed to be the key contaminants of concern.

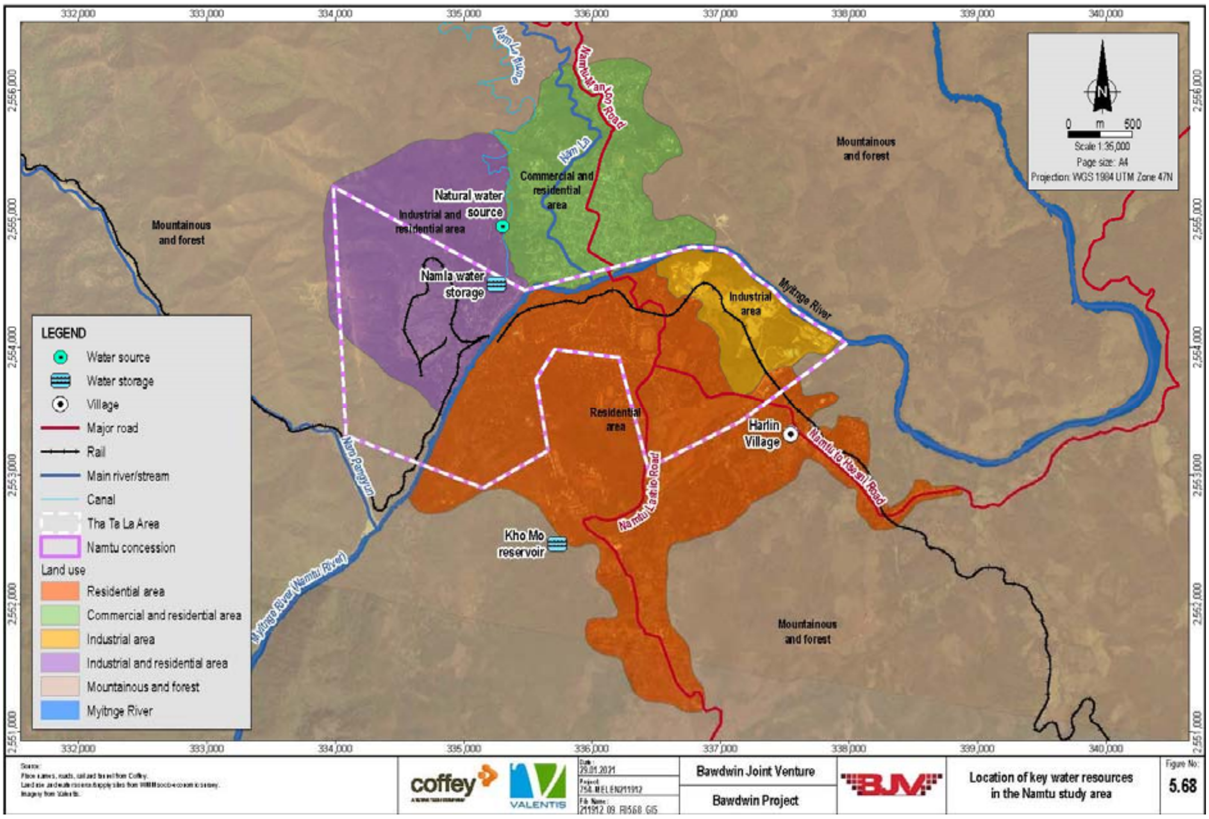

Figure 5.68 Location of key water resources in the Namtu study area

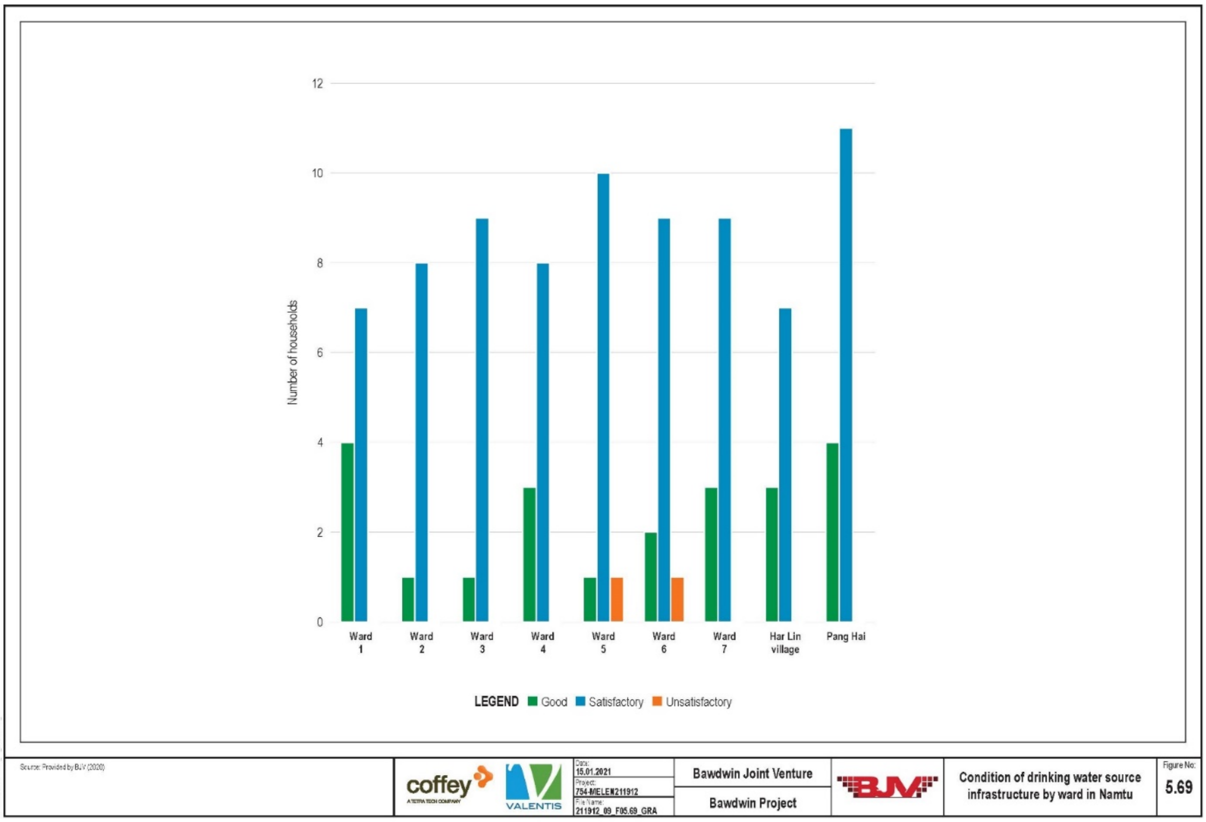

Figure 5.69 Condition of drinking water source infrastructure by ward in Namtu

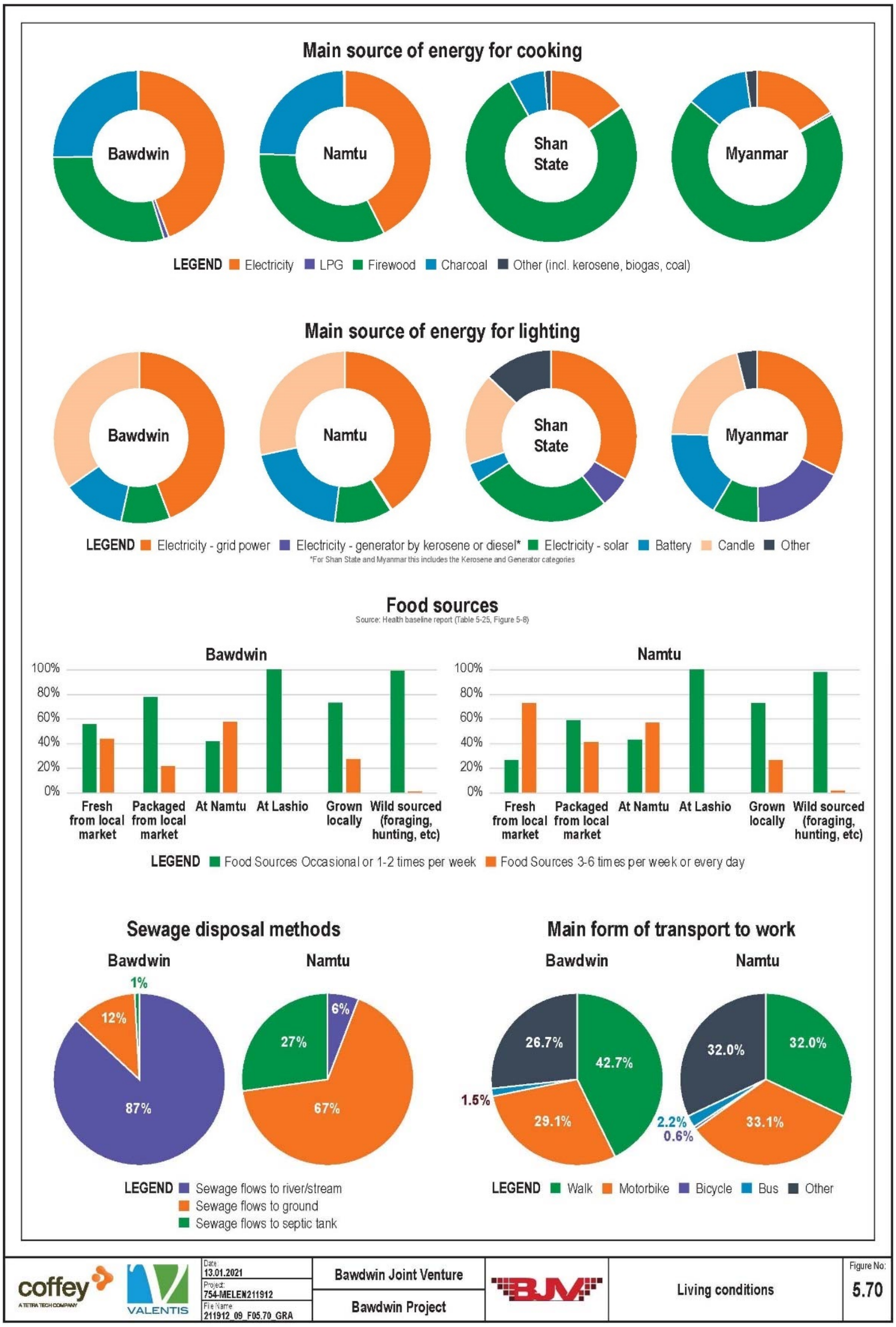

Figure 5.70 Living conditions

Plate 5.96 Housing in Bawdwin study area

Plate 5.97 Housing in Namtu study area

Plate 5.98 House in Yan Naing Kwe ward

Plate 5.99 Kitchen of a house in Bawdwin

Plate 5.100 Toilet facility in Namtu

Plate 5.101 Waste dumping site in Bawdwin mine area

Contaminants such as particulate material and metals can cause toxic and other health effects in humans. Chronic exposures to certain metals can cause a number of long-term health effects. Metal toxicity is dependent on the route of exposure (primarily entering the body's system via inhalation or ingestion), the type of metal and what form it is in which will also influence its absorption into the body. Metals that are inhaled or ingested (via sources such as food or drink) have the potential to cause adverse health effects, depending on the dose and period of exposure. Metals such as arsenic, cadmium, copper, lead, mercury, selenium and zinc usually occur in soil at low concentrations as a result of natural process such as weathering of rocks and minerals.

Particulates in airborne dust enter the body via inhalation. The very fine particulates are able to reach the lower parts of the lung where they may become lodged or enter the systemic system. Laboratory and epidemiological studies have identified that these particles, if present in elevated levels, have the potential to cause adverse health impacts in susceptible people.

People living near lead mining and processing operations (even ones currently not in production, such as the historical Bawdwin mine) may be exposed to lead (and other contaminants) by breathing dust particulates in air, drinking water, eating foods, or swallowing dust or dirt that contain lead. Fresh vegetables grown in lead containing soils may have lead dust particulates on the surface and hand-to-mouth contact may also occur after exposure to lead-containing soil or dust. In humans, exposure to lead can result in a wide range of biological effects depending upon the level and the duration of the exposure. Health effects range from inhibition of enzymes to the production of significant changes to body functions and death. Such changes occur over a broad range of doses.

Environmental exposure pathways

The communities of Bawdwin and Namtu share many similarities; both have been and are being exposed to the impacts of environmental degradation brought about by a long history of mining and smelting in the local area. Currently the exposure to contaminant metals is higher at Bawdwin than in Namtu, due to the rural nature of the communities in the Bawdwin concession area and the local geology with high levels of natural as well as mine-derived contaminants. However, historical and current processing activities at Namtu is also likely to contribute to exposure of contaminants. Current mineral processing at Namtu is being undertaken by other companies that are not linked to the project.

The environmental media and likely exposure pathways identified in this baseline assessment include:

- Ingestion of lead from dust or other material on hands and face
- Inhalation of vaporised lead when smoking with hands contaminated with dust or other material containing lead
- Direct ingestion of lead and arsenic in water used for cooking.
- Incidental ingestion of lead and arsenic water during bathing, washing, cleaning or swimming.
- Inhalation of fine dust particulates (PM_{10}) and lead in particulate matter when undertaking activities outdoors.
- Incidental ingestion of lead in dust in the ambient air.
- Ingestion of lead in dust deposited on surfaces including food, floor, toys and other materials, particularly by young children.
- Inhalation of disturbed dust indoors which contains fine particulates and lead.
- Ingestion of lead and other metal contaminants in or on locally grown foods.

Exposure assessment

An assessment of environmental exposure pathways was completed in the health baseline study (Appendix G), which was informed by socio-economic baseline study (Appendix E), as well as environmental investigations described in Section 5.1 for soils and existing contamination, Section 5.2 for groundwater, Section 5.3 for surface water, Section 5.5 for air quality and Section 5.6 for existing noise.

Investigations of air, water, and soil showed that there a range of contaminants that were recorded at elevated concentrations in Bawdwin and Namtu study areas, but particularly the Bawdwin study area. To ensure the protection of human health, international agencies have derived health-based screening criteria for water, soil and air for contaminants of concern or pollutants that may cause ecological or human health impacts.

Based on available data evaluation of metals in soil, water, air and food, the presence of lead and other metals indicates exposures to the identified receptor populations may occur via multiple exposure pathways. Contaminants of concern recorded above health screening criteria levels in the Bawdwin and Namtu study areas are presented in Table 5.85.

Table 5.85 Confirmed contaminants of concern above recommended health screening criteria

Source	Exposure Pathway	Bawdwin	Namtu
Surface water	Ingestion of drinking water. Ingestion of water used in cooking. Incidental ingestion of water during washing, cleaning, irrigation etc. Inhalation of aerosols. Dermal contact.	Antimony, arsenic, cadmium, lead, nickel, and zinc.	Lead
Groundwater (springs)		Antimony, arsenic, cadmium, copper, lead, nickel, and zinc	No data available.
Drinking water		Bacteria (*E. coli*), arsenic, cadmium, lead, manganese	Lead and manganese
Soils (general)	Inhalation of particulates. Incidental ingestion. Dermal contact.	Antimony, arsenic, cadmium, chromium, cobalt, lead, nickel, and zinc	Antimony, arsenic, cadmium, cobalt, lead, nickel, and zinc
Garden (gardens)	Ingestion of home grown produce/ animal products.	Antimony, arsenic, cadmium, chromium, copper, cobalt, lead and selenium	No data available.
Food	Ingestion of food.	Arsenic, cadmium, and lead	Arsenic, cadmium and lead
Ambient air	Inhalation of particulates. Incidental ingestion. Dermal contact.	TSP, PM_{10}, chromium, and lead	TSP, PM_{10}, chromium, lead
Dust	Inhalation of particulates. Incidental ingestion. Dermal contact.	Dust deposition and lead content	Dust deposition and lead content
Noise	Audible noise.	Noise exceedances	Noise exceedances

A preliminary conceptual site model for health exposures to contaminants of concern was developed based on the locations, behaviours of contaminants of particular concern in various source media and their potential transport. The preliminary conceptual site model forms the basis for identifying potential receptors and the selection of potentially complete exposure pathways.

The conceptual site model for the Bawdwin area and the potential exposure pathway linkages are presented in Figure 5.71.

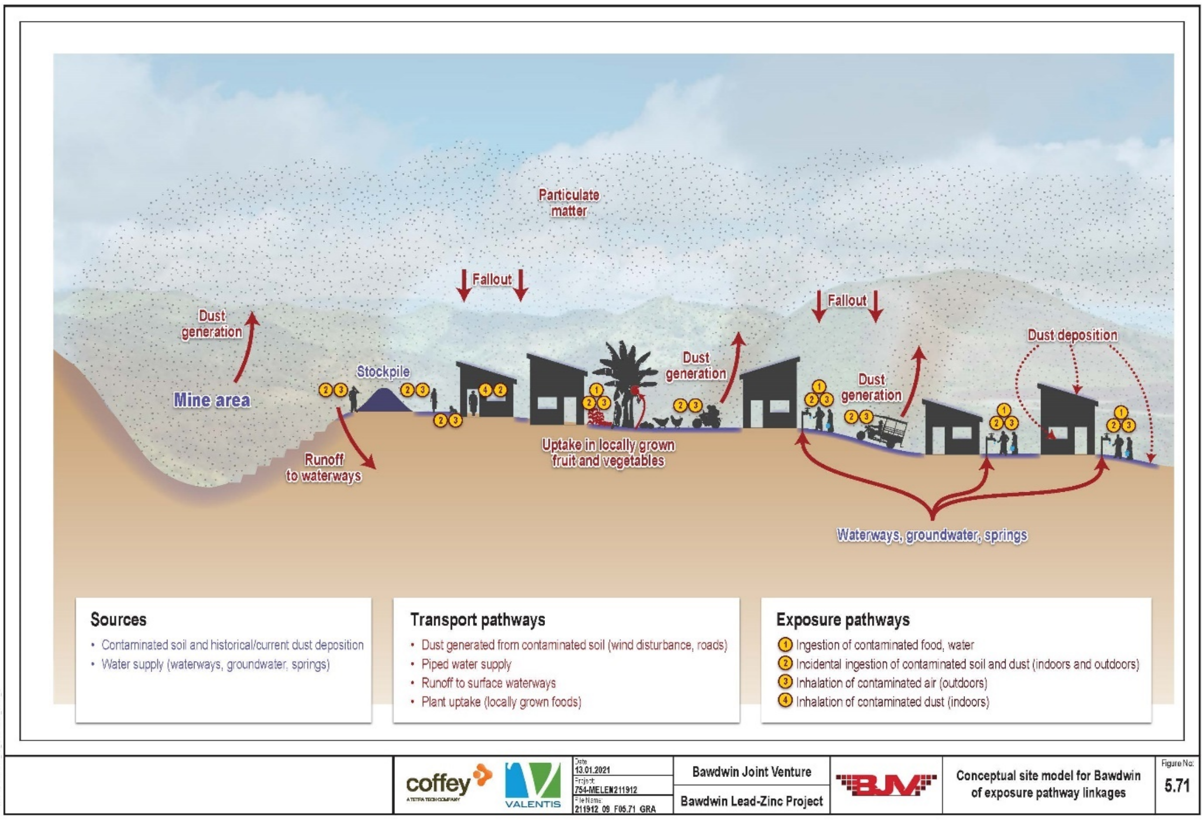

Figure 5.71 Conceptual site model for Bawdwin of exposure pathway linkages

Lead in the environment

People living near lead mining and processing operations (such as the former Bawdwin mine) may be exposed to lead by breathing dust particulates in air, drinking water, eating foods, or swallowing dust or dirt that contain lead. Lead released into air may also come from burning of solid waste that contains lead, windblown dust, burning or weathering of lead-painted surfaces, fumes and exhaust from leaded gasoline, and cigarette smoke. Fresh vegetables grown in lead containing soils may have lead dust particulates on the surface and hand-to-mouth contact may also occur after exposure to lead-containing soil or dust.

The proportion of samples exceeding the selected lead health screening criterial as well as the potential exposure pathways associated with each media are presented in Table 5.86.

Table 5.86 Exposure analysis of lead in analysed media

Media		Percentage of samples exceeding screening criteria		Potential exposure pathway
		Bawdwin	Namtu	
Household water supply		48%	6%	• Direct ingestion of lead, arsenic and other metal contaminants in water used for drinking or cooking. • Incidental ingestion of lead and other metal contaminants water during bathing, washing, cleaning or swimming.
Soil	Gridded soil sampling (XRF) (1)	100% (1) 21% (2)	-	• Inhalation of fine dust particulates (PM_{10}) and lead in particulate matter generated when undertaking activities outdoors. • Incidental ingestion of lead in soil or from dust generated when undertaking activities outdoors. • Ingestion of lead on surfaces including food, floor, toys and other materials, particularly by young children. • Inhalation of disturbed soil indoors which contains fine particulates and lead.
	Targeted soil sampling	100%	100%	
	Garden soil sampling	95%	NA	
Air	Dust deposition gauges	100%	100%	• Inhalation of fine dust particulates (PM_{10}) and lead in particulate matter when undertaking activities outdoors. • Incidental ingestion of lead in dust in the ambient air. • Ingestion of lead in dust deposited on surfaces including crops, food, floor, toys and other materials, particularly by young children. • Inhalation of disturbed dust indoors which contains fine particulates and lead.
	Particulate matter in ambient air (high volume air sampler)	56%	30%	
Food: Blended meals		75%	39%	• Ingestion of lead and other metal contaminants in or on locally grown foods, or foods grown and transported from local areas

NA – Sampling not conducted
[1]Bawdwin village areas
[2]Tiger camp area

The number of exceedances in all media tested indicates the potential exposure pathways identified for the populations of interest in Bawdwin are complete (or confirmed). Whilst there are strong indicators that a number of the exposure pathways occur for the populations in the Namtu study area, there is increased uncertainty due to the smaller dataset in this location as the focus of this study on the Bawdwin and Tiger Camp communities.

The levels of lead measured in environmental media in Bawdwin indicates that residents are potentially exposed to elevated lead (and other metals) via multiple media and exposure pathways. There is a significantly high potential these exposures may pose a serious health risk to the population in this study area.

Lead concentrations in blood

Separate to EIA health investigations, BJV on behalf of WMM undertook an occupational health investigation of the blood lead levels in workers at Bawdwin between April and June 2020. The investigation involved the use of a LeadCare ll portable lead analysis instrument to measure the concentration of lead in blood. This testing was completed for a sample of local employees and also a sample of recently engaged contract personnel. The latter were not residents locally and were therefore considered a control group for WMM workers.

The investigation tested blood lead concentrations of 85 employees and 61 contractors. Of the 85 employees, 26 were women between the ages of 24 and 59 years, and 59 were males between the age of 31 to 71 years. All the employees tested had resided in Bawdwin or Tiger Camp for at least 10 years and 65% of those tested had lived in Bawdwin for their entire life. The contract workers were all males between 17 and 57 years, who had only resided in Bawdwin for 2 to 18 days prior to testing. The age distribution and period of time working at Bawdwin tested are in Table 5.87 and Table 5.88.

Table 5.87 Age of Bawdwin workers and contract workers tested

Age	Permanent workers			Contract workers
	Male	Female	Total	Total (All Male)
<20	0%	0%	0%	8%
21-30	0%	0%	0%	36%
31-40	7%	15%	9%	26%
41-50	34%	50%	39%	28%
51+	59%	35%	52%	2%

Table 5.88 Employment length of permanent workers tested

Years employed at the mine	Male	Female	Total
<1	0%	0%	0%
10-14	3%	0%	2%
15-19	7%	15%	9%
20-24	17%	31%	21%
25-29	19%	35%	24%
30-35	31%	8%	24%
35+	24%	12%	20%

The results of the blood lead level testing are shown in Table 5.89 and Figure 5.72. All of the permanent workers had blood lead levels over the 10 µg/dL threshold above which adverse effects are expected, compared with 48% of the contract workers. Over 65% of permanent workers had measured blood lead levels greater than 40 □g/dL, and over 18% had measured levels at 65 □g/dL or over. As 65 □g/dL is the maximum level measurable by the LeadCare ll instrument, some of these workers may have blood lead levels exceeding this.

The United States CDC considers blood lead levels to be elevated when above 5 µg/dL (CDC, 2016), with adverse effects when levels are above 10 µg/dL including increased blood pressure, and impacts to renal, reproductive and neurological functions (NHMRC, 2015). Potential health effects associated with a blood lead level of over 40 □g/dL include neurobehavioural effects, blood abnormalities, cognitive impairment and gastrointestinal problems. Above 60 µg/dL, effects can include blood abnormalities, lead encephalopathy and may cause death at particularly high levels (around 120 µg/dL) (NHMRC 2015).While the blood lead levels of nearly half of the contract workers exceeded 10 µg/dL, the maximum level was 27.5 □g/dL. The contract workers were not local residents and had only been employed on site for a short amount of time. Compared to the contract workers, the permanent workers tested had considerably higher blood lead levels (Table 5.89, Figure 5.72).

Symptoms and onset of lead poisoning may vary due to individual susceptibility, but it is likely that most of the permanent workers at Bawdwin experience adverse health effects associated with the toxic levels of lead in their bodies. While some individuals with elevated blood lead levels may be asymptomatic, the signs and symptoms of lead toxicity may be more evident in the workers who had blood lead levels measured at 65 µg/dL or over.

Female workers typically had lower blood lead levels, which may be due to the type or location of employment at the mine. Most of the females surveyed did either general work (other, not in the pit or plant) (35%) or office work (27%). Most men were involved in general pit and plant work (39%). Men who worked near exposure sources often had elevated blood lead levels, such as those who did general work and the pit and plant (ranging between 30.5 µg/dL and 65 µg/dL), and geologists and samplers (ranging between 17.6 µg/dL and 65 µg/dL). Men who were less exposed also had elevated blood lead levels, such as those who did office work (65 µg/dL) and security (ranging between 37.4 µg/dL and 65 µg/dL). This indicates occupational exposure may not be the only exposure pathway for these workers.

Table 5.89 Blood lead concentration ranges and percentage of affected workers

Blood lead concentration range (µg/dL)	Permanent workers	Contract workers
<10	0%	52%
10-19	1%	38%
20-29	12%	10%
30-39	20%	0%
40-49	27%	0%
50-59	14%	0%
60-65*	26%	0%

*The maximum level measurable by the LeadCare II instrument is 65 µg/dL.

5.9.9 Land use

Most (86%) of the survey respondents of the Bawdwin study area use the land for residential purposes. Some small areas of land are used for raising domestic animals and for small shops. At Bawdwin, there is limited agricultural activity, although there are some areas used to grow vegetables and crops that are sold in local markets and some also sold in Namtu and Lashio with jengkol and corn being the primary produce being sold. Plate 5.102 shows an example of crops near Tiger Camp. In contrast, 58% of respondents in the Namtu study area use the land for residential purposes, with other land uses including and animal raising.

Approximately 21% of respondents in the Namtu study area have land they use for small private gardens (Plate 5.103 and 5.104), whereas only 1.5% of respondents in the Bawdwin study area reported that they use land for agriculture. A proportion of Bawdwin residents use gardens for subsistence use, growing seasonable vegetables. Livestock is only raised for domestic consumption. Cattle, chicken and pigs were found in both study areas. As there is limited agricultural activity in the study areas, the key food sources are the main market in Pan Heik and a bazaar near Namtu Station. No survey respondents reported hunting activities.

The different land uses within the Bawdwin study area are shown in Figure 5.73, showing buildings, residential areas, industrial and mining areas, and mountainous and forest areas. Most residential areas consist of WMM staff housing, office buildings and the hospital area.

Plate 5.102 Crops in Tiger Camp

Plate 5.103 Home garden in Namtu

Plate 5.104 Home garden in Namtu

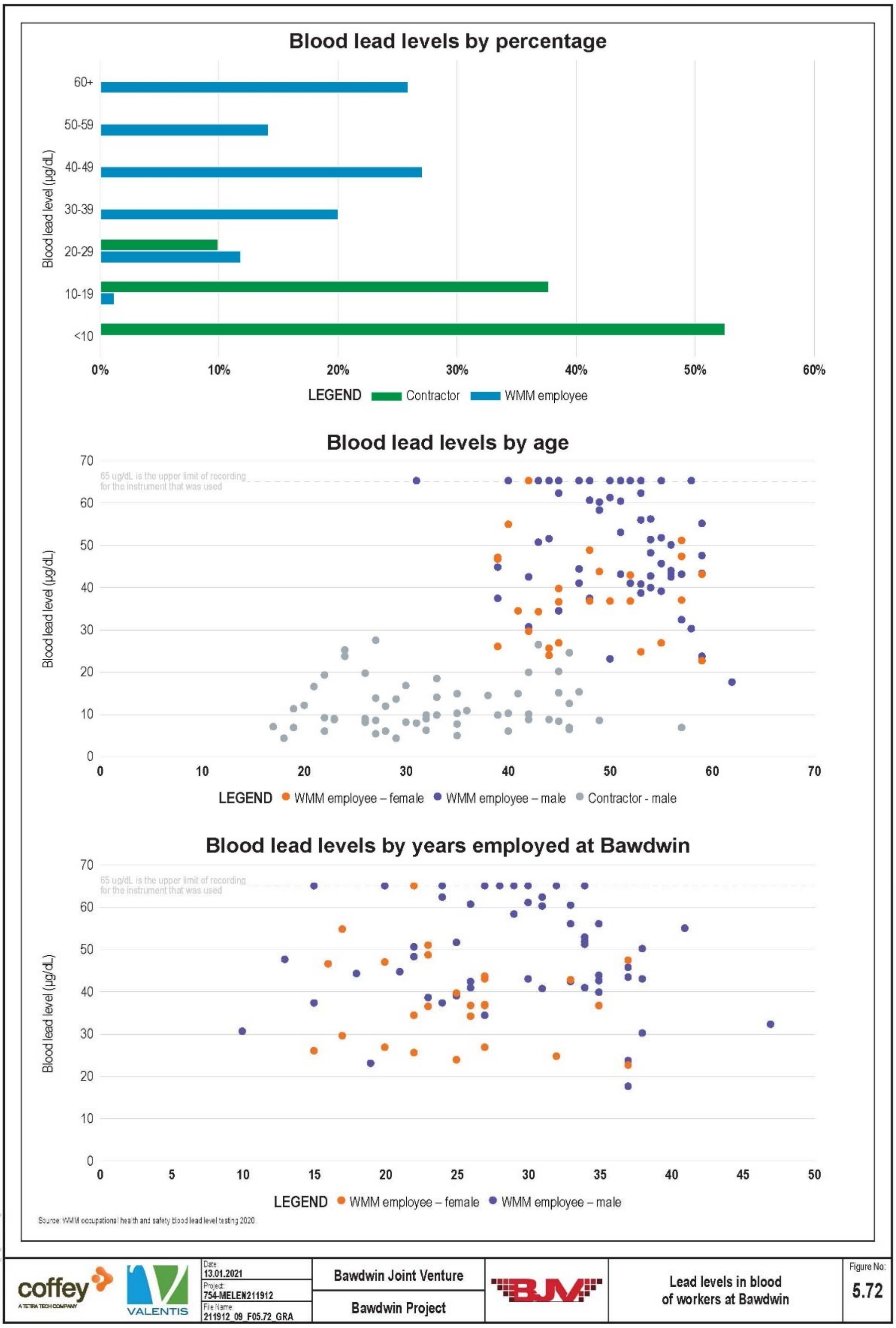

Figure 5.72 Lead levels in blood of workers at Bawdwin

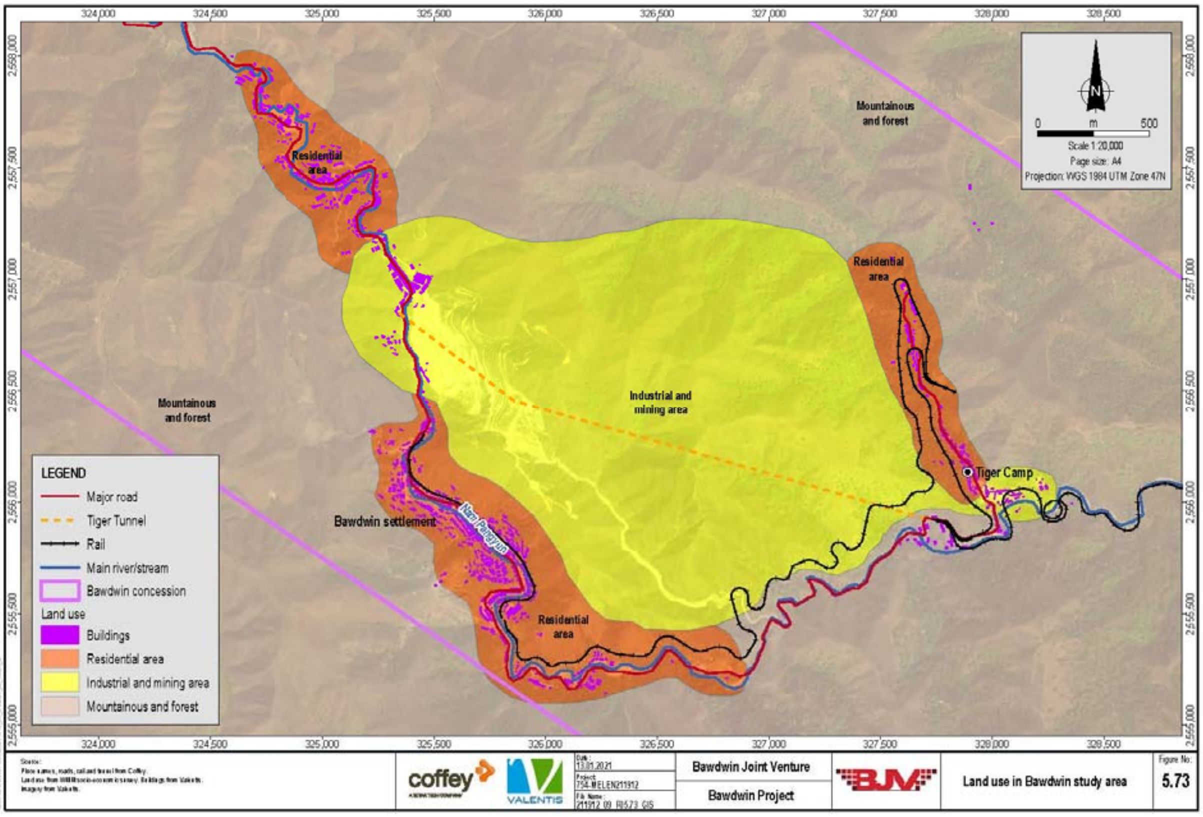

Figure 5.73 Land use in the Bawdwin study area

The different land uses within the Namtu study area are shown in Figure 5.74, showing residential areas, commercial and residential areas, industrial areas, and mountainous and forest areas. Residential areas make up the largest portion of the study area bound by mine related industrial plants.

Land use surrounding the Bawdwin concession area is primarily agricultural with the principal staple crops being paddy, corn and vegetables, while tea and jengkol are the principal cash crops. Villages in the Hu Hsar and Hin Poke village tracts, including the Nam La and Loi Mi farms, largely rely on farming, so land use is primarily agricultural in these areas. Farming households often have livestock which may roam free, including cows, goats and chickens.

5.9.10 Infrastructure facilities

Public infrastructure in the Bawdwin and Namtu study areas consists of religious buildings, recreation centres, post offices, railway stations and hospitals. There is a total of 37 community facilities in the Bawdwin study area, and 35 in the Namtu study area. The types of service each provides and their locations are presented in Table 5.90 and Table 5.91. Households in the farming hamlets in the Bawdwin concession report using the Bawdwin and Tiger Camp shops and schools, and may access other facilities when required.

A general overview of the location of various infrastructure facilities in each study area are shown in Figure 5.75 and Figure 5.76. In addition to the community (public) facilitates, private hospitals and health centres are also located within Bawdwin and Namtu.

Table 5.90 Community facilities in Bawdwin study area

Facilities	**Upper Village Wards**				**Lower Village Wards**				**Tiger Camp Wards**	**Total**
	Aung Chan Thar	**Yan Naing Kwe**	**Yadanar Myay**	**Thiri Mingalar**	**Pyi Taw Aye**	**Aung Tha Pyay**	**Mingalar Kwe**	**Aung Theikdhi**	**Tiger Camp 1, 2**	
Bazaar					X		X	X		3
Shops	X	X		X	X	X	X		X	7
Pre-school					X				X	2
School (primary, post-primary and middle)	X		X	X			X		X	5
Secondary School							X		X	2
Sikh Temple			X		X	X				3
Church					X		X			2
Cemetery				X				X	X	3
Hospital (public)					X					1
Health Centre									X	1
Monastery	X	X	X	X	X			X	X	7
Train Station									X	1
Cinema									X	1
Sporting oval								X		1
Total	**3**	**2**	**3**	**4**	**7**	**2**	**5**	**3**	**8**	**37**

Source: Appendix E

Table 5.91 Community facilities in Namtu study area

Facilities	Wards								Total
	Ward 1	Ward 2	Ward 3	Ward 4	Ward 5	Ward 6	Ward 7	Har Lin	
Bazaar						X			**1**
Shops	X	X	X	X	X	X	X	X	**8**
Industry	X					X	X	X	**4**
Pre-school		X	X			X			**3**
Primary School	X	X		X	X	X	X		**6**
Secondary School			XX						**2**
Temple (Mosque or Hindu)	X*				X	X	X*		**4**
Church			X					X	**2**
Cemetery			X						**1**
Hospital (public)				X					**1**
Monastery			X	X	X		X	X	**5**
Golf course									**1**
Total	**4**	**3**	**5**	**4**	**4**	**6**	**5**	**4**	**35**

Source: Appendix E
* Mosque temple

Villages in the Hu Hsar and Hin Poke village tracts surrounding Bawdwin are dependent on Bawdwin for access to some health and education facilities. Table 5.92 outlines the facilities available in the villages as indicated by the surveys undertaken by BJV.

Table 5.92 Community facilities in surrounding villages

Facilities	Hin Poke				Hu Hsar					
	Hsai Gaung	Kone Kayar	Nam Hkun	Nam La	Hu Hsar	Haik Taung (Pa)	Yaw Ba Gang	Haik Taung (Ka)	Lone Jar	Haik Taung
Health centre										X
Market										
Pre-school					X					X
Primary School			X		X	X	X	X	X	X
Secondary school		X			X	X		X	X	
Monastery School		X								

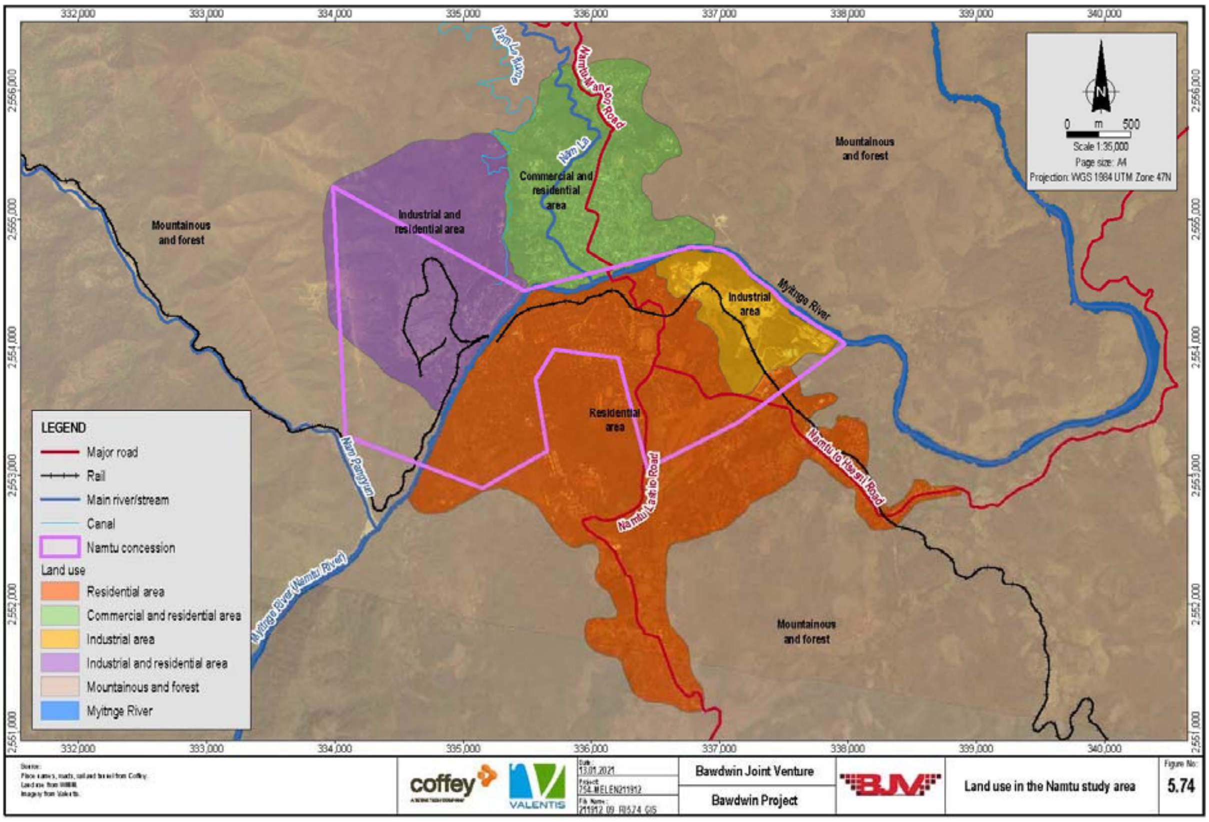

Figure 5.74 Land use in the Namtu study area

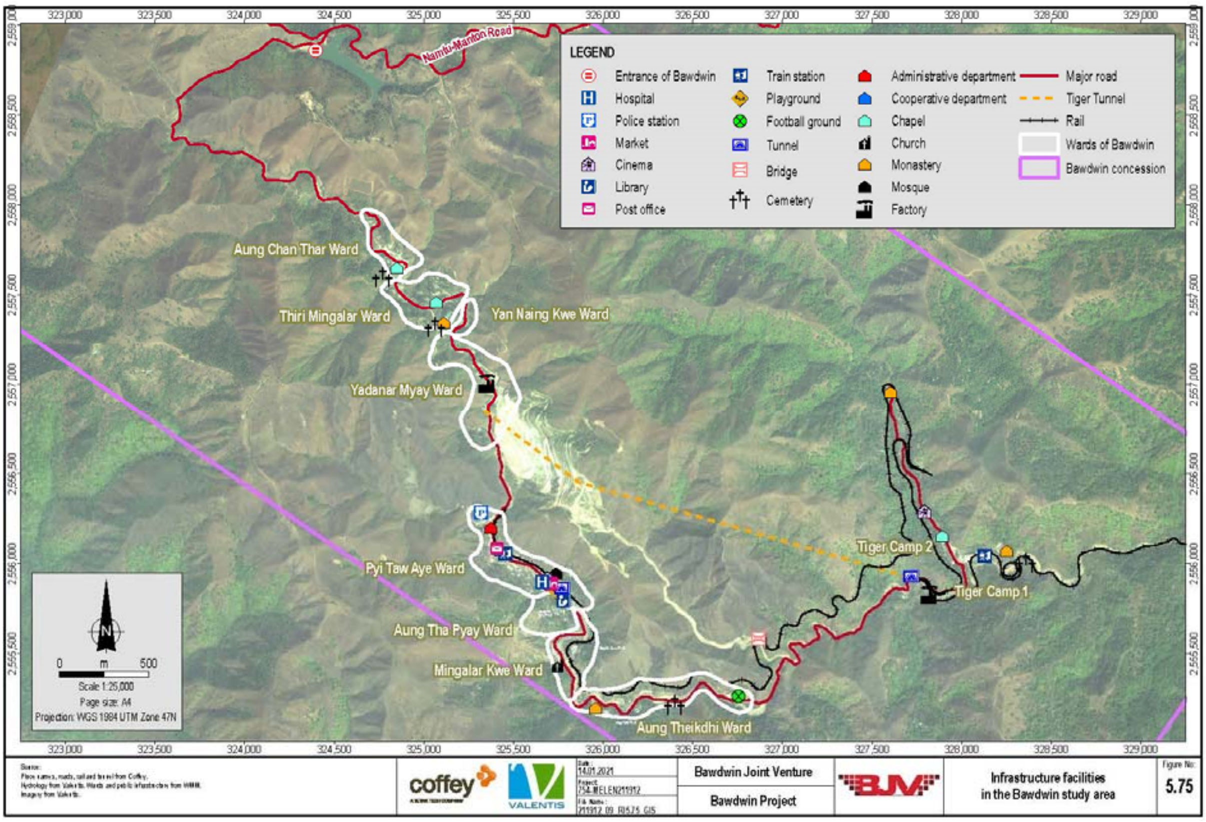

Figure 5.75 Infrastructure facilities in Bawdwin study area

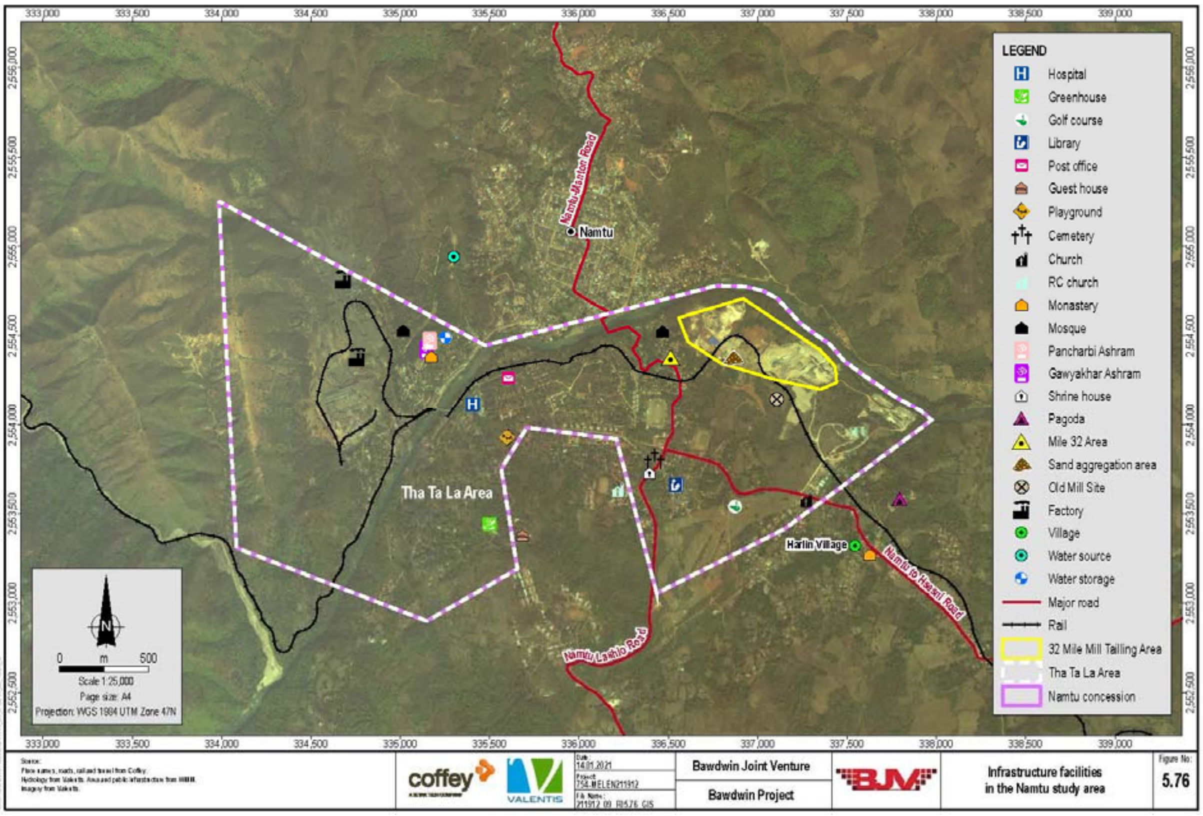

Figure 5.76 Infrastructure facilities in the Namtu study area

Water supply and infrastructure

The main resources for domestic water, water used for drinking, washing and bathing in the Bawdwin study area, are the upper Nam Pangyun and other natural water sources (springs and streams). Water from the Nam Pangyun enters the public supply system at the Bawdwin settling pond, about 0.5 km upstream of the head of upper village. From there, water is piped down the Nam Pangyun valley to the Bawdwin upper and lower villages, supplemented by piped water captured from side streams.

Public water ponds and storage are present in Bawdwin, and hold water from the Nam Pangyun Reservoir and natural water springs. Some houses have separate water pipelines.

All Bawdwin wards depend on the settling pond, particularly during the dry season. In addition to the settling pond there are two key water sources in the Bawdwin area and in the Tiger Camp area, as well as several water storage tanks for day-to-day use (often uncovered). The key water sources and storage areas in Bawdwin are shown in Figure 5.66. Water sources are easily accessible and close to wards, with storage tanks usually no further than 200 m from homes. At least one or two water sources can be used for more than one ward in the community. There is sufficient domestic water for the community within the study area, although water availability is limited during the dry season (two to three months).

According to the household surveys, most households within the Bawdwin study area use water from streams and canals (40%), followed by public tap (36%) and house connection (20%). Of the survey respondents within the Bawdwin study area, 49.2% of people collect water once a day or less, 11.9% twice a day and 38.9% three times a day or more.

Namtu water supply includes the Nam La, supplying areas north of the Myitnge River via a flume, and the Kho Mo Reservoir (a natural pond located approximately 2 km south of the Myitnge River at Namtu). The Kho Mo Reservoir supplies Tha Ta La wards south of the Myitnge River and is the main domestic water source for Namtu.). The reservoir has been noted to be insufficient during the summer period. The location of water resources in the Namtu study area is shown in Figure 5.68.

The majority of households in the Namtu study area use water from the public tap (46%), followed by river, streams and canals (34.9%) and household connection (15.4%). Most households fetch water once per day or less (49.7%), while a large percentage (26.9%) fetches water more than three times per day.

Plates 5.105, 5.106 and 5.107 show examples of water storage and sources in Bawdwin and Namtu wards.

Education infrastructure

Within the Bawdwin wards there is one nursery, one preschool, one primary school, two post-primary schools (kindergarten to grade 7 or 8), and one high school. The high school in Mingalar Kwe ward services the Bawdwin wards and Tiger Camp (Plate 5.108). Tiger Camp has an additional nursery, primary school and middle school (Plate 5.109). Plate 5.110 shows a primary school near Aung Chan Thar ward in upper Bawdwin village.

Educational facilities within the Namtu study area include three preschools, four primary schools, one middle school and one high school.

Villages from Hu Hsar and Hin Poke village tract reported having primary schools (except for Nam La and Hsai Gaung villages) but rely on the secondary and high-school service only available at Bawdwin. Loi Mi farm, within Hin Poke village tract, does not have a school and relies on schools in Bawdwin. Farms within the Bawdwin concession report using Bawdwin and Tiger Camp schools.

WMM also have a workplace training facility in Namtu; however, the facility is not actively used and needs some repair and maintenance.

Plate 5.105 Example of water storage in Namtu

Plate 5.106 Example of a water source for Bawdwin wards

Plate 5.107 Example of a water source in Aung Theikdhi ward

The closest universities to the study area is located in Lashio. There are two institutions, Lashio University, which focuses on liberal arts, humanities and science, and the Technical University of Lashio, which focuses on engineering and technology. Other universities in Shan State are located in Taunggyi, Panglong, and Kyaingtong.

Electricity

A 33 kV transmission line from Mansam Falls and Kon Nyaung hydroelectric power stations currently supplies electricity to Bawdwin mine, Bawdwin village, Wallah Gorge and Tiger Camp. The power stations are run-of-river generating plant, with output dependent on river flows. The transmission line terminates at the Bawdwin villages.

According to household surveys across both study areas, approximately 90% of the community has access to electricity for cooking and lighting. However, there is a lack of maintenance on the distribution lines, particularly clearance of vegetation due to limited budgets and security concerns, which can disturb supply and cause shorts. This leads the community to rely on charcoal or firewood for cooking and solar or battery powered lamps and candles for lighting.

In the Bawdwin study area, approximately 44.3% of households rely on electricity for their main source of energy for cooking, followed by 29.8% that use firewood, and 24.8% that use charcoal (Figure 5.70). Four of the 420 respondents reported that they depend on liquified petroleum gas for their main source of energy for cooking, and only one respondent reported using biogas. For lighting purposes, approximately 60.2% of households in the Bawdwin study area rely on electricity for their main source, with 50.7% from grid power and 9.5% from a domestic solar system. The other main sources of energy for lighting are candles (28%) and battery-operated lamps (11.7%).

In the Namtu study area, approximately 50.7% of households rely on electricity for their main source of energy for cooking, followed by 28% that use charcoal, and 11.7% that use firewood (Figure 5.70). The remining 9.5% depend on biogas for their main source of energy for cooking. For lighting purposes, approximately 52.3% of households in the Namtu study area rely on electricity for their main source, with 40.7% from grid power, 11.1% from a solar system and 0.5% from a kerosene or diesel generator. The other main sources of energy for lighting are candles (28.2%) and battery-operated lamps (19.5%).

The electricity usage in both the Bawdwin and Namtu study areas is higher than the Shan State and Myanmar average (Figure 5.70). Contrastingly, no villages in the Hu Hsar and Hin Poke village tracts or households in Loi Mi farm reported having access to electricity. Nam La farms are located in proximity to the Nam La substation however it is uncertain whether they have access to this electricity source.

Transport

The road and traffic baseline study (Valentis, 2020) assessed the existing transport route between Bawdwin and the Mandalay-China National Highway 3 (also known as the Oriental Highway), located 3 km west of Lashio. The route is discussed below in terms of the segment within the Bawdwin mine concession area, between Bawdwin and Namtu, and between Namtu and Lashio via National Highway 3.

Bawdwin mine concession area (Bawdwin)

Within the Bawdwin mine concession area, the Bawdwin Mine access road extends from the football field to the junction with the Manton to Namtu road. The access road is a single to 1.5 vehicle wide, gravel and sand road, with eight crossings over the Nam Pangyun. Whilst the road is in reasonable condition, the condition of the bridge crossings vary based on the material, with the steel and wooden bridges of moderate to poor condition. The road is shared between vehicles, motorbikes and pedestrians, and passes through Bawdwin villages and mine infrastructure areas (Figure 5.77). Plate 5.111 and Plate 5.112 show roads within the Bawdwin concession and Plate 5.113 shows a bridge crossing.

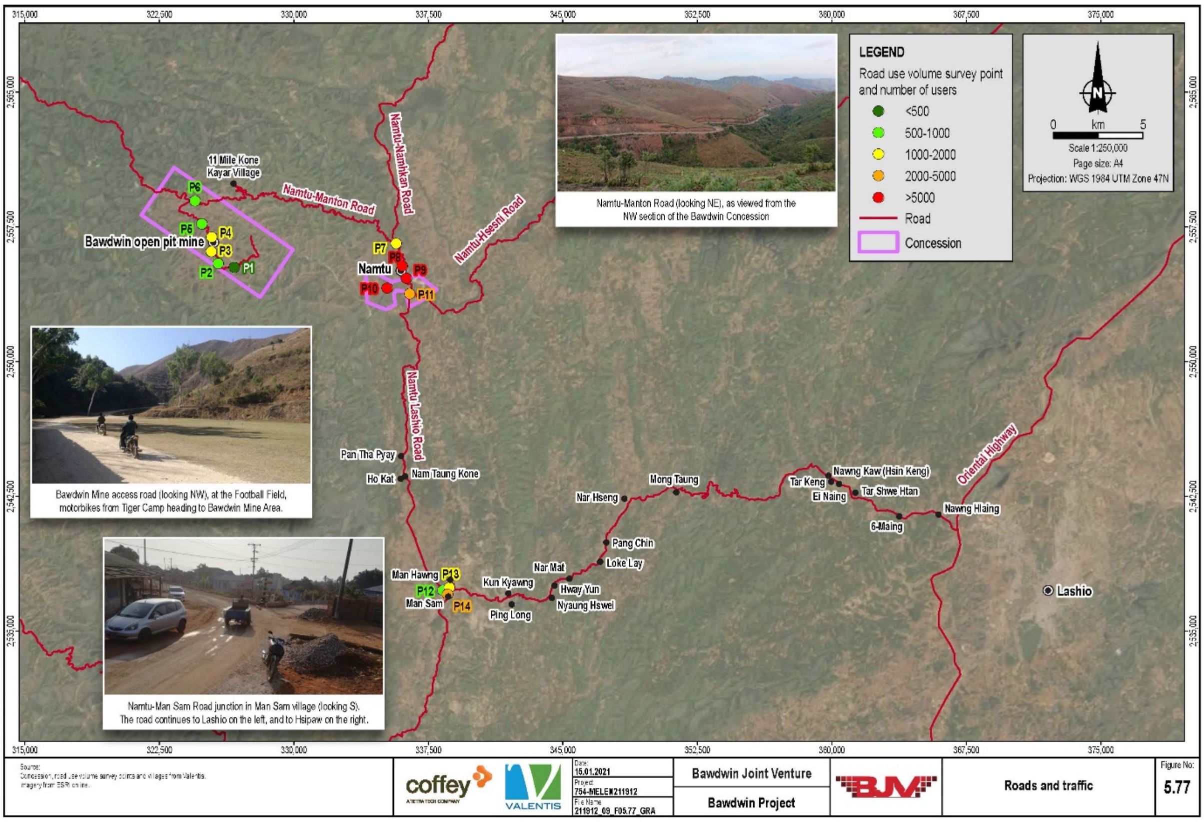

Figure 5.77 Roads and traffic

Plate 5.108 No 2. Basic Education High School (Mingalar Kwe ward)

Plate 5.109 No 4. Basic Education Middle School (Upper Tiger Camp)

Plate 5.110 Primary School in Aung Chan Thar ward

Plate 5.111 Roads in Bawdwin

Plate 5.112 Road in Bawdwin alongside the Nam Pangyun

Plate 5.113 Piers Bridge No.1

Traffic in Bawdwin comprised 83% motorcycles, 5% other motorised vehicles (trucks, minibuses and tractors), and 12% non-motorised and pedestrian traffic (Figure 5.78). Traffic was greater on weekdays during the monitoring period, with an average of 45 cars per hour, as opposed to 42 cars per hour on weekend days.

According to the household surveys, most of the respondents in the Bawdwin study area walk for their primary mode of transportation to work, followed by motorbike, then bus. Most of the remaining respondents did not report any mode of transportation as they stay at home or work from home. Given the only high school in the Bawdwin study area is within a Bawdwin ward (Mingalar Kwe), field survey respondents indicated students having to travel from Tiger Camp face difficulty in the rainy season when the access road is flooded, although this is infrequent.

Farming households within the Bawdwin concession and the nearby Loi Mi farms primarily report using motorbikes or walking to access Bawdwin and Tiger Camp shops and schools, often using access roads or unsealed roads and tracks.

Bawdwin to Namtu (Namtu to Manton Road)

The route traverses the Namtu to Manton road for 20 km between the Bawdwin Mine Road junction and Namtu, and a 4 km stretch through Namtu along the Manton to Lashio Road. This route passes through the Kyu Hsawt, Baw Twin and Namtu village tracts (Figure 5.77). This segment of the Manton to Namtu road is a predominantly single lane, poor-quality bitumen road, with occasional wider (1.5 vehicle width) sections. The road passes several waterways, including four uncontrolled floodways, and mountainous terrain, with the elevation decreasing from 1,230 m at Bawdwin to 550 m at Namtu. Consequently, the road is prone to damage and disruption from soil and rock landslides and flood debris. Despite constant monitoring and frequent repairs, the quality of the road remains poor to good.

The segment of the Manton to Lashio road passing through Namtu is in moderate to good condition. The road is a single to double lane bitumen road which crosses the Myitnge River twice. This is a busy stretch of road, shared by vehicles and pedestrians. Traffic in Namtu comprised 75% motorcycles, 8% other motorised vehicles (cars, minibuses, trucks, buses and tractors), and 17% non-motorised and pedestrian traffic (Figure 5.78). The main mode of commuting to work in the Namtu study area according to the household survey is motorbiking, followed by walking, then others, mostly tuk-tuks or trishaws (three-wheeled cabs). Other modes of transportation to work that are lesser used in the Namtu study area are bussing and biking. Weekend traffic was greater than weekday traffic, with an average of 474 vehicles recorded per hour during monitoring on weekend days and 400 vehicles per hour on weekdays.

A shared car service operates one return trip daily between Bawdwin and Namtu. Tiger Camp is also accessible from Namtu on the WMM operated rail service which operates once weekly. No public transportation is available from Bawdwin to Manton Town (approximately 25 km northwest of Bawdwin).

In both Bawdwin and Namtu most transport can be attributed to people commuting to work/school. Motorbikes being the dominant form of transport is consistent with trends observed nationally in rural Myanmar. Motorbikes can be hired for 10,000 MMK (~$7.50 USD) each way between Namtu and Tiger Camp.

Namtu to the junction with National Highway 3

Between Namtu and the junction with National Highway 3 near Lashio, the route traverses 66 km along the Namtu – Man Sam road, through ten village tracts (Figure 5.77). This is a bitumen road which varies in width between single to 1.5 vehicle width and is in moderate to good condition. The road passes through 14 villages including Man Sam and Ei Naing. Closer to the National Highway 3, past Ei Naing, the road was busy with industrial traffic, likely due to its proximity to Lashio.

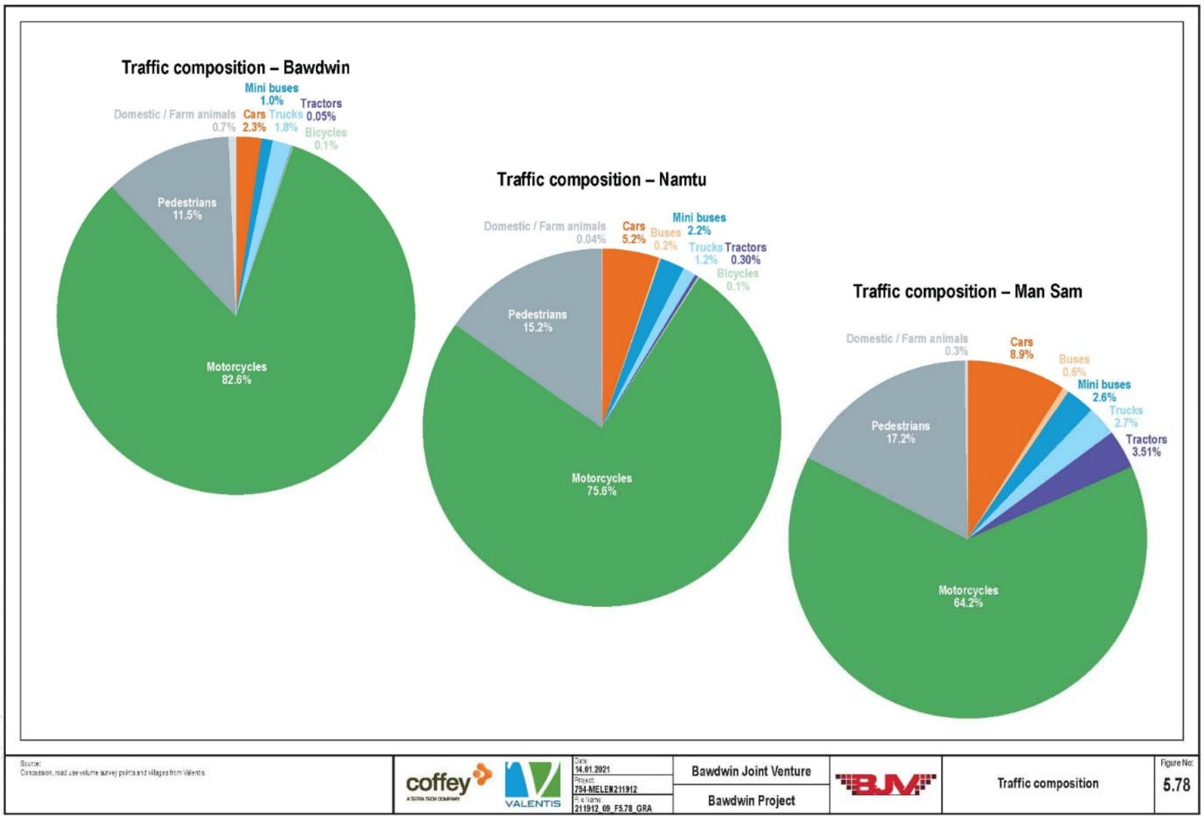

Figure 5.78 Traffic composition

Vehicles and pedestrians tended to share the road when passing through villages. Traffic in Man Sam comprised 64% motorcycles, 19% other motorised vehicles (cars, mini buses, trucks, buses and tractors), and 17% non-motorised and pedestrian traffic, including domestic/farm animals (Figure 5.78). Most of the traffic is transiting through Man Sam, due to the major junction between the Namtu to Man Sam road, Man Sam to Lashio road, and the Man Sam to Hsipaw road.

Public transport is available between Namtu and Lashio, in the form of a return minibus service with two return trips daily. A train historically ran between Lashio and Namtu townships.

5.9.11 Sensitivity of health values

This section builds on the aspects of community health discussed earlier in Section 5.9 and describes the sensitivity of health values in terms of their importance, vulnerability and resilience. Sensitivity in this context is a quantification of how sensitive the values are to change as a result of the project. Sensitivity is based on the importance of the value, the vulnerability of the value to change, and the resilience of the value in terms of its ability to overcome changes and maintain its inherent value.

The sensitivity of community health was determined by considering the current state (or condition) of community health of each receptor group, the degree to which the value is susceptible to change, and its' resilience or capacity to absorb, adapt or recover from such changes. The sensitivity is also influenced by the availability of medical treatment, the susceptibility of the people to hazardous exposures, and their understanding and/or acceptance and use of health services.

As described in Section 5.9.2, the study area was divided into groups, each with varying degrees of dependence/connectivity to the project. These were:

- Bawdwin military base
- Bawdwin upper village.
- Bawdwin lower village.
- Tiger Camp village.
- Tiger Camp farms.
- Nam La farms.
- Loi Mi village and associated farms.
- Neighbouring villages outside the Bawdwin concession area including villages in Hu Hsar, Hin Poke and Kyu Hsawt village tracts.
- Residents of Nam Pangyun valley.
- Namtu township.
- Villages along the export route.
- Project workforce (with respect to occupational health and safety).

The key receptor groups are described in Table 5.58 and shown on Figure 5.38

Definitions for each level of sensitivity are provided in Table 5.93.

Table 5.93 Importance, vulnerability and resilience definitions and ratings

	Definition	Ratings		
		Low	**Medium**	**High**
Importance	The extent to which the value is important to people.	N/A	N/A	The importance of community health is inherently high as it is fundamental to the health and wellbeing of individuals and the community.
Vulnerability	The extent to which communities are susceptible to changes in health conditions. This relates to existing health status and exposures.	Environment has a negligible effect on physical or mental health. Not currently exposed to environmental hazards. Sufficient quality water, sanitation and waste practices.	Environment may cause moderate and manageable cases of injury or illness. Currently exposed to some environmental hazards. May have degraded water quality and somewhat poor sanitation and waste practices.	Environment may cause serious, irremediable and unmanageable health effects including fatalities and serious injury and / or illness. Currently exposed to existing poor quality water, poor sanitation and waste practices, and existing exposure to environmental hazards.
Resilience	The extent to which people can adapt or recover from changes in a value. In a health context, this relates to the how readily the people impacted by change can adapt.	Low resilience; the people have no or limited capacity and/or resources to absorb, adapt to, and recover from changes to health. No appreciation or awareness of health risks and no preventative practices in place. Contaminants have a cumulative health effect, such as lead, and are not readily eliminated from the body.	Some resilience; the people have some capacity and/or resources to absorb, adapt to and recover from changes to health. Moderate appreciation or awareness of health risks and some preventative practices in place. Contaminants have a moderate health effect and are readily eliminated from the body.	High resilience; the people have experienced similar change and have the resources to absorb, adapt to and recover from changes to health. Comprehensive appreciation and awareness of health risks with preventative practices in place. Contaminants do not have a cumulative health effect and are readily eliminated from the body.

The importance, vulnerability and resilience of community health across the receptor groups are rated in Table 5.94.

Table 5.94 Importance, vulnerability, resilience and sensitivity of community health at each receptor group

Receptor group/value	Importance	Vulnerability	Resilience	Sensitivity
Bawdwin Military Base	**High** Health is highly valued by people residing or working within the military base	**High** Highly vulnerable due to the existing exposure to environmental hazards from historical mining (soil, dust, water and food), and their proximity to the project.	**Low** The key contaminants of concern (lead, and $PM_{2.5}$ and PM_{10} general dust) have a cumulative effect. Existing exposures are assumed to be high based on baseline environmental results. The military base has low resilience to changes with limited capacity and/or resources to absorb, adapt to, and recover from changes to the value or health effects.	**High**
Bawdwin upper village – community health	**High** Health is highly valued by the community.	**High** Highly vulnerable, due to the existing exposure to environmental hazards from historical mining (soil, dust, water and food), the community's proximity to the project, use of groundwater fed springs for drinking water and presence of sensitive receptors (children or women of childbearing age).	**Low** The key contaminants of concern (lead, and $PM_{2.5}$ and PM_{10} general dust) have a cumulative effect. Existing exposures are assumed to be high based on baseline environmental results. Communities have low resilience to changes with limited capacity and/or resources to absorb, adapt to, and recover from changes to the value or health effects.	**High**
Bawdwin lower village – community health	**High** Health is highly valued by the community.	**High** Highly vulnerable, due to the existing exposure to environmental hazards from historical mining (soil, dust, water and food), the community's proximity to the project, use of groundwater fed springs for drinking water and presence of sensitive receptors (children or women of childbearing age).	**Low** The key contaminants of (lead, and $PM_{2.5}$ and PM_{10} general dust) have a cumulative effect. Existing exposures are assumed to be high based on baseline environmental results. Communities have low resilience to changes with limited capacity and/or resources to absorb, adapt to, and recover from changes to the value or health effects.	**High**
Bawdwin lower village farms – community health	**High** Health is highly valued by the community.	**High** Due to some areas likely to be contaminated from historical mining (soil, dust, water) to a lesser degree than Bawdwin villages, the farms use of groundwater fed springs for drinking water and presence of sensitive receptors (children or women of childbearing age).	**Low** The key contaminants of concern (lead, and $PM_{2.5}$ and PM_{10} general dust) have a cumulative effect. Current levels of exposure are likely to be less than Bawdwin villages due to separation from current mine footprint. Community health strongly reliant on facilities/services at Bawdwin.	**High**

Receptor group/value	Importance	Vulnerability	Resilience	Sensitivity
			The people have limited capacity and/or resources to absorb, adapt to, and recover from changes to the value or health effects.	
Tiger Camp village – community health	**High** Health is highly valued by the community.	**High** Highly vulnerable, due to the existing exposure to environmental hazards from historical mining (soil, dust, water and food), the community's proximity to the project, being located in a valley with minimal dispersal of particulates, dust and noise, use of groundwater fed springs for drinking water and presence of sensitive receptors (children or women of childbearing age).	**Low** The key contaminants of concern (lead, and $PM_{2.5}$ and PM_{10} general dust) have a cumulative effect. Existing exposures are assumed to be high based on baseline environmental results. Communities have low resilience to changes with limited capacity and/or resources to absorb, adapt to, and recover from changes to the value or health effects.	**High**
Tiger Camp farms – community health	**High** Health is highly valued by the community	**High** Due to some areas likely to be contaminated from historical mining (soil, dust, water) to a lesser degree than Tiger Camp village, their proximity to the project, use of groundwater fed springs for drinking water and presence of sensitive receptors (children or women of childbearing age).	**Low** The key contaminants of (lead, and $PM_{2.5}$ and PM_{10} general dust) have a cumulative effect. Communities have low resilience to changes with limited capacity and/or resources to absorb, adapt to, and recover from changes to the value or health effects.	**High**
Nam La farms – community health	**High** Health is highly valued by the community.	**Medium** There may be some contamination of air, soil, water, however, though to a lesser degree than villages closer to historic mining operations. The community health of the farms may be vulnerable due to some existing contamination, the farms proximity to the project, use of groundwater fed springs for drinking water and presence of sensitive receptors (children or women of childbearing age).	**Medium** The key contaminants of concern (lead, and $PM_{2.5}$ and PM_{10} general dust) have a cumulative effect. Existing exposures are assumed to be moderate based on baseline environmental results. Communities have medium resilience to changes with some capacity and/or resources to absorb, adapt to, and recover from changes to the value or health effects.	**Medium**
Loi Mi farms – community health	**High** Health is highly valued by the community	**Medium** There may be some contamination of air, soil, water, though to a lesser degree than villages closer to historic mining operations. The	**Medium** The key contaminants of concern (lead, and $PM_{2.5}$ and PM_{10} general dust) have a cumulative effect.	**Medium**

Receptor group/value	Importance	Vulnerability	Resilience	Sensitivity
		community health of the farms may be vulnerable due to some existing contamination, their proximity to the project, use of groundwater fed springs for drinking water and presence of sensitive receptors (children or women of childbearing age).	Existing exposures are assumed to be moderate based on baseline environmental results. Communities have medium resilience to changes with some capacity and/or resources to absorb, adapt to, and recover from changes to the value or health effects.	
Residents of the Nam Pangyun valley – community health	**High** Health is highly valued by the community	**High** Due to some areas being in proximity to expected contamination in the Nam Pangyun riverbed from historical mining, and uncertainty regarding current source of drinking water.. Due to some areas being in proximity to expected contamination in the Nam Pangyun riverbed from historical mining, and uncertainty regarding current source of drinking water.	**Medium** The key contaminants of concern (lead, and $PM_{2.5}$ and PM_{10} general dust) have a cumulative effect. Existing exposures are assumed to be high based on baseline environmental results. The artisanal mining community is transient and has some resilience to change due to this. However, in general the community is assessed to have low resilience to changes with limited capacity and/or resources to absorb, adapt to, and recover from changes to the value or health effects.	**High**
Namtu villages and wards – community health	**High** Health is highly valued by the community	**High** Potentially high existing exposures to gases, metals (particularly lead), fine particulate matter and noise, reliance on the Nam La for drinking water which may be impacted by the project and presence of sensitive receptors (children or women of childbearing age).	**Low** The key contaminants of concern (lead, and $PM_{2.5}$ and PM_{10} general dust) have a cumulative effect. Existing exposures are assumed to be high based on baseline environmental results. Communities have low resilience to changes with limited capacity and/or resources to absorb, adapt to, and recover from changes to the value or health effects.	**High**
Villages and hamlets surrounding Bawdwin – community health	**High** Health is highly valued by the community	**Medium** Vulnerability of villages and hamlets surrounding the Bawdwin concession is considered moderate. The influence of historic contamination from the site is expected to be low.	**Medium** The key contaminants of concern (lead, and $PM_{2.5}$ and PM_{10} general dust) have a cumulative effect. Existing exposures are assumed to be low based on distance from historic operations. Communities have medium resilience to changes with some capacity and/or resources to absorb,	**Medium**

Receptor group/value	**Importance**	**Vulnerability**	**Resilience**	**Sensitivity**
			adapt to, and recover from changes to the value or health effects.	
Residents along the export route – community health	**High** Health is highly valued by the community	**Medium** Existing exposures commensurate with living near a major road with elevated levels of particulates, dust, gases and noise, and presence of sensitive receptors (children or women of childbearing age). The vulnerability to change is assessed to be moderate.	**Medium** The key contaminants of concern (lead, and $PM_{2.5}$ and PM_{10} general dust) have a cumulative effect. Existing exposures to lead are assumed to be low based on distance from historic operations. However exposures relating to road use are expected to be high. Communities have medium resilience to changes with some capacity and/or resources to absorb, adapt to, and recover from changes to the value or health effects.	**Medium**
Project workforce - health	**High** Health is highly valued by the project workforce	**High** Blood lead concentration testing indicated all permanent Bawdwin workers and 48% of contractors working at Bawdwin who were tested in 2020 had elevated blood lead levels.	**Medium** The key contaminants of concern (lead, and $PM_{2.5}$ and PM_{10} general dust) have a cumulative effect and are not readily eliminated from the body following chronic exposure periods. Workers have some capacity and/or resources to absorb, adapt to, and recover from changes to the value or health effects (i.e. BJV operated health facilities).	**High**

5.9.12 Sensitivity of socio-economic values

Socio-economic values are qualities of the social environment that are conducive to individual wellbeing now and into the future, and for which community stakeholders have a high regard. Each social value is characterised by a range of indicators and is associated with stakeholders who have an interest in the value within the community domain.

The social values are developed by assessing stakeholder interests in relation to social conditions and their indicators. The identification of relevant overarching components and associated social values for the community domains associated with the project has been derived from the social baseline study, engagement with villages in the surrounding village tracts about their relationship to the communities in the Bawdwin concession area, and research on social conditions in northern Shan State.

This section builds on the description of socio-economic features in Section 5.9 and describes the sensitivity of socio-economic values in terms of their importance, vulnerability and resilience. Sensitivity in this context is a quantification of how sensitive the values are to change as a result of the project. Sensitivity is based on the importance of the value, the vulnerability of the value to change, and the resilience of the value in terms of its ability to overcome changes and maintain its inherent value.

Related values, such as access to water and land resources are discussed in specific sections to provide suitable context. For the purposes of assessing social, economic and health impacts as a result of the project three broad social components were defined, which provide a range of supporting values. These are presented in Table 5.95.

Table 5.95 Socio-economic components and supporting values

Socio-economic components	Relevant supporting values
Local economies, livelihoods and land use	Diverse economies with employment opportunities. Sustainable livelihoods (either secure access to productive agricultural land or non-agricultural employment opportunities). Access to goods and services.
Living conditions, social cohesion and security	Adequate living conditions and infrastructure (housing, roads, communications, water, sanitation, power etc). Visual amenity. Harmonious social relations and inclusion. Security and safety. Social cohesion, wellbeing and identity. Social equality. Effective local and regional governance. Environmental safety and amenity.
Access to health, education and other services	Health. Education and training. Commercial services. Spiritual and religious support.

The sensitivity of social, economic and cultural components was determined by considering their current state (or condition), the degree to which the value is susceptible to change to the Bawdwin mine and supporting infrastructure, and its' resilience or capacity to absorb, adapt or recover from such changes.

As described in Section 5.9.2, the study area was divided into social catchments each with varying degrees of dependence/connectivity to the project. These were:

- Bawdwin and Tiger Camp villages.
- Other households outside Bawdwin and Tiger Camp villages within the Bawdwin concession area.
- Neighbouring villages outside the Bawdwin concession area including Hu Hsar, Hin Poke and Kyu Hsawt village tracts.

- Inhabitants in the Nam Pangyun valley between Tiger Camp and Namtu Town.
- Namtu township.
- Villages along the road between Namtu Town and Lashio.

Definitions for each level of sensitivity are provided in Table 5.96.

Table 5.96 Importance, vulnerability and resilience definitions and ratings

	Definition	Ratings		
		Low	**Medium**	**High**
Importance	The extent to which the value is important to people or the economy this encompasses factors such as dependency, level of use, benefit, and economic value.	Limited dependency or influence in terms of social cohesion, economic prosperity sustainable livelihoods and community health.	Some dependency and influence in terms of social cohesion, economic prosperity sustainable livelihoods and community health.	Critical or highly dependent on the value in terms of social cohesion, economic prosperity sustainable livelihoods and community health.
Vulnerability	The extent to which communities are susceptible to changes in social, economic and health conditions.	Low vulnerability to impairment of social wellbeing.	Vulnerable to impairment of social wellbeing for an individual or a group of individuals.	Highly vulnerable to impairment of social wellbeing for the majority of the community.
Resilience	The extent to which people can adapt or recover from changes in a value. In a social, economic and health context, this relates to how readily the people impacted by change can adapt.	Very low resilience; the people have no or limited capacity and/or resources to absorb, adapt to, and recover from changes to the value.	Some resilience; the people have some capacity and/or resources to absorb, adapt to and recover from changes to the value.	High resilience; the people have experienced similar change and have the resources to absorb, adapt to and recover from changes to the value.

The importance, vulnerability and resilience of socio-economic components are rated across six social catchments are rated in Table 5.97.

Table 5.97 Importance, vulnerability, resilience and sensitivity of local economy and livelihoods

Value	Importance	Vulnerability	Resilience	Sensitivity
Local economies, livelihoods and land use				
Bawdwin and Tiger Camp villages	**High** Due to the nature of these communities with employment and accommodation linked to the Bawdwin and Namtu concession permits, the Bawdwin mine is highly important to their livelihoods and economic security. There are few other sources of income or other livelihoods in these communities.	**High** Due to the ability to earn an income and participate in the cash economy being intrinsically related to the Bawdwin mine with few other sources of income the villages are highly vulnerable to any material changes in their existing employment arrangements.	**Low** Bawdwin and Tiger Camp villages are highly dependent on the Bawdwin mine for employment and support of the local economy and therefore have limited resilience.	**High**
Surrounding communities including Hu Hsar, Hin Poke and Kyu Hsawt village tracts.	**Low** Livelihoods in the area are dependent on agriculture as their main source of livelihoods. The Bawdwin concession area is of low importance to their livelihoods or local economies.	**Low** Low vulnerability due to changes to the Bawdwin concession area due to their high reliance on agriculture and limited economic connectivity with Bawdwin villages.	**Low** Livelihoods and local economies are based almost exclusively on agriculture, which is susceptible to drought and environmental changes.	**Low**
Nam Pangyun valley	**Medium** People are able to support livelihoods through the utilisation of land and terrestrial resources in the form of artisanal mining of the river bed for minerals. These people are thought to reside in the location temporarily to exploit discarded minerals.	**High** Livelihood (at least temporarily) is vulnerable to change if ability to continue artisanal mining changes .	**Low** Communities have little capacity to recover from changes to livelihood due to limited resources for alternative income.	**High**
Namtu township	**Medium** Currently mining provides a small proportion of jobs for Namtu, based on the last census. The broader Namtu community is less dependent on the Bawdwin operations with other employment opportunities including government and other services.	**Medium** Namtu town is somewhat vulnerable to changes in the local economy and livelihoods as many residents are employed in the mining sector, however there are alternative forms of employment in the area.	**Medium** Namtu town is somewhat resilient to changes in the local economy or livelihoods as a result of mining as employment/income is more diversified and the town is less reliant on the Bawdwin mine than residents in the mine concession area.	**Medium**

Living conditions, social cohesion and security				
Bawdwin and Tiger Camp villages	**High** A high value is placed in harmonious family and community relationships and supportive systems of social organisation. Reasonable living conditions within the Bawdwin and Tiger Camp villages, which are the accommodation facilities for the former mine and associated infrastructure workforce. The existing visual amenity is influenced by the historical mining activities. However, views are picturesque and valued.	**High** Due to the intrinsically related linkages between the communities and the mine the villages are highly vulnerable to any material changes caused by the project. Most housing in Bawdwin and Tiger Camp villages is leased from ME-1. Living conditions are influenced by numerous exposure pathways to contaminants associated with legacy mine operations with limited prevention of exposure to potentially harmful or hazardous materials.	**Low** Limited resilience due to organisational structure influenced by the operation of the Bawdwin mine (e.g., land tenure, house ownership etc).	**High**
Surrounding communities including Hu Hsar, Hin Poke and Kyu Hsawt village tracts.	**Medium** Typical living conditions of rural Myanmar supported by agriculture. Utilise some social services in Bawdwin concession. Typical viewsheds up rural upland areas in Shan State.	**Medium** Dependent on agriculture for livelihoods, which also influences living conditions. Adequate infrastructure with linkages to major villages. Some vulnerability to change as a consequence of changes to the Bawdwin due to social services and markets accessed in the concession.	**Medium** Due to their isolated nature there is some resilience to changes in living conditions, social cohesion and security.	**Medium**
Namtu township	**High** Supportive and stable social structures. Value is placed in harmonious family and community relationships and supportive systems of social organisation.	**Medium** Due to the linkages between the town and the mine, Tha Ta La Wards 1-7 wards are vulnerable to material changes caused by the project. Some exposure pathways to contaminants associated with legacy mine operations.	**Medium** Some resilience due to distance to the mine and the size of the town with a range of other sectors.	**Medium to high**
Nam Pangyun valley	**Medium** Some permanent inhabitants with agricultural livelihoods along the valley. However, most inhabitants are artisanal miners that are believed to be displaced persons seeking livelihoods that access the area on an as needs/temporary basis.	**High** The permanent inhabitants are located on the upper banks of the Nam Pangyun and have some vulnerability to changes along the valley. The artisanal miners have no legal status or rights and are therefore vulnerable to changes.	**Medium** The permanent inhabitants are likely to have some resilience to change so long as livelihoods are maintained. The artisanal miners reside in temporary shelters along the Nam Pangyun valley and are expected to have some resilience to changes due to mobility.	**Medium**
Access to health, education and other services				

Bawdwin and Tiger Camp villages	**High** There are existing education, commercial, health and religious facilities at Bawdwin and Tiger Camp and therefore there are reasonable pathways to gain an education, health and religious guidance. These services are important to these communities.	**High** Educational and health facilities are supported by the Bawdwin Concession holder (currently WMM). Therefore, the continued access these services is to an extent dependent on the mine.	**Low** Limited resilience due to organisational structure influenced by the operation of the Bawdwin mine.	**High**
Surrounding communities including Hu Hsar, Hin Poke and Kyu Hsawt village tracts.	**Medium to high** Many of these villages have a significant level of dependence on services available in Bawdwin villages including schools, commercial services, health facilities and religious institutions.	**Medium to high** Due to the reliance on services within Bawdwin villages, there is moderate to high vulnerability to any changes of these services with limited alternative options.	**Low to medium** Due to the remote nature of these villages, there is limited alternatives and therefore a lower level of resilience due to changes of these existing services.	**Medium to high**
Nam Pangyun valley	**Low** Understood to have limited or no access to Bawdwin or Tiger Camp education, commercial. health and religious services currently	**Low** Low vulnerability to changes to these services as it is understood that there is a low or no dependency on education, health or other services at Bawdwin.	**Medium** Some resilience to any changes in existing services in Bawdwin since there is understood to be low or no dependency on these.	**Low**
Namtu township	**High** There are existing education, health, religious and commercial facilities at Namtu and reasonable pathways to gain an education and access training which enhances future opportunities. The importance of these facilities and opportunities they provide were important to these communities.	**Low** Educational, health, religious and commercial facilities in Namtu are not affiliated with the mine and therefore have low vulnerability to change as a result of mining activities.	**High** There are several education, health, religious and commercial facilities in Namtu and these are not influenced by mining activities/organisational structure	**Medium**

5.9.13 Summary

The existing socio-economic and health baseline can be characterised as follows:

- Employment in the mining sector is a main source of income and an opportunity for subsidised housing for people in the Bawdwin and Namtu study areas. The mining sector is highly important for livelihoods of those communities.
- Survey results indicate education levels in the Bawdwin and Namtu areas are higher than Shan State, with only 6% and 8% of people in Bawdwin and Namtu, respectively having no education, as opposed to 45% in Shan State. There are 9 schools in Bawdwin and 11 in Namtu.
- The majority of community members in the Bawdwin and Namtu study areas are Bamar, and practice Buddhism. There are 12 religious facilities in Bawdwin and 11 in Namtu.
- Most households from Bawdwin and Namtu study areas have ready access to piped water; although, these sources may be substituted during periods of rain due to consequent turbidity.
- The annualised food consumption frequency results indicated the household diets in all of the wards/villages studied, had a good diversity of food, with remarkable similarities between the Bawdwin and Namtu communities.
- The main form of transport in Bawdwin and Namtu is by motorcycle and walking. Roads are often narrow (single to 1.5 vehicles wide) and shared by vehicles and pedestrians.
- The population profiles and the overall environmental health circumstances of the Bawdwin and Namtu communities are fairly similar. Residents tend to be long-term in their communities and in their individual houses. Houses are basic with generally larger house sizes in Namtu.
- Toilet and waste facilities are more developed in Namtu than in Bawdwin; most households in Namtu have their own toilet and most do not discharge to local rivers or streams, unlike Bawdwin.
- Despite limited healthcare facilities, most survey respondents indicated they were in good health.
- There are a range of hazardous environmental health exposure pathways in the study area. These primarily relate to the inhalation, ingestion of or dermal contact with dust, metals (mainly lead) and bacteria (*E. coli).*
- Blood lead level investigations of a subset of the existing workforce identified that 48% of contract workers and 100% of permanent Bawdwin workers who were tested had elevated blood lead levels.

5.9.14 Uncertainties and limitations

The key uncertainties and limitations relating to the existing socio-economic and health environment are:

- Of the four study areas (Bawdwin, Namtu, regional villages, Shan State regional villages), only Bawdwin and Namtu communities were surveyed in the field. Consequently, there is a focus on these communities and details regarding the socio-economic environment of the artisanal miners and other inhabitants of Nam Pangyun Valley and regional villages (including those along the export route) have not been captured to the same extent.
- Only a proportion of the Bawdwin and Namtu populations were surveyed and results are assumed to be representative of the whole population of these communities.
- As only a single survey for each aspect (socio-economic, health, traffic and transport) was undertaken, any temporal variability in results is not accounted for.

- Investigations of community health aspects relied upon publicly available health statistics, questionnaires and investigation of environmental conditions, as opposed to clinical examination of people from the study area.
- The health baseline report (Appendix G) had a number of limitations and constraints, primarily regarding the planning and data collection phases. Additional limitations concerned the absence of detailed historical and current health data, detailed medical assessment and collection/analysis of biological samples. Nevertheless, it is considered that the results of the study provide a robust assessment of community health to inform this EIA.
- In the absence of detailed medical assessment and collection/analysis of biological samples, any conclusions regarding the potential impact of lead contamination on the residential population are limited.

Bawdwin Project

Environmental Impact Assessment
Chapter 6 – Impact assessment

October 2023

Bawdwin Project

Prepared for

Win Myint Mo Industries Company Limited

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6 Impact assessment

6.1 Approach to impact assessment

This chapter assesses the project impacts to the environmental and social values identified in Chapter 5.

The impact assessment method used in this chapter is a 'significance assessment'. This is a values-based approach that assesses the potential significance of impacts by considering the sensitivity of values to change, and the magnitude of change that they are predicted to experience as a result of project-related activities. This framework is consistent with current international environmental and social impact assessments for resource development projects, and reflects the approach described in Environmental Impact Assessment Guidelines for the Mining Sector in Myanmar (October 2018).

Assessment of potential impacts is based on specialist judgement and technical assessment supported by baseline field data and scientific literature. Particular emphasis has been placed on ensuring that the EIA describes the rationale, justification and any limitations and uncertainties of the assessment. A general method to assess the significance of impacts involves the following:

- Describing the existing environmental conditions of the project's area of influence, in particular the environmental or social values and including the sensitivity of defined environmental or social values or receptors, which may be affected by the project. Sensitivity was defined by assessing the importance of each value or receptor, its vulnerability to change, and its resilience or ability to recover. Environmental values and receptors along with their assessed sensitivity are defined and justified in Chapter 5.
- Consideration of potential, credible effects associated with all phases of the project, mechanisms and pathways that may lead to these effects, and the resulting impacts in the context of the existing conditions. The identification of potential impacts is based on:
    - knowledge of the existing environment and specific conditions that exist at the time of assessment;
    - the project configuration;
    - experience of the ESIA consultant with other mining operations in similar environments; and,
    - issues of concern identified by stakeholders.
- Development of management measures, where the measures described are technically and economically feasible within the context of the project and reflect WMM's commitments.
- Assessing the magnitude of change the environmental or social value or receptor experiences as a result of the project following implementation of proposed management measures.
- Assessing the significance of the residual impact. The residual impact is the impact that is predicted to occur following successful implementation of avoidance and management measures that address that impact.

Impacts can either be positive (beneficial) or negative. The impact magnitude (very low, low, medium, high or very high) was determined considering the amount and type of change based on the following aspects:

- Spatial extent or the scale of the effect or impact.
- Severity or intensity, which considers the scale or degree of change from the existing conditions as a result of the impact; severity can also be considered in terms of the intensity of the impact.
- Duration or frequency, which considers the timescale or frequency of the impact, i.e., if it is temporary, short-term or long-term.

The significance (very low, low, moderate, high or major) of residual impacts was rated using a matrix approach, by multiplying the sensitivity of the value or aspect and the magnitude of the impact to that value or aspect. The matrix of residual impact significance is shown in Table 6.1. A visual explanation of the relationship between significance, magnitude and sensitivity is shown in Figure 6.1.

Table 6.1 Matrix of residual impact significance

Magnitude of Impact		Sensitivity of Receptor				
		Very low	**Low**	**Medium**	**High**	**Very High**
Positive	**Very high**	Moderate	High	Major	Major	Major
	High	Low	Moderate	High	Major	Major
	Medium	Low	Low	Moderate	High	High
	Low	Very low	Low	Low	Moderate	Moderate
	Very low	Very low	Very low	Very low	Low	Moderate
Negative	**Very low**	Very low	Very low	Very low	Low	Moderate
	Low	Very low	Low	Low	Moderate	Moderate
	Medium	Low	Low	Moderate	High	High
	High	Low	Moderate	High	Major	Major
	Very high	Moderate	High	Major	Major	Major

The uncertainty (low, medium or high) associated with the significance assessment is noted for each impact. The uncertainty ranking is based on the available information, level of assumptions, certainty of predictions and confidence in the accuracy of the inputs that produce the significance rating.

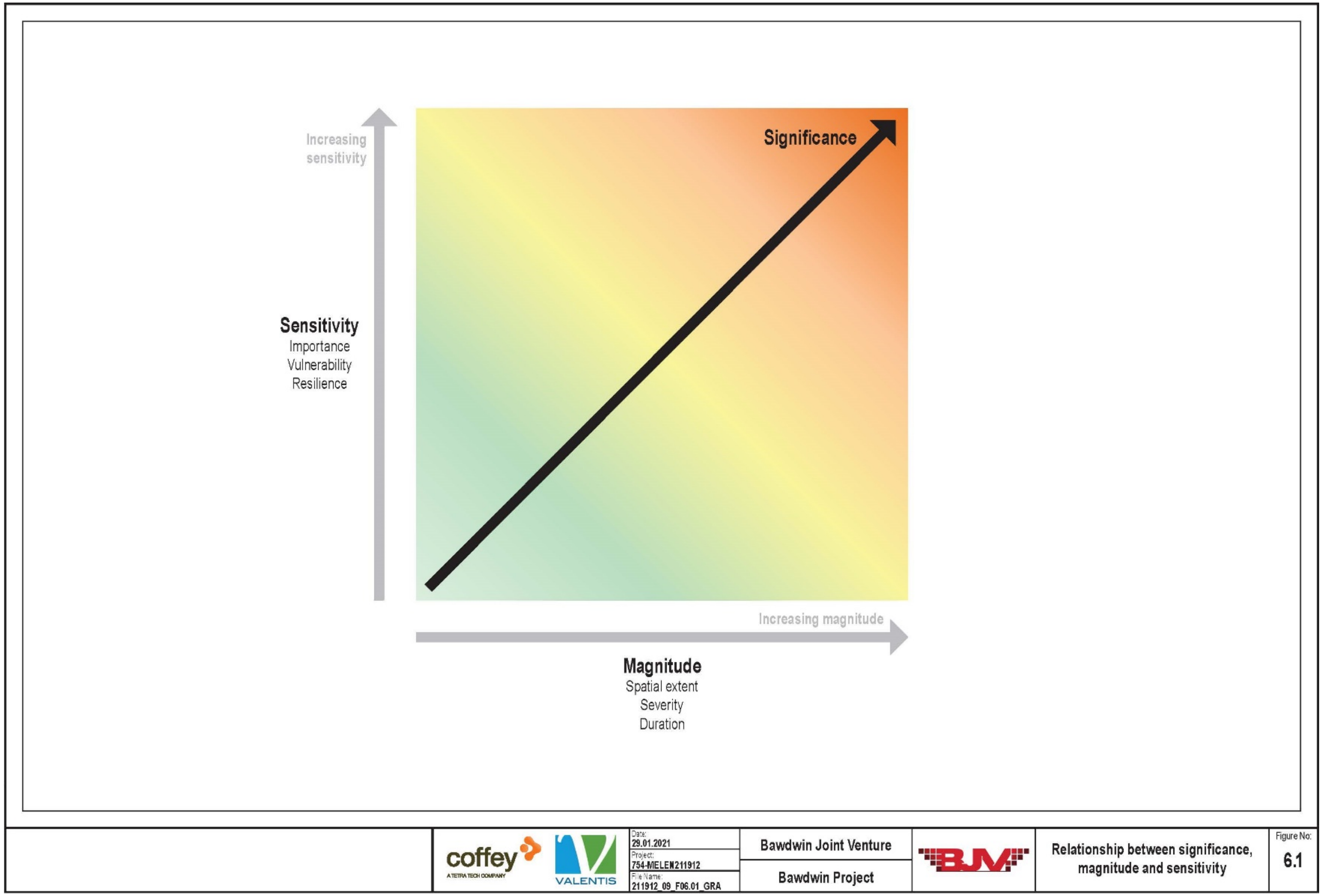


Figure 6.1 Relationship between significance, magnitude and sensitivity

6.2 Landform and soils impact assessment

6.2.1 Approach to impact assessment

This section assesses the project impacts to the landform and soils values identified in Section 5.1. Section 5.1 described the levels of importance, vulnerability and resilience associated with each of the landform and soils values in the study area.

The impact assessment approach adopted in this section is a 'significance assessment'. The significance assessment method is described in Section 6.1. A significance assessment of landform and soils impacts involves:

- Identifying the nature of the impact to a landform or soil values in the project area.
- Determining the magnitude of the impact through an assessment of the spatial extent, severity and duration of the impact.
- Assessing the significance of the residual impact (i.e., with assumed successful implementation of avoidance and management measures). The significance (very low, low, moderate, high or major) of the impact to a landform and soil value is determined by considering the importance, vulnerability and resilience of the landform and soil value (as assessed in Section 5.5.6) and the predicted magnitude of the impact to the value. Impact magnitude (very low, low, medium, high or very high) is determined based on the spatial extent, severity and duration of the impact.

6.2.2 Sources of potential impact

To assess the potential impacts to landform and soils, this assessment is based on the following 'terrain units' defined in Section 5.1:

- **Steep mountain terrain**: This includes most of the terrain in the project area and is dominated by steep mountains, and narrow ridges and crests.
- **Lower mountain slopes and valley floors**: This includes the lower slopes and floors of the Nam Pangyun, ER and Wallah valleys.
- **Undulating hills of the northern and western study area**: This includes areas of less steep, undulating terrain in the northern corner of the study area around the Bawdwin Reservoir where most of the elevation ranges from approximately 1,200 to 1,300 m above sea level, and in the western corner of the study area where elevation ranges from 1,300 to 1,400 m above sea level.

Changes to the terrain units have the potential to affect associated landform and soils values by:

- Reducing the capacity of the terrain unit's landform and soils to support ecosystems.
- Reducing the capacity of the terrain unit's landform and soils to support beneficial land uses (including current and potential future land uses).

Potential impacts to the terrain units and their associated values include:

- Physical disturbance of landforms and soils:
  - Reduced landform stability due to ground disturbance.
  - Direct loss of soil and changes to landform due to major earthworks and mining.
  - Loss of topsoil due to increased erosion or poor soil management of disturbed land.
  - Modification of soil structure due to surface compaction and inadequate management of soil stockpiles.

- Contamination of soils:
  - Reduced capacity to support plant growth and rehabilitation due to mixing of existing contaminated soils with non-contaminated soils, as well as increased contamination from other potential sources such as metalliferous leachate and acid mine drainage.

This section only addresses impacts to landform and soils values from an immediate ecological or land use point of view (i.e., vegetation and land use supported by, or potentially supported by, the landform and soil). Potential secondary impacts on related values as a result of direct impacts to landform and soils are addressed in impact assessment sections for biodiversity (Section 6.8), human health (Section 6.11), visual landscape and amenity (Section 6.10), surface water (Section 6.4), groundwater (Section 6.3) and cultural heritage (Section 6.9).

The potential impacts to terrain units and their associated values are described below.

Physical disturbance of landform and soils

Reduced landform stability due to ground disturbance

Physical land disturbance has the potential to destabilise landforms, causing, or increasing the potential for, landslips. Landslips can bury fertile topsoil and plant propagules, breaking up soil aggregates and exposing less fertile subsoils and regolith (i.e., unconsolidated material overlying the solid bedrock). Disturbance could also reduce the amount of available topsoil for land rehabilitation and other land uses.

The project is in a seismically active zone along geological faults, with steep slopes and thin vegetation cover, and receives sporadic high intensity rainfall in the wet season. These features make the area susceptible to landslips, although there is limited evidence of recent large landslips having occurred. Small landslips are known to occur throughout the steeper areas (as shown in Figure 5.5), particularly where groundwater springs are located (Witcomb, pers. com., 2020).

The stability of the existing landforms could be exacerbated by ground disturbance for construction of infrastructure in steep areas; particularly where excavation and cut-and-fill occurs. The potential for increased instability will typically be greater where slope angles are higher.

Direct loss of soils and changes to landform due to major earthworks and mining

Project construction and mining operations will involve large-scale land and vegetation clearance, removal and relocation of topsoil and subsoil, and significant changes to the existing landform. These changes will take place in the context of a landscape that has already been extensively modified from centuries of mining activity. The landform changes due to historic mining activity and occupation include the development of the existing 21.9 ha mine pit and associated mining excavations, such as adits; construction of access roads; slag, tailings and waste rock disposal areas along the Pangyun valley; and terracing for agriculture and housing.

Existing landforms will be significantly altered due to development of the open pit, the TSF and Wallah Gorge waste rock dump. Construction of the embankments of the TSFs and Wallah Gorge waste rock dump will result in significant raised landform structures in their respective valleys. During operations, landform changes will be significant as the existing open pit widens and deepens, and the Wallah Gorge waste rock dump is developed and TSFs storages filled.

Overall, the project infrastructure footprint is 469.1 ha. The open pit will expand to a footprint of 95.9 ha (from its current 21.9 ha) and will extend 250 m below the existing pit floor and approximately 495 m below the surface elevation. The Wallah Gorge waste rock dump will have a total footprint of 107.2 ha and extend 315 m vertically from the toe of the waste rock dump to the maximum elevation of the final dump. The TSFs will have area footprint of 149.0 ha and be up to 155 m vertically above the existing ground level.

Altered landforms can indirectly affect local ecosystems and land uses due to changes to surface runoff regimes, increased erosion, changes to land stability and reduced land availability for future land uses. This subsection addresses impacts directly related to soil and landform values, while impacts to other related values due to changes to landform and soils are considered in subsequent subsections.

Soils will be removed from areas where project buildings and infrastructure will be constructed, to allow for development of foundations. Soils removed from these areas will be stockpiled and used (where suitable) for rehabilitation elsewhere. The loss of land capability in such areas will be due to the physical presence of the building/infrastructure rather than the loss of soil itself. During project closure, buildings and infrastructure will be removed and the sites rehabilitated. Soils will be permanently removed, as will landform, from the open pit expansion.

During construction of infrastructure locations in steep terrain, particularly roads, most of the excess spoil will be side-cast, whereby excavated material will be tipped downslope of the area being excavated. Side-cast material is uncompacted and settles at a natural angle of repose. In high rainfall areas, side-cast areas are susceptible to erosion over time.

Figure 6.2 shows the extent of the project footprint where direct disturbance to landform and soils will occur and the locations of the key changes to landform arising from the project – the open pit, the TSFs and the Wallah waste rock dump. The figure also shows the extent of the existing pit compared to the final pit.

Figure 6.3 shows a three-dimensional view of the proposed TSF, waste rock dump and open pit, illustrating the key landform changes in the Bawdwin concession area.

Loss of topsoil due to increased erosion or poor soil management

Project earthworks and mining will result in exposure of bare soils to potential erosion from wind and rainfall runoff. The steepness of the terrain and the scale of the project facilities will require excavation, filling or cut-and-fill of the ground surface during construction. Constructed landforms such as the TSFs and waste rock dump and cut and fill areas for newly constructed roads will be particularly prone to erosion.

Increased erosion may occur in areas where vegetation is cleared (e.g., roads and unsealed hardstand areas around project infrastructure) and where soils are stockpiled for later use in rehabilitation. Increased erosion may also occur where changes to existing surface water drainage are made around project infrastructure.

Soil erosion can remove and transport topsoil and disperse it in downstream areas, reducing the capability of the land for supporting ecosystems and land uses involving growing plants and crops. Erosion can also reduce the availability of topsoil for land rehabilitation. Over time, erosion can lead to a permanent loss of substrate for vegetative growth, particularly in steeper areas where the soil profile is thin.

All of the terrain units in the project area are susceptible to erosion, particularly in areas where soils are situated on steep, unstable slopes where vegetation cover is thin and soil profile is shallow. In addition to steep terrain, low vegetation cover and thin soil profiles, the region experiences sporadic heavy rainfall events from May to September, which contribute to the study area's susceptibility to erosion (Knight Piésold, 2020).

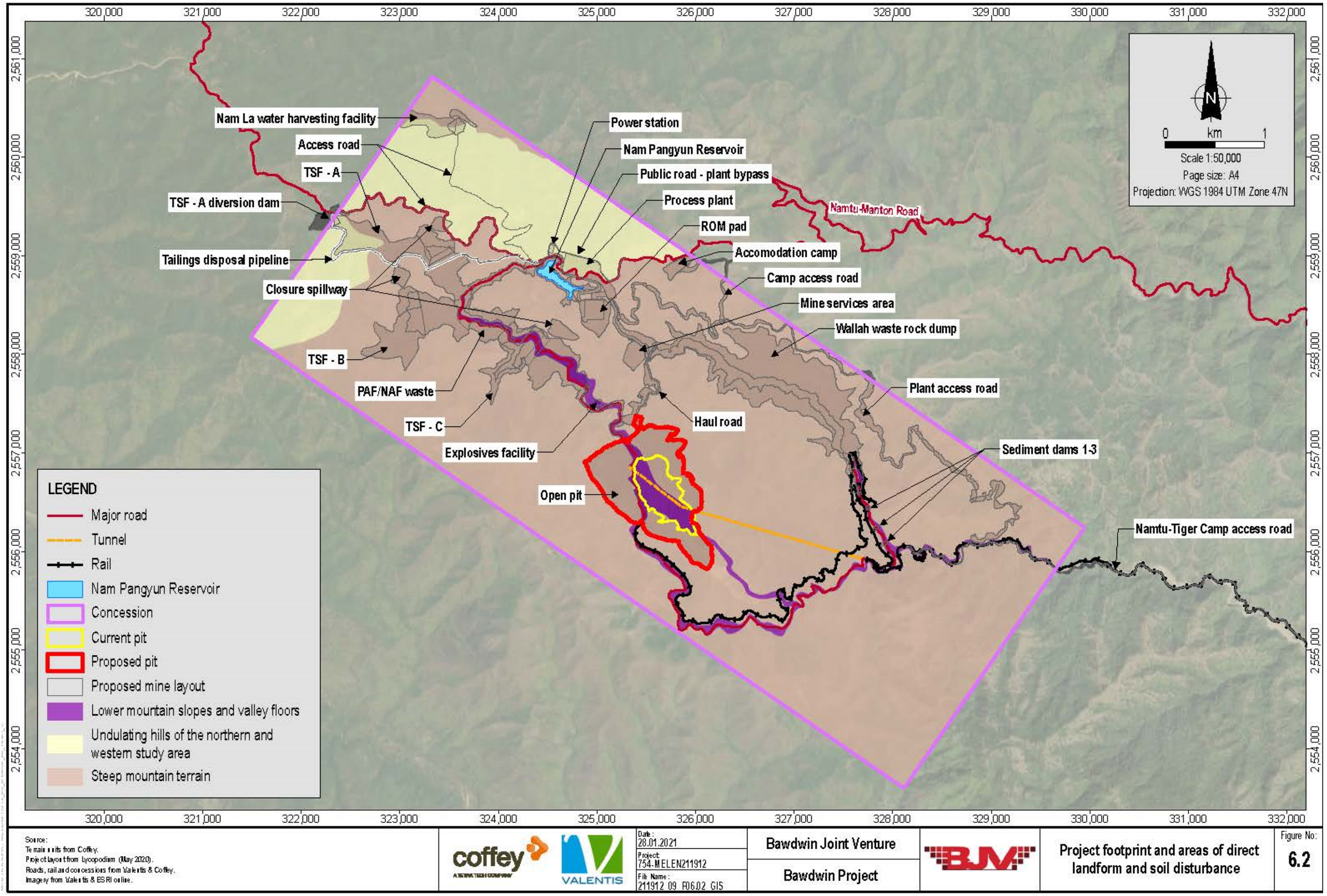


Figure 6.2 Project footprint and areas of direct landform and soil disturbance

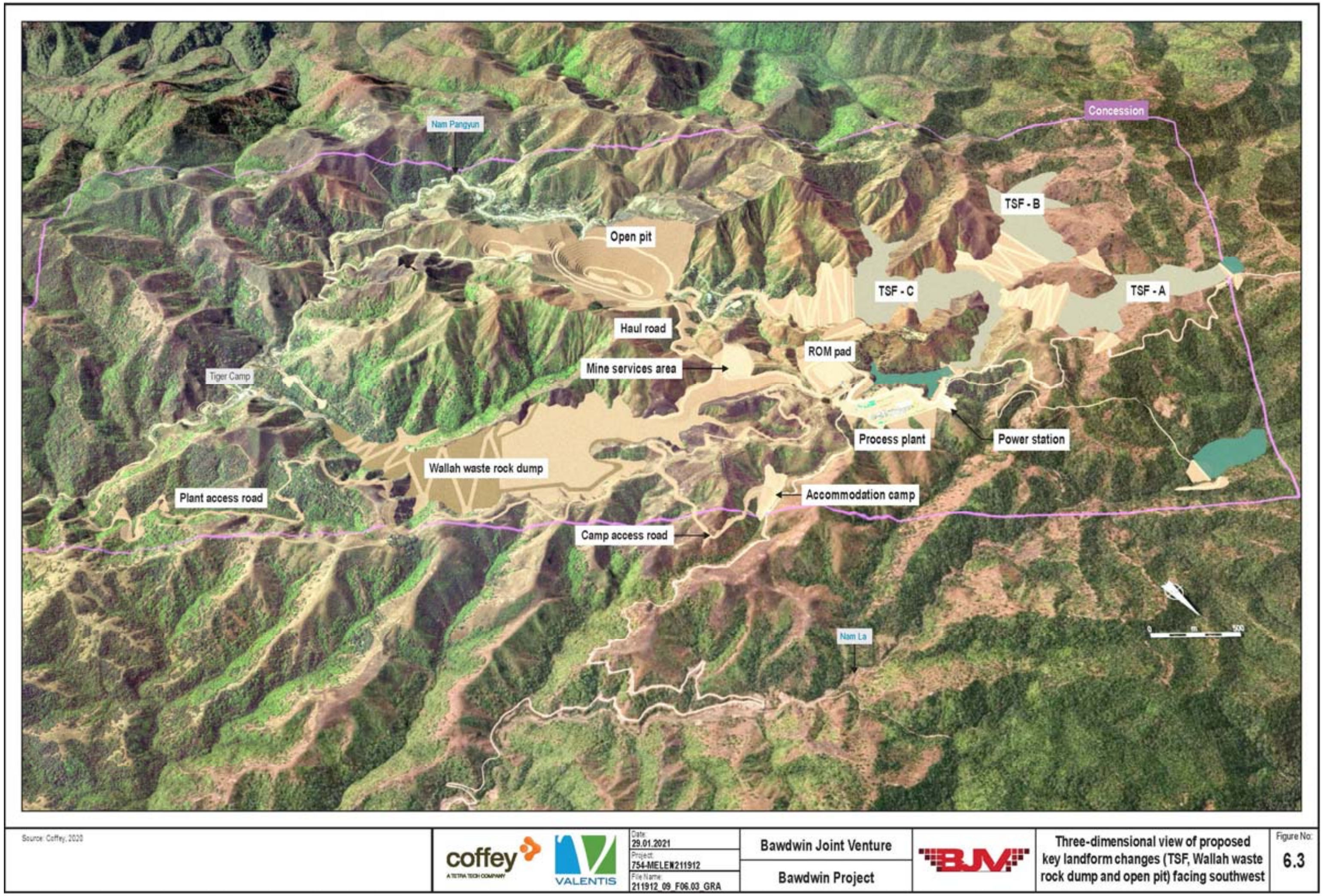


Figure 6.3 Three-dimensional view of proposed key landform changes (TSFs, waste rock dump and open pit) facing southwest

Modification of soil structure

Changes to the structure of soil have the potential to limit the capability of soils to support plant growth. Modifications can occur through surface compaction of soils by, for example, machinery and through inadequate management of stockpiled soil.

The construction of project infrastructure will lead to soil compaction throughout the project area. This will occur due to physical pressure placed upon soils from heavy machinery, vehicles and facilities as well as surface rolling for site preparation. The physical properties (e.g., drainage and aeration) of the soil will change when compacted, potentially making it difficult for vegetation to successfully re-establish during the rehabilitation phase of the project. The extent of soil compaction will be restricted to within the project footprint, with the areas of highest compaction being around the mine infrastructure, vehicle parking areas and along roads.

Large volumes of soil will be excavated, transported and stockpiled during construction and operations, for use in future operations and rehabilitation activities. Soils removed from disturbed areas will be stockpiled for future use where possible, but this will be constrained by the feasibility of stripping soils on steep slopes and subsequent recovery of soils. If it is not possible to adequately recover topsoils, the capability of remaining soils to support successful land rehabilitation may limited. Additionally, if recovered topsoils are not stored correctly and/or where stockpiles are not adequately managed, compaction, erosion and mixing of different soil horizons could result in changes to soil structure. These changes could adversely affect the capability of soils to support successful land rehabilitation.

Contamination of soils

Contamination of soil may reduce its capacity to support plant growth due to ecotoxicity, subsequently reducing its suitability for rehabilitation.

Existing widespread and severe soil contamination is present in the study area (in the form of high metals concentrations including arsenic, nickel, lead and zinc) due to many centuries of mining, ore processing and disposal of waste material (see Section 5.1). Land disturbance and soil handling has the potential to mix the existing highly contaminated soils with uncontaminated (or low-level contamination) soils. This impact may result in high ecotoxicity of soils in areas that were not previously impacted by mining activities, limiting their ability to support plant growth, including in rehabilitation.

The project also has the potential to cause soil contamination due to accidental spills and leaks of hazardous substances, use of contaminated water for dust suppression, dust (containing contaminants) depositing on soils, and seepage of metalliferous leachate and acid mine drainage. Accidental spills and leaks of hazardous substances are assessed in Chapter 7, as these are considered to be unplanned events following the implementation of avoidance and management measures.

Some of the ore to be mined is potentially acid forming (PAF) material and approximately 1%, or 1.5 Mt, of waste rock is expected to be PAF. If the PAF material is exposed to air and water, an acidic, metal-rich leachate is likely to form. This leachate may migrate through soils and cause acidification and increased metals concentrations in groundwater and surface water. Ore and waste rock and tailing material that is not PAF can also produce metalliferous (circumneutral) drainage.

Water emanating from the TSFs, waste rock dump, ore stockpiles and the open pit could potentially contain dissolved metals that have been leached from mine materials and hence could introduce elevated metals concentrations into underlying soils. The key impacts of metal leaching in terms of impact on environmental values would be to groundwater and surface water rather than the soils through which the leachate will pass. Soils most likely to be affected would be those close to areas where waste rock or tailings are stored and those at a depth where they would have limited existing potential to support plant growth (i.e. not surficial soils).

Impacts to soils from metalliferous drainage are not considered further. Impacts of leachates containing dissolved metals on surface water and groundwater values are assessed in sections 6.3 and 6.4, respectively.

Summary of potential impacts

Project activities could result in adverse impacts to the landform and soils of the terrain units in the project area and their associated values. Table 6.2 summarises these potential impacts and the phases of the project in which they are expected to occur.

Table 6.2 Potential landform and soil impacts during project construction, operation and closure

Sources of potential impact	Construction	Operation	Closure
Changes to landform due to development of the open pit, TSFs and Wallah waste rock dump affecting surface water runoff, increasing soil erosion, and reducing potential future land uses.	X	X	X
Reduced landform stability due to ground disturbance increasing the potential for landslips, which may bury topsoil or break soil aggregates, change the landform, and/or reduce the amount of topsoil available for land rehabilitation.	X	X	X
Loss of topsoil due to increased erosion or poor soil management of disturbed land following construction of landforms (TSFs, WRD), earthworks and mining, reducing the capability of land to support ecosystems, land uses, and rehabilitation.	X	X	
Modification of soil structure due to surface compaction changing physical properties of the soil, potentially affecting revegetation.	X	X	
Modification of soil structure due to inadequate management of soil stockpiles by compaction, mixing of different soil horizons, erosion, or returning horizons incorrectly, potentially affecting land rehabilitation.	X	X	X
Contamination of soils due to inadvertent mixing of contaminated and non-contaminated soils resulting in reduced capacity to support plant growth and rehabilitation and use of contaminated water for dust suppression.	X	X	

X = occurring in this phase

6.2.3 Design, management and mitigation

This section outlines the design and management measures for avoiding and reducing impacts to landform and soils.

Fundamental design controls

Constructed landforms such as the TSFs, Wallah Gorge waste rock dump and pit will be designed for long-term stability and reduced erosion potential. Site specific factors will be considered in the design, including the locally steep terrain and high rainfall environment at Bawdwin. Seepage and drainage design controls and slope profiles (i.e., slope shapes and angles of engineered dams and embankments) will be selected to minimise the potential for erosion.

The TSF design will reflect the following aspects:

- The existing site knowledge base.
- International good practice standards, in particular the Global Industry Standard on Tailings Management (Global Tailings Review, 2020) and the International Commission on Large Dams (ICOLD) standards and guidelines.
- Relevant Australian guidelines.

Seepage design controls to be implemented include the cut-off trench, underdrainage system, embankment internal drainage system and operational and closure spillways. Sections 4.8.2 and 4.8.8 provide further detail on these design controls.

The waste rock dump overall slope profile less than 1V:3H (a ratio of 1 unit vertical rise to 3 three units horizontal distance), comprised of batter slopes (1V:2.5H), 10 m wide benches and 25 m wide ramps. A 25 m wide external surface layer of fresh waste rock on the front face of the dump will improve the geotechnical stability and reduce the long-term erosion potential of the dump. The waste rock dump also includes underdrains to promote drainage of water through the dump and reduce seepage through the base. A series of surface drains (i.e., bench, ramp and toe drains) will collect surface runoff for discharge from the waste rock dump in a controlled manner. The captured seepage and runoff will be directed to a series of three sediment dams where the water will be either diluted with runoff or treated, to meet Myanmar mining effluent standards. For further detail on this surface drainage and underdrainage systems see Section 4.7.2. For a schematic of the surface drainage system refer to Figure 4.22 and for a schematic of the underdrain system refer to Figure 4.21 in Section 4.7.2.

The waste rock dump will be progressively rehabilitated during operations. Once a bench of the dump is complete, the outer face will be rehabilitated with a closure cover (a composite store and release cover system with a growth medium on top to encourage revegetation) placed over the surface. The TSFs will also be rehabilitated with a store and release cover system as they are completed. The covers will be comprised of materials that will not become a source of contaminants, will be resistant to erosion and will be suitable of supporting vegetation growth.

For all key items of project infrastructure that will be constructed, detailed designs will be developed that will take into account the site conditions, further geotechnical investigations as required and will also specify construction methods. The application of good practice engineering and design will minimise the likelihood of major landslips and instability to landform.

Environmental management

To reduce magnitude of impact to landforms and soils, environmental management measures will include:

- Minimise vegetation clearing by using previously disturbed or degraded areas as a first preference for locating infrastructure and mine activities.
- Conduct major land disturbance and earth moving activities during the dry season, where practicable.
- Avoid compaction of topsoil and disturbance by restricting vehicle, plant and equipment movement to designated tracks, as far as practicable.
- Avoid side-casting in locations that could impact the natural flow of drainage channels, creeks and rivers.
- Cover and stabilise exposed areas susceptible to erosion (due to project disturbance) using appropriate materials such as vegetation debris, jute netting, geogrid matting, or mulch.
- Stabilise minor landslips and other areas of landform instability impacted by the project (e.g., soil binders, synthetic matting and engineered structures).
- Install landform and soil stabilisation measures on side hill cuts to reduce slumping and/or erosion.
- Implement and maintain erosion and sediment controls, including site specific measures as necessary. Typical controls include:
  - Locate and design infrastructure to limit runoff to watercourses.
  - Install structures to intercept sediment-laden surface runoff to reduce sediment delivery to watercourses.
  - Install diversion drains to intercept uncontaminated surface runoff around facilities and divert away from cleared areas, where practicable.
  - Discharge water in a manner that prevents scouring and erosion.
  - Stockpile spoil and/or topsoil materials away from watercourses (i.e., maintain a minimum of 10 m from watercourse banks), where practicable.
  - Grade access roads adjacent to watercourses to drain away from watercourses.

  - Minimise the extent, and time, that ground surfaces and stockpiles are exposed through staged works wherever possible.

- Undertake progressive rehabilitation and revegetation of disturbed areas (including the TSFs and waste rock dump) to minimise the length of time that disturbed areas are exposed to wind and erosion.
- Use quick-growing ground vegetation to reduce the erosive impacts of rainfall and surface water flow in rehabilitation areas.
- Rehabilitate compacted soils by surface ripping progressively where practicable and at closure.
- Implement a general revegetation program in the Bawdwin concession area focussing on stabilising and covering areas of exposed land to minimise erosion and generation of dust.

To minimise contamination of soils, standard environmental management measures will include:

- Develop site-specific soil environmental criteria for lead and heavy metals concentrations and monitor their concentrations in soils to be disturbed, stored/handled, and/or used in rehabilitation or construction (e.g., hardstands, road base etc.,). Use the criteria to determine whether the soils are suitable for intended use (i.e., won't spread contamination to unaffected areas and create new areas of problematic soils); need special treatment for disposal (e.g., buried deep in the sub surface profile (or otherwise isolate and capped)); or are able to be placed back in the soil profile as topsoil for rehabilitation purposes.
- Recover and stockpile soils in project footprint which are uncontaminated/ have levels of contamination that are suitable for land rehabilitation for the intended end land uses, provided that recovery is physically feasible and safe.
- Treat and dispose of, or manage on site, contaminated soils based on the type and scale of contamination.
- Bury soils of lower-level contamination deeper in the soil profile (if suitable to do so) and below the soil root zone and cap with uncontaminated soil.
- Treat and dispose of hazardous waste including fuels, oils, chemicals and highly contaminated soil offsite at a licenced facility using suitably qualified contractors.
- Store and handle hazardous materials including fuels, oils and chemicals in accordance with good international practice, including designing appropriately secured and bunded facilities to meet appropriate standards for storage of hazardous materials.
- Strip and stockpile recoverable topsoil and subsoil separately in approved locations, and erect clear signage to identify these different areas.
- Train site personnel in hazardous materials management and appropriate soil management.
- Avoid using contaminated water for dust suppression purposes on any roads, or soils that are not already contaminated with metals.

Land rehabilitation

Rehabilitation of land will be completed where required and may include land stabilisation, contamination management, soil management, erosion and sediment control and revegetation. A progressive rehabilitation approach will be taken to minimise the length of time that disturbed areas are exposed to potential erosion and to facilitate progressive revegetation. The rehabilitation strategy will take into account issues raised during community consultation and incorporate these into the rehabilitation objectives and end land use objectives.

Progressive rehabilitation involves rehabilitating cleared areas as soon as possible after clearance to reduce erosion and runoff and allow vegetation establishment. Initial stages of rehabilitation will involve land stabilisation and erosion control to ensure the land is stable and suitable for revegetation. This may involve stabilisation measures to reduce the likelihood of landslips, slumping and erosion occurring. The erosion and sediment management plan will outline measures to limit soil disturbance and erosion during construction, operations and closure of the mine. This will aid in ensuring the landforms are stable and able to be rehabilitated and revegetated effectively.

Effective rehabilitation and revegetation will require soils to be managed in accordance with the management measures outlined in this section. Soil management involves the removal, storage and later use of topsoil and subsoil, to ensure soil resources can be reused effectively during rehabilitation. These measures are aimed at minimising contamination of soils and the suitable storage of stockpiled soils, to ensure soils are able to be reused where possible and promote successful vegetation growth. Where soils cannot be reused, ripping of compacted soils will be undertaken to promote successful vegetation growth. The existing condition of soils in the project area is generally poor (refer to Section 5.1), due to the ongoing impacts of historical mining. High concentrations of metals in the soils will be considered during rehabilitation to ensure the soils provide a suitable substrate for vegetation growth.

Revegetation will initially involve quick-growing ground cover vegetation to protect the landform and ensure that in the long term, permanent vegetation can be established. The mine closure and rehabilitation plan will outline specific aspects of revegetation. After project closure it is expected that compacted areas will be successfully rehabilitated by surface ripping and any existing land capability to support plant growth will be able to be regained.

6.2.4 Residual impact assessment

This section assesses the residual significance of impacts identified in Section 6.2.2 after implementation of the management measures outlined in Section 6.2.3. The magnitude of each residual impact is assessed based on the impact’s spatial extent, severity and duration. The significance of each residual impact is assessed, taking into consideration the sensitivity of the value (see Section 5.1) and the impact magnitude.

Table 6.3 presents the criteria used to determine the magnitude of each impact to landform and soils values.

Uncertainties related to the residual impact assessment are discussed in Section 6.2.6.

Table 6.3 Criteria used to determine magnitude of residual impacts to landform and soils

Criteria	Very low	Low	Medium	High	Very high
Spatial extent	Impact affects a very small area within existing disturbance areas and the project footprint	Impact is entirely within existing disturbance areas. Impact affects a localised area.	Impact is within existing disturbance and undisturbed/minimally disturbed areas. Impact affects a moderate area (i.e., within the local catchment).	Impact is within previously undisturbed (or minimally disturbed) areas. Impact affects a widespread area.	Impact extent is very high (i.e., extends beyond the concession area boundaries or is of regional scale).
Severity	Recovery of soils and landform values likely without, or with minimal, rehabilitation effort.	Recovery of soils and landform values likely without, or with minimal, rehabilitation effort and using standard management measures.	Recovery of soils and landform values can be partly achieved with some reduction in land and soil capability.	Rehabilitation is very difficult and most of the land and soil capability is reduced or lost.	Land and soil cannot be rehabilitated and land and soil capability is lost.
Duration	Impact is very short in duration (i.e., days).	Impact is short term (i.e., months or less).	Impact is medium term (1 to 2 years).	Impact is long term (3 to 15 years).	Impact is greater than 15 years or permanent.

Reduced landform stability due to ground disturbance

The highest risk of reduced landform stability is where mining and large-scale earthworks will occur in steep terrain (i.e., open pit mine, power station, process plant, ROM pad, mine services area and along access and haul roads). Other risk areas of landform instability are the TSF and the Wallah waste rock dump structures. Reduced landform stability could result in land slip and subsequent loss of topsoil and potential land use capability.

The mountainous and hilly terrain within the project area will be exposed to instability as a result of vegetation clearance, topsoil removal, mining activities, and excavation of regolith. The steep mountain terrain unit is inherently susceptible to instability due to its steep slopes (slopes in most of the study area are greater than 20%, including within the steep mountain terrain unit), weak soil structure, high rainfall and seismicity in the region. Most of the mining activity to date has occurred on the lower mountain slopes and valley floors terrain unit and there is little evidence of major landslips caused by mining-related disturbance in the valley.

The key measures to reduce the potential instability and landslips are project design and engineering methods that provide for stable landforms as project infrastructure is built and mining progresses. Erosion and drainage management measures, as well as progressive surface rehabilitation, will also be implemented to achieve stable landforms.

Major landslips on steep mountain slopes would have considerable impacts down-slope, depending on the location. The risks associated with major landslips and other landform stability related unplanned or infrequent events, including a TSF failure, are assessed in Chapter 7.

The steep mountain terrain unit has the highest potential for landslips given its steepness, thin soil profiles and low vegetation cover. Mining and most of the higher risk construction activities (large scale earthworks for facilities such as the process plant, mine services area, ROM pad, power station and accommodation camp) will also occur in this terrain unit. The impact to the steep mountain terrain unit is considered to be of **low significance** based on the **low magnitude** of impact and **medium sensitivity** of the terrain unit (Table 6.4).

Table 6.4 Residual impact significance summary - reduced capacity to support ecosystems and beneficial land uses due to reduced landform stability - affecting steep mountain terrain unit

Value	**Sensitivity of value**			
Steep mountain terrain unit - capacity to support ecosystems and beneficial land uses	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Terrain not currently an important area for building construction or agriculture and not likely to be in the future due to steepness. Supports limited vegetation growth and ecosystems due to pre-existing vegetation clearance, thin soil profile and erosion.	**Medium** Medium to high susceptibility to landslip, prone to erosion and vulnerable to additional loss of topsoil. Highly contaminated soils around the Nam Pangyun, ER and Wallah valleys. Soils have lower contaminant concentrations further away from these areas within the study area.	**Medium** Due to the steepness it will probably be very difficult to rehabilitate landslip, erosion or additional contamination. Limited potential to regain associated ecosystem value and beneficial land use.	**Medium**
Impact	**Magnitude of impact**			
Reduced capacity to support ecosystems and beneficial land uses due to reduced landform stability	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Due to use of good engineering practices and design widespread landform instability is not expected to occur. Any project induced landslips are expected to be confined to small areas.	**Low** The type of slope failure that may occur is likely to be minor slumping or landslip that can be rehabilitated without permanent loss of land capability and the avoidance of additional land instability hazards.	**Medium** Low severity events with a low spatial extent can be rehabilitated or stabilised within 1 to 2 years.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Medium Landform stability, and associated impacts and construction controls and designs are subject to further investigation as part of the detailed design phase. Information herein is based on the current feasibility study information and baseline investigations.			

The lower mountain slopes and valley floors terrain unit and undulating hills of the northern and western study area are less likely to experience impacts from land instability, as the topography is generally less steep in these areas. The impact to the lower mountain slopes and valley floors is considered to be of **low significance** based on the **low magnitude** of impact and **medium sensitivity** of the terrain unit (Table 6.5). The impact to the undulating hills of the northern and western study area is considered to be of **low significance** based on the **low magnitude** of impact and **medium sensitivity** of the terrain unit (

Table 6.6).

Table 6.5 Residual impact significance summary - reduced capacity to support ecosystems and beneficial land uses due to reduced landform stability - affecting lower mountain slopes and valley floors

Value	**Sensitivity of value**			
Lower mountain slopes and valley floors - capacity to support ecosystems and beneficial land uses	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium Important area for building construction and supports growing of gardens for food. Supports limited vegetation growth and ecosystems due to pre-existing vegetation clearance, thin soil profile and erosion.	**Low** Relatively low susceptibility to landslip but prone to erosion, particularly where fill material has been used. Thin soil profile but generally thicker than steep mountain ridges, crests and the steep mid to upper slopes. Highly contaminated with heavy metals from previous slag and waste rock disposal and fill material.	**High** Due to the widespread existing contamination and lack of vegetation it is likely that this terrain unit would be able to withstand additional contamination without further loss of value or beneficial use. The valley floors would be easier to rehabilitate than the slopes.	**Medium**
Impact	**Magnitude of impact**			
Reduced capacity to support ecosystems and beneficial land uses due to reduced landform stability	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Due to use of good engineering practices and design widespread landform instability is not expected to occur. Any project induced landslips are expected to be confined to small areas.	**Low** The type of slope failure that may occur is likely to be minor slumping or landslip that can be readily rehabilitated and not result in large-scale permanent loss of land capability or creation of additional land instability hazards.	**Low** Low severity events with a low spatial extent can be readily rehabilitated, resulting in a short-term impact.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Medium Landform stability, and associated impacts and construction controls and designs are subject to further investigation as part of the detailed design phase. Information herein is based on the current feasibility study information and baseline investigations.			

Table 6.6 Residual impact significance summary - reduced capacity to support ecosystems and beneficial land uses due to reduced landform stability - affecting undulating hills of the northern and western study area

Value	**Sensitivity of value**			
Undulating hills of the northern and western study area - capacity to support ecosystems and beneficial land uses	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Not currently an important area for building construction but could be in the future due to flatter terrain. Supports higher quality vegetation and has potential for supporting more vegetation growth and agriculture.	**Medium** Medium susceptibility to landslip but high susceptibility to erosion if disturbed and vegetation cleared. Soil profile probably thicker and more stable with more gentle slopes. Soils have lower levels of contamination than other terrain units.	**Medium** Due to low levels of existing contamination and erosion, extensive rehabilitation may be required to regain associated value and beneficial use, however, may be more readily achievable due to the flat topography.	**Medium**
Impact	**Magnitude of impact**			
Reduced capacity to support ecosystems and beneficial land uses due to reduced landform stability - undulating hills of the northern and western study area	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Due to use of good engineering practices and design widespread landform instability is not expected to occur. Any project induced landslips are expected to be confined to small areas.	**Low** The type of slope failure that may occur is likely to be minor slumping or landslip that can be rehabilitated without permanent loss of land capability and the avoidance of additional land instability hazards.	**Medium** Low severity events with a low spatial extent can be rehabilitated or stabilised within 1 to 2 years.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Medium Landform stability, and associated impacts and construction controls and designs are subject to further investigation as part of the detailed design phase. Information herein is based on the current feasibility study information and baseline investigations.			

Changes to landform due to major earthworks and mining

Significant changes to the local landform will remain even after implementation of management measures. These landform changes are assessed below for the key project features.

The open pit will have a footprint of around 95.9 ha and will extend 250 m below the existing pit floor. The TSFs will fill in the valleys that they are located with embankment heights of 132.8 m, 147.0 m and 161.4 m for TSFA, TSFB and TSF C respectively and a total footprint of around 149.0 ha. The Wallah waste rock dump will fill the portion of the Wallah Valley that it sits in and will be 315 m high and 107.2 ha in area.

Figure 6.4 shows the current landform in the Bawdwin concession area compared with the landform changes due to the open pit and other key project features (TSFs and waste rock dump). All of these landform changes will be permanent.

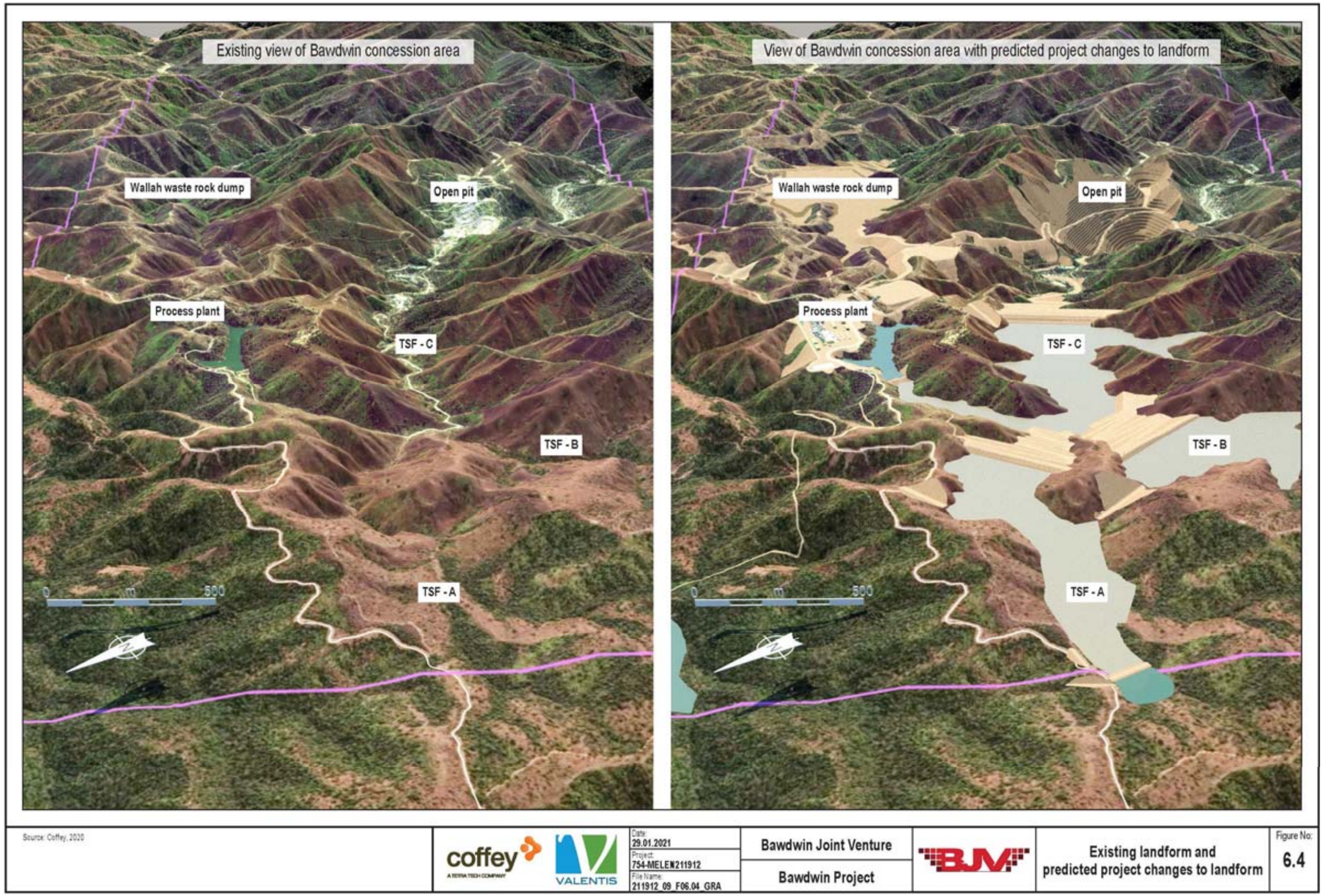


Figure 6.4 Existing landform and predicted project changes to landform

Open pit

As the open pit will remain as an excavation that will become a pit lake at closure, any land capability (current and future) will be directly lost in this area. The expansion of the existing pit to the east across a portion of the Nam Pangyun valley will occur in an area already highly disturbed from historic mining. The expansion of the existing pit to the north and south encroaches into the steep mountain terrain into areas that are not highly disturbed from previous activities. The impact to the steep mountain terrain unit is considered to be of high significance based on the high magnitude of impact and medium sensitivity of the terrain unit (Table 6.7). The impact to the lower mountain slopes and valley floors is considered to be of high significance based on the high magnitude of impact and medium sensitivity of the terrain unit (Table 6.8).

Table 6.7 Residual impact significance summary - changes to landform due to expansion and operation of the open pit - affecting steep mountain terrain unit

Value	**Sensitivity of value**			
Steep mountain terrain unit - capacity to support ecosystems and beneficial land uses	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Terrain not currently an important area for building construction or agriculture and not likely to be in the future due to steepness. Supports limited vegetation growth and ecosystems due to pre-existing vegetation clearance, thin soil profile and erosion.	**Medium** Medium to high susceptibility to landslip, prone to erosion and vulnerable to additional loss of topsoil. Highly contaminated soils around the Nam Pangyun, ER and Wallah valleys. Soils have lower contaminant concentrations further away from these areas within the study area.	**Medium** Due to the steepness it will probably be very difficult to rehabilitate landslip, erosion or additional contamination. Limited potential to regain associated ecosystem value and beneficial land use.	**Medium**
Impact	**Magnitude of impact**			
Changes to landform due to expansion and operation of the open pit	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium The part of the open pit located in the steep mountain terrain is largely located within existing disturbance area. Impact affects a moderate area (i.e., within the local catchment).	**Very high** The impacts will not be able to be rehabilitated and the current and potential future uses (although currently highly limited in most areas in this terrain unit) of the unit will be lost.	**Very high** The landform changes will be permanent.	**High**
	Residual impact significance			**High**
	Assessment of uncertainty			
	Low The size and location of the pit expansion is known and has been overlain with the surrounding landform units with a 3D visualisation of the open pit developed. Impacted areas are well understood.			

Table 6.8 Residual impact significance summary - changes to landform due to expansion and operation of the open pit - affecting lower mountain slopes and valley floors

Value	**Sensitivity of value**			
Lower mountain slopes and valley floors - capacity to support ecosystems and beneficial land uses	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium Important area for building construction and supports growing of gardens for food. Supports limited vegetation growth and ecosystems due to pre-existing vegetation clearance, thin soil profile and erosion.	**Low** Relatively low susceptibility to landslip but prone to erosion, particularly where fill material has been used. Thin soil profile but generally thicker than steep mountain ridges, crests and the steep mid to upper slopes. Highly contaminated with heavy metals from previous slag and waste rock disposal and fill material.	**High** Due to the widespread existing contamination and lack of vegetation it is likely this terrain unit would be able to withstand additional contamination without further loss of value or beneficial use. The valley floors would be easier to rehabilitate than the slopes.	**Medium**
Impact	**Magnitude of impact**			
Changes to landform due to expansion and operation of the open pit	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low The part of the open pit located in the lower mountain slopes and valley floors terrain unit is entirely within existing disturbance areas.	**Very high** The impacts will not be able to be rehabilitated and the current and potential future uses of the terrain unit will be lost.	**Very high** The landform changes will be permanent.	**High**
	Residual impact significance			**High**
	Assessment of uncertainty			
	Low The size and location of the pit expansion is known and has been overlain with the surrounding landform units with a 3D visualisation of the open pit developed. Impacted areas are well understood. As the area will be a void (mine pit), there will be no future land uses that can be regained in the impacted areas.			

Tailings storage facilities and waste rock dump

Construction of the TSFs (including TSFs, embankments, closure spillways and the diversion dam) and waste rock dump (including sediment dams) will result in the topography of the landform permanently changing (Figure 6.4). The TSFs and WRD are located across all three terrain units. Rehabilitation of the TSFs and WRD will be conducted progressively when practicable, resulting in recovery of some of the capacity of the landform to support ecosystems and beneficial uses over time. The impact to the steep mountain terrain unit is of **high significance** based on the **high magnitude** of impact and **medium sensitivity** of the terrain unit (Table 6.9). The impact to both the lower mountain slopes and valley floor terrain unit and the undulating hills of the northern and western study area terrain unit is of **moderate significance** based on the **medium magnitude** of impact and **medium sensitivity** of these terrain units (Table 6.10 and Table 6.11).

Table 6.9 Residual impact significance summary - changes to landform due to construction of the tailings storage facility and waste rock dump - affecting steep mountain terrain unit

Value	**Sensitivity of value**			
	Importance	***Vulnerability***	***Resilience***	***Sensitivity***

Steep mountain terrain unit - capacity to support ecosystems and beneficial land uses	**Low** Terrain not currently an important area for building construction or agriculture and not likely to be in the future due to steepness. Supports limited vegetation growth and ecosystems due to pre-existing vegetation clearance, thin soil profile and erosion.	**Medium** Medium to high susceptibility to landslip, prone to erosion and vulnerable to additional loss of topsoil. Highly contaminated soils around the Nam Pangyun, ER and Wallah valleys. Soils have lower contaminant concentrations further away from these areas within the study area.	**Medium** Due to the steepness, it will probably be very difficult to rehabilitate landslip, erosion or additional contamination. Limited potential to regain associated ecosystem value and beneficial land use.	**Medium**
Impact	**Magnitude of impact**			
Changes to landform due to construction of the tailings storage facility and waste rock dump	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	High 231 ha of the TSF and WRD are located in areas of steep mountain terrain. This a widespread, previously undisturbed (or minimally disturbed) areas.	**Medium** The TSF and waste rock dump will eventually be rehabilitated, and some land capability may be returned (although this will need to be confirmed during detailed closure planning). Topography changes while very different to current topography will be somewhat compatible with surrounding terrain.	**Very high** Changes to topography will be permanent, however the capacity of the land to support ecosystems and beneficial uses may return in the long-term after rehabilitation	**High**
	Residual impact significance			**High**
	Assessment of uncertainty			
	Medium The topography change due to this feature has been developed in a 3D visualisation with the surrounding terrain and the topography change is well understood. However, the ability of land capability to be successfully regained at the TSF and waste rock dump sites will need to be confirmed during detailed closure planning.			

Table 6.10 Residual impact significance summary - changes to landform due to construction of the tailings storage facilities and waste rock dump - affecting lower mountain slopes and valley floor

Value	**Sensitivity of value**			
Lower mountain slopes and valley floor - capacity to support ecosystems and beneficial land uses	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium Important area for building construction and supports growing of gardens for food. Supports limited vegetation growth and ecosystems due to pre-existing vegetation clearance, thin soil profile and erosion.	**Low** Relatively low susceptibility to landslip but prone to erosion, particularly where fill material has been used. Thin soil profile but generally thicker than steep mountain ridges, crests and the steep mid to upper slopes. Highly contaminated with heavy metals from previous slag and waste rock disposal and fill material.	**High** Due to the widespread existing contamination and lack of vegetation it is likely this terrain unit would be able to withstand additional contamination without further loss of value or beneficial use. The valley floors would be easier to rehabilitate than the slopes.	**Medium**
Impact	**Magnitude of impact**			

Changes to landform due to construction of the tailings storage facility and waste rock dump	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low 15 ha of the TSF and WRD are located within the lower mountain slopes and valley floor unit. The impact will affect a localised area of this terrain unit.	**Medium** The TSF and waste rock dump will eventually be rehabilitated, and some land capability may be returned (although this will need to be confirmed during detailed closure planning). Topography changes while very different to current topography will be somewhat compatible with surrounding terrain.	**Very high** Changes to topography will be permanent, however the capacity of the land to support ecosystems and beneficial uses may return in the long-term after rehabilitation.	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	Medium The topography change due to this feature has been developed in a 3D visualisation with the surrounding terrain and the topography change is well understood. However, the ability of land capability to be successfully regained at the TSF and waste rock dump sites will need to be confirmed during detailed closure planning			

Table 6.11 Residual impact significance summary - changes to landform due to construction of the tailings storage facilities and waste rock dump - affecting undulating hills of the northern and western study area

Value	**Sensitivity of value**			
Undulating hills of the northern and western study area - capacity to support ecosystems and beneficial land uses	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Not currently an important area for building construction but could be in the future due to flatter terrain. Supports higher quality vegetation and has potential for supporting more vegetation growth and agriculture.	**Medium** Medium susceptibility to landslip but high susceptibility to erosion if disturbed and vegetation cleared. Soil profile probably thicker and more stable with more gentle slopes. Soils have lower levels of contamination than other terrain units.	**Medium** Due to low levels of existing contamination and erosion, extensive rehabilitation may be required to regain associated value and beneficial use, however, may be more readily achievable due to the flat topography.	**Medium**
Impact	**Magnitude of impact**			
Changes to landform due to construction of the tailings storage facilities and waste rock dump	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low 10 ha of the TSF and WRD are located within the undulating hills terrain unit. The impact will affect a localised area of this terrain unit.	**Medium** The TSF and waste rock dump will eventually be rehabilitated, and some land capability may be returned (although this will need to be confirmed during detailed closure planning). Topography changes while very different to current topography will be somewhat compatible with surrounding terrain.	**Very high** Changes to topography will be permanent, however the capacity of the land to support ecosystems and beneficial uses may return in the long-term after rehabilitation	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			

	Medium The topography change due to this feature has been developed in a 3D visualisation with the surrounding terrain and the topography change is well understood. However, the ability of land capability to be successfully regained at the TSF and waste rock dump sites will need to be confirmed during detailed closure planning

Loss of topsoil due to increased erosion or poor soil management

Erosion of topsoil is likely to occur during construction and operations, even with implementation of management measures.

The highest erosion risks will be where large areas of soils are exposed in steep terrain. These areas will comprise the construction sites for key infrastructure such as the power station, process plant, ROM pad, mine services area, TSFs, waste rock dump, accommodation camp, haul road and access road (see Figure 6.2). Up to 161.2 ha total area will be exposed to potential erosion during construction of the power station (0.3 ha), process plant (10.3 ha), ROM pad (9.2 ha), accommodation village (3.3 ha), mine services area (4.4 ha), haul roads and batters (14.8 ha), access roads (48.6 ha), TSFs embankments and diversion dam (69.8 ha) and sediment dams (0.6 ha). The majority of this area is in the steep mountain terrain (76.5%), with less in the undulating hills of the northern and western study area (6.7%) and lower mountain slopes and valley floor unit (9.9%).The remaining 6.8% was not mapped, and is comprised of 11 ha of the area that the access roads will be constructed on.

Although the TSFs and Wallah waste rock dump will be progressively covered and rehabilitated, the exposed areas prior to rehabilitation will be prone to erosion. Ongoing erosion is likely to occur around unsealed roads and hardstand areas during operations. Up to 356.8 ha total area will be exposed to potential erosion during operations, with exposed areas including the open pit (95.9 ha), TSFs (excluding the diversion dam and closure spillways) (139.1 ha), Wallah WRD and sediment dams (107.1 ha) and haul roads and batters (14.8 ha). The majority of this area is in the steep mountain terrain unit (86.7%), with less in the undulating hills of the northern and western study area (2.3%) and lower mountain slopes and valley floor unit (11.0%).

Measures will be implemented to manage surface drainage around construction sites, limit erosion and intercept suspended solids and sediment. Where practicable, disturbed sites (with the exception of unsealed roads and hardstand areas) will either be covered by sealed surfaces or progressively rehabilitated and revegetated. Other sites may be required to remain unsealed and unvegetated throughout operations, in which case they will be revegetated at closure. At these sites, measures implemented will include compaction, run-on management and sediment interception. Construction on or near natural drainage lines will be planned for the dry season, where practicable. The waste rock dump and TSF embankments, batters and benches will be designed (i.e., selection of optimal batter slopes and bench widths) (see Chapter 4 for detail on design of these facilities) to increase their long-term stability and reduce erosion potential. Most surfaces will be either covered, rehabilitated or stabilised after construction. Areas that will remain uncovered are roads and parts of the TSF and waste rock dump embankments. These areas will be subjected to ongoing drainage and erosion management to manage localised erosion.

Poor management of soils, including those in stockpiles, can alter the structure of the soil profile upon returning the soil to the land during rehabilitation. Protection of soil stockpiles from weathering (i.e., erosion), and separating material types to allow soil profiles to be re-established (e.g., topsoil and subsoil) during rehabilitation will give the greatest chance of successful rehabilitation of soils so they retain a structure supportive of plant growth and land stability. This impact will affect all three terrain units; however, the steep mountain terrain unit will be the most extensively impacted as it hosts most of the major construction areas (i.e., around the power station, process plant, ROM pad and mine services area) and given the steepness of the terrain, disturbed land will be relatively difficult to rehabilitate. With an appropriate closure and rehabilitation plan in place and training of site personnel, it is expected that poor management of stockpiled soils will be largely avoided.

After rehabilitation, the existing land and soil capability is expected to be mostly returned over time, except in areas of extensive ongoing erosion, where any increased erosion of steeper terrain could permanently reduce the soil profile to very low levels. These conditions limit the potential for achieving long term stable landform and vegetation growth and are expected to be very difficult to fully rehabilitate. The impact to the steep mountain terrain unit is considered to be of **high significance** based on the **high magnitude** of impact and **medium sensitivity** of the terrain unit (Table 6.12). The impact to the lower mountain slopes and valley floors is considered to be of **moderate significance** based on the **medium magnitude** of impact and **medium sensitivity** of the terrain unit (Table 6.13). The impact to the undulating hills of the northern and western study areas is considered to be of **low significance** based on the **low magnitude** of impact and **medium sensitivity** of the terrain unit (Table 6.14).

Erosion will occur within the open pit itself due to rainfall runoff as well as the in-pit diversion of the Nam Pangyun. The pit will be continually disturbed as it is mined and will not be suitable for supporting ecosystems or land use.

Table 6.12 Residual impact significance summary - reduced capacity to support ecosystems and beneficial land uses due to loss of topsoil due to increased erosion or poor soil management - affecting steep mountain terrain unit

Value	**Sensitivity of value**			
Steep mountain terrain unit - capacity to support ecosystems and beneficial land uses	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Terrain not currently an important area for building construction or agriculture and not likely to be in the future due to steepness. Supports limited vegetation growth and ecosystems due to pre-existing vegetation clearance, thin soil profile and erosion.	**Medium** Medium to high susceptibility to landslip, prone to erosion and vulnerable to additional loss of topsoil. Highly contaminated soils around the Nam Pangyun, ER and Wallah valleys. Soils have lower contaminant concentrations further away from these areas within the study area.	**Medium** Due to the steepness it will probably be very difficult to rehabilitate landslip, erosion or additional contamination. Limited potential to regain associated ecosystem value and beneficial land use.	**Medium**
Impact	**Magnitude of impact**			
Reduced capacity to support ecosystems and beneficial land uses due to loss of topsoil due to increased erosion or poor soil management	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Topsoil loss will occur partly within existing disturbance areas and undisturbed areas of the steep mountain terrain unit. Most of the disturbance will occur in this terrain unit.	**High** Recovery of topsoil (for storage and later reuse) will be more difficult in the steep mountain terrain unit and the reestablishment of ecosystem capacity post stabilisation and rehabilitation will be more challenging but expected to return some capacity over time.	**High** Due to the steepness it will probably take longer to re-establish ecosystem capacity.	**High**
	Residual impact significance			**High**
	Assessment of uncertainty			
	Medium Assumptions have been made on the achievability of successful rehabilitation. However, the ability of land capability to be successfully regained at affected locations will need to be confirmed during detailed closure planning.			

Table 6.13 Residual impact significance summary - reduced capacity to support ecosystems and beneficial land uses due to loss of topsoil due to increased erosion or poor soil management - affecting lower mountain slopes and valley floors

Value	**Sensitivity of value**			
Lower mountain slopes and valley floors - reduced capacity to support ecosystems and beneficial land uses	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium Important area for building construction and supports growing of gardens for food. Supports limited vegetation growth and ecosystems due to pre-existing vegetation clearance, thin soil profile and erosion	**Low** Relatively low susceptibility to landslip but prone to erosion, particularly where fill material has been used. Thin soil profile but generally thicker than steep mountain ridges, crests and the steep mid to upper slopes. Highly contaminated with heavy metals from previous slag and waste rock disposal and fill material.	**High** Due to the widespread existing contamination and lack of vegetation it is likely that this terrain unit would be able to withstand additional contamination without further loss of value or beneficial use. The valley floors would be easier to rehabilitate than the slopes.	**Medium**
Impact	**Magnitude of impact**			
Reduced capacity to support ecosystems and beneficial land uses due to loss of topsoil due to increased erosion or poor soil management	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Topsoil loss will occur partly within existing disturbance areas and undisturbed areas.	**Low** Recovery of topsoil (for storage and later reuse) and subsequent reestablishment of ecosystem capacity and land capability is expected to readily achievable in this terrain unit.	**Medium** Impacts will be medium term due to erosion management and progressive rehabilitation of areas that are able to be progressively rehabilitated.	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	Medium Assumptions have been made on the achievability of successful rehabilitation. However, the ability of land capability to be successfully regained at affected locations will need to be confirmed during detailed closure planning.			

Table 6.14 Residual impact significance summary - reduced capacity to support ecosystems and beneficial land uses due to loss of topsoil due to increased erosion or poor soil management - affecting undulating hills of the northern and western study area

Value	**Sensitivity of value**			
Undulating hills of the northern and western study area - capacity to support ecosystems and beneficial land use	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Not currently an important area for building construction but could be in the future due to flatter terrain. Supports higher quality vegetation and has potential for supporting more vegetation growth and agriculture.	**Medium** Medium susceptibility to landslip but high susceptibility to erosion if disturbed and vegetation cleared. Soil profile is likely to be thicker and more stable with more gentle slopes than other terrain units. Soils have lower levels of contamination than other terrain units.	**Medium** Due to low levels of existing contamination and erosion, extensive rehabilitation may be required to regain associated value and beneficial use, however, may be more readily achievable due to the flat topography.	**Medium**
Impact	**Magnitude of impact**			
Reduced capacity to support ecosystems and beneficial land uses due to loss of topsoil due to increased erosion or poor soil management	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low A small part of the project footprint is expected to disturb this terrain unit.	**Medium** Recovery of topsoil (for storage and later reuse) will be more difficult on the steeper sections of this terrain unit. The reestablishment of ecosystem capacity post stabilisation and rehabilitation will be more challenging but expected to return some capacity over time.	**Low** While erosion will occur long-term, impacts will be short term due to erosion management and progressive rehabilitation.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Medium Assumptions have been made on the achievability of successful rehabilitation. However, the ability of land capability to be successfully regained at affected locations will need to be confirmed during detailed closure planning.			

The same impacts (and associated significance ratings) are predicted during project decommissioning and closure implementation activities, when buildings and infrastructure are removed and remaining earthworks and rehabilitation works are being implemented. The mine will be closed under a mine closure plan to be developed and submitted to the Department of Mines for approval in accordance with the Myanmar Mines Law (1994) and the Myanmar Mines Rules (2018), and any subsequent revision of those laws and rules in force at the time closure is planned. The main objective of mine closure will be to achieve long-term physical, chemical, and biological stability of the site to minimise potential environmental, health and safety risks. Rehabilitation activities, outlined in Section 6.2.3, will be undertaken to aid in achieving this objective. The post-closure site will be designed to require minimal active maintenance and monitoring. Ongoing erosion is expected to gradually diminish as post-closure rehabilitation progresses and vegetation cover is established. No significant erosion impacts are predicted to occur after closure, with successful implementation of management measures during closure and rehabilitation.

Modification of soil structure

Topsoil modification will occur in the form of compaction around construction sites, and unsealed roads and hardstand areas. Key compaction areas will include the haul road, access roads; and around the power station, process plant, ROM pad and accommodation camp. Compaction will arise from surface preparation during construction and physical presence of buildings and infrastructure, as well as ongoing movements of heavy vehicles and machinery. Compaction of soil results in loss of soil structure, reduced water infiltration and reduced oxygenation. Soil compaction can also lead to increased surface runoff.

Surface compaction will mostly occur during construction where large machinery and vehicle traffic will access construction areas. Some areas (i.e., unsealed roads and hardstand areas) will remain compacted during operations. After project closure, compacted areas are expected to be successfully rehabilitated by surface ripping. Surface compaction will affect all three terrain units, with the steep mountain terrain unit most extensively impacted as most of the major construction and road areas are located within it.

The impact to the steep mountain terrain unit, lower mountain slopes and valley floors, and undulating hills of the northern and western study areas are considered to be of **low significance** based on the **medium magnitude** of impact and **medium sensitivity** of these terrain units (Table 6.15, Table 6.16 and Table 6.17).

Table 6.15 Residual impact significance summary - reduced capacity to support ecosystems and beneficial land uses due to soil compaction modifying the soil structure - affecting steep mountain terrain unit

Value	**Sensitivity of value**			
Steep mountain terrain unit - capacity to support ecosystems and beneficial land uses	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Terrain not currently an important area for building construction or agriculture and not likely to be in the future due to steepness. Supports limited vegetation growth and ecosystems due to pre-existing vegetation clearance, thin soil profile and erosion.	**Medium** Medium to high susceptibility to landslip, prone to erosion and vulnerable to additional loss of topsoil. Highly contaminated soils around the Nam Pangyun, ER and Wallah valleys. Soils have lower contaminant concentrations further away from these areas within the study area.	**Medium** Due to the steepness it will probably be very difficult to rehabilitate landslip, erosion or additional contamination. Limited potential to regain associated ecosystem value and beneficial land use.	**Medium**
Impact	**Magnitude of impact**			
Reduced capacity to support ecosystems and beneficial land uses due to soil compaction modifying the soil structure	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Compacted areas to be rehabilitated will be highly localised within the project footprint	**Low** Any existing land capability to support plant growth will be able to be regained after rehabilitation	**Low to high** The impact may range from short-term (i.e., months during construction, with progressive rehabilitation of compacted areas) to long term (i.e., surfaces to remain compacted throughout the life of the project).	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Medium. Assumptions have been made on the achievability of successful rehabilitation. However, the ability of land capability to be successfully regained at affected locations will need to be confirmed during detailed closure planning.			

Table 6.16 Residual impact significance summary - reduced capacity to support ecosystems and beneficial land uses due to soil compaction modifying the soil structure - affecting lower mountain slopes and valley floors

Value	**Sensitivity of value**			
Lower mountain slopes and valley floors - capacity to support ecosystems and beneficial land uses	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium Important area for building construction and supports growing of gardens for food. Supports limited vegetation growth and ecosystems due to pre-existing vegetation clearance, thin soil profile and erosion.	**Low** Relatively low susceptibility to landslip but prone to erosion, particularly where fill material has been used. Thin soil profile but generally thicker than steep mountain ridges, crests and the steep mid to upper slopes. Highly contaminated with heavy metals from previous slag and waste rock disposal and fill material.	**High** Due to the widespread existing contamination and lack of vegetation it is likely that this terrain unit would be able to withstand additional contamination without further loss of value or beneficial use. The valley floors would be easier to rehabilitate than the slopes.	**Medium**
Impact	**Magnitude of impact**			
Reduced capacity to support ecosystems and beneficial land uses due to soil compaction modifying the soil structure	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very low Compacted areas to be rehabilitated will be highly localised within the project footprint	**Low** Any existing land capability to support plant growth will be able to be regained after rehabilitation	**Medium** The impact may range from short-term (i.e., months during construction, with progressive rehabilitation of compacted areas) to long term (i.e., surfaces to remain compacted throughout the life of the project)	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Medium Assumptions have been made on the achievability of successful rehabilitation. However, the ability of land capability to be successfully regained at affected locations will need to be confirmed during detailed closure planning.			

Table 6.17 Residual impact significance summary - reduced capacity to support ecosystems and beneficial land uses due to soil compaction modifying the soil structure - affecting undulating hills of the northern and western study area

Value	**Sensitivity of value**			
Undulating hills of the northern and western study area - capacity to support ecosystems and beneficial land uses	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Not currently an important area for building construction but could be in the future due to flatter terrain. Supports higher quality vegetation and has potential for supporting more vegetation growth and agriculture.	**Medium** Medium susceptibility to landslip but high susceptibility to erosion if disturbed and vegetation cleared. Soil profile probably thicker and more stable with more gentle slopes. Soils have lower levels of contamination than other terrain units.	**Medium** Due to low levels of existing contamination and erosion, extensive rehabilitation may be required to regain associated value and beneficial use, however, may be more readily achievable due to the flat topography.	**Medium**
Impact	**Magnitude of impact**			
Reduced capacity to support ecosystems and beneficial land uses due to soil compaction modifying the soil structure	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very low Compacted areas to be rehabilitated will be highly localised within the project footprint	**Low** Any existing land capability to support plant growth will be able to be regained after rehabilitation	**Medium** The impact may range from short-term (i.e., months during construction, with progressive rehabilitation of compacted areas) to long term (i.e., surfaces to remain compacted throughout the life of the project).	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Medium Assumptions have been made on the achievability of successful rehabilitation. However, the ability of land capability to be successfully regained at affected locations will need to be confirmed during detailed closure planning.			

Contamination of soils

As described in Section 5.1, across much of the study area concentrations of arsenic, copper, lead, nickel and zinc are elevated in comparison to ecosystem protection guideline levels for soil quality, due to naturally-occurring mineralisation and historical mining and mineral processing. The key areas where project ground disturbance will encounter soils containing high metals concentrations are around the existing open pit, ER valley, the Tiger Tunnel area, and Tiger Camp. Areas of existing soil contamination, in relation to the project layout, are shown in figures 5.7 to 5.11 in Section 5.1.

Most of the construction land disturbance will occur north of the major contamination areas (i.e., power station, process plant, ROM pad and mine services area) where soil metals are mostly at low concentrations below soil quality guidelines (see Section 5.1). Development of the open pit and construction of the haul road, explosives facility and accommodation camp are most likely to encounter soils with the highest metals concentrations. Routine soil monitoring will be conducted to identify contaminated soil and to ensure that such material is removed and not used for topsoil rehabilitation. Contaminated soils may be buried deeper in the soil profile (if suitable to do so) below the soil root zone and capped with uncontaminated soil. Zones where contaminated soils are buried will be recorded so their disturbance is avoided in future works where practicable. Upon project closure and rehabilitation, key contamination sources such as the TSF and Wallah waste rock dump will be capped with suitable uncontaminated material and revegetated. After rehabilitation, topsoil quality may be improved compared to the current soil quality.

Erosion of soil with known high metals concentrations in stockpiles or disturbed areas could occur even with management measures in place. Due to erosion, contaminated soil could be transported to areas where contamination is low or absent. Movement of contaminated soils in this way is not expected to result in significant loss of surrounding soil and land capacity. The project impact management measures and closure and rehabilitation strategy will be to contain existing contamination to where it currently is, and has been for many years, and not move the contamination around to new areas. Net improvement of topsoil quality is expected in many areas within the project footprint as progressive rehabilitation is implemented. The contaminated status of some areas outside the project footprint (i.e., around the periphery of the open pit, Tiger Tunnel, Tiger Camp and central Bawdwin) will remain unchanged.

The impact to the steep mountain terrain unit, lower mountain slopes and valley floors and undulating hills of the northern and western study areas is considered to be of **low significance** based on the **low magnitude** of impact and **medium sensitivity** of these terrain units (Table 6.18, Table 6.19 and Table 6.20).

Table 6.18 Residual impact significance summary - reduced capacity to support ecosystems and beneficial land uses due to movement of contaminated soils to uncontaminated areas - affecting steep mountain terrain unit

Value	**Sensitivity of value**			
Steep mountain terrain unit - capacity to support ecosystems and beneficial land uses	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Not currently an important area for building construction but could be in the future due to flatter terrain. Supports higher quality vegetation and has potential for supporting more vegetation growth and agriculture.	**Medium** Medium susceptibility to landslip but high susceptibility to erosion if disturbed and vegetation cleared. Soil profile is likely thicker and more stable with more gentle slopes than other terrain units. Soils have lower levels of contamination than other terrain units.	**Medium** Due to low levels of existing contamination and erosion, extensive rehabilitation may be required to regain associated value and beneficial use, however, may be more readily achievable due to the flat topography.	**Medium**
Impact	**Magnitude of impact**			
Reduced capacity to support ecosystems and beneficial land uses due to movement of contaminated soils to uncontaminated areas	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Any spread of contamination is expected to be localised and avoided by implementation of management practices, with large parts of the project area that may be impacted by soil contamination are already disturbed with a high level of existing contamination.	**Low** Due to existing extent of soil contamination further contamination or spread of contamination is unlikely and if it occurs is unlikely to cause any significant loss of soil and land capacity.	**Very high** Contamination that is within the existing extent of contamination may not be rehabilitated by WMM and may remain after closure.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	High The exact locations and depths of soil contamination are not known for all areas of disturbance. The baseline soil sampling grid did not cover the whole study area, but a large enough proportion of it to provide inference of spatial trends. Also, the sampling only investigated one depth in the soil profile. Site-specific investigations will be required to further understand soil contamination extent and risk. WMM have not yet conducted a materials balance for closure or determined the ability to remediate all areas of contamination.			

Table 6.19 Residual impact significance summary - reduced capacity to support ecosystems and beneficial land uses due to movement of contaminated soils to uncontaminated areas - affecting lower mountain slopes and valley floors

Value	**Sensitivity of value**			
Lower mountain slopes and valley floors - capacity to support ecosystems and beneficial land uses	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium Important area for building construction and supports growing of gardens for food. Supports limited vegetation growth and ecosystems due to pre-existing vegetation clearance, thin soil profile and erosion.	**Low** Relatively low susceptibility to landslip but prone to erosion, particularly where fill material has been used. Thin soil profile but generally thicker than steep mountain ridges, crests and the steep mid to upper slopes. Highly contaminated with heavy metals from previous slag and waste rock disposal and fill material.	**High** Due to the widespread existing contamination and lack of vegetation it is likely that this terrain unit would be able to withstand additional contamination without further loss of value or beneficial use. The valley floors would be easier to rehabilitate than the slopes.	**Medium**
Impact	**Magnitude of impact**			
Reduced capacity to support ecosystems and beneficial land uses due to movement of contaminated soils to uncontaminated areas	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Any spread of contamination is expected to be localised and avoided by implementation of management practices. Large parts of the project area that may be impacted by soil contamination are already disturbed with a high level of existing contamination.	**Low** Due to existing extent of soil contamination further contamination or spread of contamination is unlikely and if it occurs is unlikely to cause any significant loss of soil and land capacity.	**Very high** Contamination that is within the existing extent of contamination may not be rehabilitated by WMM and may remain after closure	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	High The exact locations and depths of soil contamination are not known for all areas of disturbance. The baseline soil sampling grid did not cover the whole study area, but a large enough proportion of it to provide inference of spatial trends. Also, the sampling only investigated one depth in the soil profile. Site-specific investigations will be required to further understand soil contamination extent and risk. WMM have not yet conducted a materials balance for closure or determined the ability to remediate all areas of contamination.			

Table 6.20 Residual impact significance summary - reduced capacity to support ecosystems and beneficial land uses due to movement of contaminated soils to uncontaminated areas - affecting undulating hills of the northern and western study area

Value	**Sensitivity of value**			
Undulating hills of the northern and western study area - capacity to support ecosystems and beneficial land uses	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Not currently an important area for building construction but could be in the future due to flatter terrain. Supports higher quality vegetation and has potential for supporting more vegetation growth and agriculture.	**Medium** Medium susceptibility to landslip but high susceptibility to erosion if disturbed and vegetation cleared. Soil profile is likely thicker and more stable with more gentle slopes than other terrain units. Soils have lower levels of contamination than other terrain units.	**Medium** Due to low levels of existing contamination and erosion, extensive rehabilitation may be required to regain associated value and beneficial use, however, may be more readily achievable due to the flat topography.	**Medium**
Impact	**Magnitude of impact**			
Reduced capacity to support ecosystems and beneficial land uses due to movement of contaminated soils to uncontaminated areas	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very low Any spread of contamination by soil movement is expected to be localised and avoided by implementation of management practices. The terrain unit has low levels of existing disturbance/ contamination presently.	**Medium** Existing metals concentrations are mostly low[1] (i.e., not detected and/or below soil quality guidelines), so there is a lack of existing contaminated soils if these soils were to become contaminated the capacity of the terrain unit may be reduced.	**High** Any inadvertent contamination of this land unit during operations may be able to be remediated prior to closure.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	High The exact locations and depths of soil contamination are not known for all areas of disturbance. The baseline soil sampling grid did not cover the whole study area, but a large enough proportion of it to provide inference of spatial trends. Also, the sampling only investigated one depth in the soil profile. Site-specific investigations will be required to further understand soil contamination extent and risk.			

Summary of residual impacts

Table 6.21 provides a summary of the residual impacts and their significance. The table outlines the impact, the applicable terrain unit and the associated values impacted, the sensitivity of the terrain unit, the impact phase (i.e., construction, operations, closure), the impact magnitude, the key management measures to reduce impact, the impact significance rating and the supporting justification for the significance rating.

[1] This statement is based on low concentrations of arsenic, lead and zinc detected across this terrain unit during baseline sampling. Copper and nickel were not analysed from samples in this area, although it is assumed that copper and nickel concentrations would also be lower in this terrain unit as there was no previous mine waste disposal in this area upstream of Bawdwin.

Table 6.21 Summary of assessment of residual landform and soil impacts

Impact	Terrain unit and sensitivity (see Section 5.1.6)	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Reduced capacity to support ecosystems and beneficial land uses due to reduced landform stability	Steep mountain terrain unit • Medium sensitivity	Construction and operations	Low magnitude • Low spatial extent • Low severity • Medium duration	• Constructed landforms designed for long-term stability and reduced erosion potential, with consideration of the locally steep terrain and high rainfall environment • Landform and stabilisation measures • Erosion and sediment control measures	Low	Maintenance of land stability will be factored into project design. Erosion and drainage management measures, as well as progressive surface rehabilitation, will be implemented to manage the stability of landforms. Impact magnitude is low as the type of slope failure that may occur is likely to be minor slumping or landslip and impacts are expected to be temporary and able to be rehabilitated. Mining and the majority of high risk construction will occur in this terrain unit.	Medium • Further investigation into landform stability and associated impacts and construction controls and designs required.
	Lower mountain slopes and valley floors • Medium sensitivity	Construction and operations	Low magnitude • Low spatial extent • Low severity • Low duration	• Constructed landforms designed for long-term stability and reduced erosion potential, with consideration of the locally steep terrain and high rainfall environment • Landform and stabilisation measures • Erosion and sediment control measures	Low	Maintenance of land stability will be factored into project design. Erosion and drainage management measures, as well as progressive surface rehabilitation, will be implemented to manage the stability of landforms. Impact magnitude is low as the type of slope failure that may occur is likely to be minor slumping or landslip and impacts are expected to be temporary and able to be rehabilitated. This terrain unit has lower susceptibility to higher land instability impacts as it is less steep and relatively less construction activities and mining will occur here than in the steep mountain terrain.	Medium • Further investigation into landform stability and associated impacts and construction controls and designs required.

Impact	Terrain unit and sensitivity (see Section 5.1.6)	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
	Undulating hills of the northern and western study area • Medium sensitivity	Construction and operations	Low magnitude • Low spatial extent • Low severity • Medium duration	• Constructed landforms designed for long-term stability and reduced erosion potential, with consideration of the locally steep terrain and high rainfall environment • Landform and stabilisation measures • Erosion and sediment control measures	Low	Maintenance of land stability will be factored into project design. Erosion and drainage management measures, as well as progressive surface rehabilitation, will be implemented to manage the stability of landforms. Impact magnitude is low as the type of slope failure that may occur is likely to be minor slumping or landslip and impacts are expected to be temporary and able to be rehabilitated. This terrain unit has lower susceptibility to higher land instability impacts as it is less steep and relatively less construction activities and mining will occur here than in the steep mountain terrain.	Medium • Further investigation into landform stability and associated impacts and construction controls and designs required.
Changes to landform due to expansion and operation of the open pit	Steep mountain terrain • Medium sensitivity	Construction, operations and closure	High magnitude • Medium spatial extent • Very high severity • Very high duration	• Design and operate pit to maintain pit wall stability and minimise area of impact.	High	Very high severity and permanent change to the landscape in the form of a large mine void. Expansion of an existing pit across a highly disturbed zone in the Nam Pangyun valley, with severe landform changes in the southern and northern portions of the pit (away from the existing high disturbance) as it encroaches into the steep mountain terrain.	Low • Size and location of pit expansion is known and impacted areas are well understood.
	Lower mountain slopes and valley floors • Medium sensitivity	Construction, operations and closure	High magnitude • Low spatial extent • Very high severity • Very high duration	• Design and operate pit to maintain pit wall stability and minimise area of impact.	High	Very high severity and permanent change to the landscape in the form of a large void. Much of the terrain unit in this area is already highly disturbed. The extent of this impact will be limited in the context of existing disturbance.	Low • Size and location of pit expansion is known and impacted areas are well understood.

Impact	Terrain unit and sensitivity (see Section 5.1.6)	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Changes to landform due to construction of the tailings storage facilities and waste rock dump	Steep mountain terrain • Medium sensitivity	Construction, operations and closure	High magnitude • High spatial extent • Medium severity • Very high duration	• TSFs and waste rock dump designed for long-term stability and reduced erosion potential, with consideration of the locally steep terrain and high rainfall environment • Soil stockpile and storage measures • Rehabilitation measures.	High	Topography change will be permanent and covering a significant area in the terrain unit (231 ha). These elevated features are expected to be compatible with the surrounding steep hilly and mountainous terrain once rehabilitated and some land capability may be returned. The landform changes due to the TSF and waste rock dump will be in areas that have been minimally impacted by previous activities (soil contamination and some pre-existing vegetation clearance and erosion).	Medium • Topography changes are well understood. • Detailed closure planning required to confirm ability of land capability to be successfully regained.
	Lower mountain slopes and valley floors • Medium sensitivity	Construction and operations	Medium magnitude • Low spatial extent • Medium severity • Very high duration	• TSFs and waste rock dump designed for long-term stability and reduced erosion potential, with consideration of the locally steep terrain and high rainfall environment • Soil stockpile and storage measures • Rehabilitation measures.	Moderate	Topography changes will be permanent however the impact will affect a small area (15 ha) in the terrain unit. These elevated features are expected to be compatible with the surrounding steep hilly and mountainous terrain once rehabilitated and some land capability may be returned. The landform changes due to the TSF and waste rock dump will be in areas that are heavily contaminate by historic mining and have high resilience to further loss of value or beneficial use.	Medium • Topography changes are well understood. • Detailed closure planning required to confirm ability of land capability to be successfully regained.
	Undulating hills of the northern and western study area • Medium sensitivity	Construction, operations and closure	Medium magnitude • Low spatial extent • Medium severity • Very high duration	• TSFs and waste rock dump designed for long-term stability and reduced erosion potential, with consideration of the locally steep terrain and high rainfall environment • Soil stockpile and storage measures • Rehabilitation measures.	Moderate	Topography change will be permanent in a previously undisturbed area; however, only a small portion of the TSF extends into this terrain unit (10 ha).	Medium • Topography changes are well understood. • Detailed closure planning required to confirm ability of land capability to be successfully regained.

Impact	Terrain unit and sensitivity (see Section 5.1.6)	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Reduced capacity to support ecosystems and beneficial land uses due to loss of topsoil due to increased erosion or poor soil management	Steep mountain terrain • Medium sensitivity	Construction and operations	High magnitude • Medium spatial extent • High severity • High duration	• Plan for construction on or near natural drainage lines to be undertaken in the dry season, where practicable • Erosion and sediment control measures • Revegetation and rehabilitation measures • Soil stockpile and storage measures • Train site personnel in hazardous materials management and appropriate soil management	High	During construction, erosion will be localised and transient as the construction effort moves from one location to another. Erosion during operations is expected to be localised and low severity. Most of the land disturbance and subsequent rehabilitation will occur in this terrain unit. It is expected that after rehabilitation, some existing land and soil capability can be retained; however, given that much of the study area has been, and is, experiencing extensive ongoing erosion, recovery of topsoil will be more difficult here and any increased erosion of steeper terrain could permanently reduce the soil profile to very low levels, limiting potential for land stability and vegetation growth. Such areas are expected to be very difficult to fully rehabilitate.	Medium • Assumptions based on achievability of successful rehabilitation • Detailed closure planning required to confirm ability of land capability to be successfully regained.
	Lower mountain slopes and valley floors • Medium sensitivity	Construction and operations	Medium magnitude • Medium spatial extent • Low severity • Medium duration	• Plan for construction on or near natural drainage lines to be undertaken in the dry season, where practicable • Erosion and sediment control measures • Revegetation and rehabilitation measures • Soil stockpile and storage measures • Train site personnel in hazardous materials management and appropriate soil management	Moderate	During construction, erosion will be localised and transient as the construction effort moves from one location to another. Erosion during operations is expected to be localised and low severity, with land capability able to be readily regained after rehabilitation. A lower degree of land disturbance and rehabilitation will occur in this terrain unit as limited construction is planned for this terrain unit. With an appropriate closure plan in place and training of site personnel, it is expected that mismanagement of soils will be largely avoided; however, there is a small risk that soil is mismanaged or rehabilitation has low success resulting in long term localised loss of land capability.	Medium • Assumptions based on achievability of successful rehabilitation • Detailed closure planning required to confirm ability of land capability to be successfully regained.

Impact	Terrain unit and sensitivity (see Section 5.1.6)	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
	Undulating hills of the northern and western study area • Medium sensitivity	Construction and operations	Low magnitude • Low spatial extent • Medium severity • Low duration	• Plan for construction on or near natural drainage lines to be undertaken in the dry season, where practicable • Erosion and sediment control measures • Revegetation and rehabilitation measures • Soil stockpile and storage measures • Train site personnel in hazardous materials management and appropriate soil management	Low	Erosion is expected to be localised and low severity, with land capability able to be readily regained after rehabilitation. Only a very small portion of the project footprint occurs in this terrain unit. With an appropriate closure plan in place and training of site personnel, it is expected that mismanagement of soils will be largely avoided. There is a small risk that soil is mismanaged or rehabilitation has low success resulting in long term localised loss of land capability. A lower degree of land rehabilitation will occur in this terrain unit.	Medium • Assumptions based on achievability of successful rehabilitation • Detailed closure planning required to confirm ability of land capability to be successfully regained.
Reduced capacity to support ecosystems and beneficial land uses due to soil compaction modifying the soil structure	Steep mountain terrain • Medium sensitivity	Construction and operations	Low magnitude • Low spatial extent • Low severity • Low to high duration	• Vehicle and equipment movement restrictions and measures • Progressive revegetation and rehabilitation	Low	This terrain unit will be the most extensively impacted as it hosts most of the major construction and road areas, however compacted areas to be rehabilitated will be highly localised to areas within the project footprint. After project closure it is expected that compacted areas can be successfully rehabilitated by surface ripping and any existing land capability to support plant growth will be able to be regained.	Medium • Assumptions based on achievability of successful rehabilitation • Detailed closure planning required to confirm ability of land capability to be successfully regained.
	Lower mountain slopes and valley floors Medium sensitivity	Construction and operations	Low magnitude • Very low spatial extent • Low severity • Medium duration	• Vehicle and equipment movement restrictions and measures • Progressive revegetation and rehabilitation	Low	Compacted areas to be rehabilitated will be highly localised to areas within the project footprint. After project closure it is expected that compacted areas can be successfully rehabilitated by surface ripping and any existing land capability to support plant growth will be able to be regained. Soil compaction sources will be limited in this terrain unit.	Medium • Assumptions based on achievability of successful rehabilitation • Detailed closure planning required to confirm ability of land capability to be successfully regained.

Impact	Terrain unit and sensitivity (see Section 5.1.6)	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
	Undulating hills of the northern and western study area • Medium sensitivity	Construction and operations and closure	Low magnitude • Very low spatial extent • Low severity • Medium duration	• Vehicle and equipment movement restrictions and measures • Progressive revegetation and rehabilitation	Low	Soil compaction sources will be limited in this terrain unit and any compacted areas to be rehabilitated will be highly localised to areas within the project footprint. After project closure it is expected that compacted areas can be successfully rehabilitated by surface ripping and any existing land capability to support plant growth will be able to be regained.	Medium • Assumptions based on achievability of successful rehabilitation • Detailed closure planning required to confirm ability of land capability to be successfully regained.
Reduced capacity to support ecosystems and beneficial land uses due to movement of contaminated soils to uncontaminated areas	Steep mountain terrain • Medium sensitivity	Construction and operations	Low magnitude • Low spatial extent • Low severity • Very high duration	• Contaminated soil management measures • Revegetation and rehabilitation measures • Erosion and sediment control measures	Low	There may be localised instances where erosion of stockpiles or disturbed areas mobilises high metals concentrations from impacted areas to previously unimpacted areas. Whilst this is expected to be low severity, the impact may remain after closure if not rehabilitated. The project closure and rehabilitation strategy will be to contain existing contamination and not move it to new areas. There will be many instances where rehabilitation will result in a net improvement of topsoil quality. Overall, within the context of existing widespread high metals concentrations in soils, it is not expected that localised disturbance and dispersal of existing contaminated areas would result in significant loss of surrounding soil and land capacity.	High • Site specific soil contamination investigations required • Baseline data sufficient to provide spatial trends but exact locations and depths of contamination are not known for all disturbance areas. • WMM have not yet conducted a materials balance for closure or determined the ability to remediate all areas of contamination.

Impact	Terrain unit and sensitivity (see Section 5.1.6)	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
	Lower mountain slopes and valley floors • Medium sensitivity	Construction and operations	Low magnitude • Low spatial extent • Low severity • Very high duration	• Contaminated soil management measures • Revegetation and rehabilitation measures • Erosion and sediment control measures	Low	There may be localised instances where erosion of stockpiles or disturbed areas mobilises high metals concentrations from impacted areas to previously unimpacted areas. Whilst this is expected to be low severity, the impact may remain after closure if not rehabilitated. The project closure and rehabilitation strategy will be to contain existing contamination and not move it to new areas. There will be many instances where rehabilitation will result in a net improvement of topsoil quality. Overall, within the context of existing widespread high metals concentrations in soils, it is not expected that localised disturbance and dispersal of existing contaminated areas would result in significant loss of surrounding soil and land capacity.	High • Site specific soil contamination investigations required • Baseline data sufficient to provide spatial trends but exact locations and depths of contamination are not known for all disturbance areas. • WMM have not yet conducted a materials balance for closure or determined the ability to remediate all areas of contamination.
	Undulating hills of the northern and western study area • Medium sensitivity	Construction and operations	Low magnitude • Very low spatial extent • Medium severity • High duration	• Contaminated soil management measures • Revegetation and rehabilitation measures • Erosion and sediment control measures	Low	There may be highly localised instances where contaminated soils are encountered as a very small area of project footprint is in this terrain unit. Baseline sampling indicates that contamination is rare in this terrain unit, so any contamination that occurs expected to be of medium severity as it may reduce the capacity of the terrain unit.	High • Site specific soil contamination investigations required • Baseline data sufficient to provide spatial trends but exact locations and depths of contamination are not known for all disturbance areas.

6.2.5 Monitoring

Monitoring and inspection of impacts on landform and soils values will include:

- Regular inspection of erosion and sediment control structures including sediment fences, drains, sediment basins and retention ponds.
- Regular inspection of steep batters and embankments for signs of instability.
- Regular audit of vegetation and soil clearance activities and the ground disturbance procedure.
- Regular inspection of soil stockpiles and soil management.
- Housekeeping audits, reviews, post-spill clean-up inspections and testing as necessary.
- Monitor the progress and success of site rehabilitation.
- Ongoing inspection of potential landslips during construction and operations to allow early identification of landslip risk and measures to be put in place (to stabilise the potential slip or to move people to safety).

6.2.6 Uncertainties and further work

The key assumptions, uncertainties and further work required to address these uncertainties are outlined in Table 6.22.

Table 6.22 Uncertainties and further work in respect of soils and landform impacts

Uncertainty	Further work	Purpose	Assumption
Ability of land capability to be regained after rehabilitation	The ability of land capability to be successfully regained at rehabilitated sites will need to be confirmed during detailed closure planning. Monitor the success of progressive rehabilitation during construction and operations.	To ensure that site-specific factors are addressed in rehabilitation.	The assessment of significance of residual impacts assumes successful implementation of design controls and management measures. Assumptions have been made on the achievability of successful rehabilitation.

Uncertainty	Further work	Purpose	Assumption
Uncertainty as to the availability of suitable material for rehabilitation	Investigate and confirm sources of suitable types and volume of capping material and rehabilitation material. This should include testwork of physical properties, chemical properties and metal concentrations, and demonstration that material balance (i.e., amount of material required for rehabilitation and closure of the site is available and able to be recovered and stored securely for later use).	To ensure that suitable material is available for capping and rehabilitation of land	Significant volumes of topsoil are required for capping of landforms at closure. For the impact assessment it has been assumed that there will be adequate supply of suitable capping materials is available for progressive rehabilitation and final closure rehabilitation works.
Changes to landform stability, and associated impacts, are very difficult to quantify. The magnitude of the impact will depend on the location and size of the slip, and to what extent current and future ecosystem value and land use potential is lost.	Detailed design and further geotechnical investigations as required for each construction area.	To identify areas of geotechnical instability and confirm stability of landforms and identify additional appropriate management measures and design controls.	For this impact, a range of impact magnitude and significance ratings are given to reflect the highly variable nature of this impact..
Changes to landform stability, and associated impacts, are very difficult to quantify. The magnitude of the impact will depend on the location and size of the slip, and to what extent current and future ecosystem value and land use potential is lost.	Detailed design and further geotechnical investigations as required for each construction area.	To identify areas of geotechnical instability and confirm stability of landforms and identify additional appropriate management measures and design controls.	For this impact, a range of impact magnitude and significance ratings are given to reflect the highly variable nature of this impact.
The soil sampling grid does not cover the whole study area. Also, the soil sampling only investigated one depth in the soil profile.	Site-specific investigations regarding existing soil contamination, potential suitable cover soils and material balances.	To further understand soil contamination risk and identify appropriate management measures for contaminated soils To determine if adequate 'clean' soil and material is available to feasibly rehabilitate disturbance footprint of the project.	A large enough proportion of the study area was sampled to allow inference of spatial trends for the EIA. Assumptions were made on likely soil quality based on extrapolation of data from existing baseline sampling locations and proximity to previous mining and industrial land use.

6.3 Groundwater impact assessment

6.3.1 Approach to impact assessment

This section assesses the project impacts to groundwater, with reference to the groundwater values identified in Section 5.2. Section 5.2 described the levels of importance, vulnerability and resilience associated with each of the groundwater values in the study area.

The impact assessment approach adopted in this section is a 'significance assessment'. The significance assessment method is described in Section 6.1 and involves combining the sensitivity of defined values with the predicted magnitude of change as a result of the project.

As there are no ecological compliance criteria for ambient water quality in Myanmar, this section has referred to Australian and New Zealand quality guidelines for aquatic ecosystem protection (ANZG, 2018) in order to provide context for assessment of impacts to groundwater quality. The Myanmar mining effluent standards (MOECAF, 2014) are referred to in this section as a framework for assessing water quality impacts associated with effluent discharge. Reference is also made to the draft Myanmar National Drinking Water Quality Standards (NWRC, 2014), to provide a framework for the assessment of water quality impacts to springs used as drinking water sources (i.e., groundwater springs). These standards provide maximum recommended aesthetic and health limits of chemical and physical parameters for drinking water. Section 5.2 describes the existing water quality of springs and outlines the drinking water standards.

6.3.2 Potential sources of impact

The project has the potential to adversely impact the following groundwater features identified in Section 5.2:

- **Saprolite aquifer:** This is the localised aquifer system within the weathered zone that overlies the fractured rock aquifer. The saprolite is a highly chemically weathered unit that is present primarily on the hill crests, mid and upper slopes throughout the Nam Pangyun and Nam La catchments. The saprolite hydrogeological unit has been estimated to be around 20 to 50 m thick on the ridges and upper slopes, thinner on the mid slope and generally absent from the valley floors. The aquifer provides year-round flow to springs in the Nam Pangyun and Nam La catchments (discussed below).

- **Springs:** There are numerous springs within and beyond the Bawdwin project area, many of which are used by the local communities as water supplies for potable and domestic use, as well as agricultural production. These springs are fed by groundwater from the saprolite aquifer, occurring at the break of slope or where the saprolite aquifer thins on the lower valley slope. Springs probably support areas of groundwater dependent vegetation immediately surrounding the discharge points higher in the landscape, most of which have been highly altered by deforestation over centuries of mining in the study area. Spring discharge also supports the aquatic ecosystems of the Nam La and Nam Pangyun, which are considered to be partially dependent on the flow contributed by springs during the dry season. The saprolite springs are an important potable water source for communities of Bawdwin, Tiger Camp and the broader study area. The Bawdwin and Tiger Camp villages rely solely on spring flow for domestic and agricultural needs, which is supplied via a well-established network of piping and community water supply infrastructure. Similar springs may exist extensively throughout mountainous region of the study area including neighbouring catchments.

- **Fractured rock (or bedrock) aquifer:** This is the underlying fractured rock aquifer in the unweathered bedrock below the saprolite aquifer. In this aquifer, water occurs in the fractures, joints, bedding planes and cavities of the rock mass. The fractured rock aquifer is the regional aquifer present across the mountainous region. In areas outside of the vicinity of the historical Bawdwin mine, the fractured rock aquifer provides baseflow discharge that partially sustains the Nam La and Nam Pangyun and supports the groundwater-dependent ecosystems in these catchments. In the Bawdwin area, groundwater levels in the fractured rock aquifer have been, and continue to be, drawn-down by dewatering associated with historical underground mining.

Potential sources of impact to groundwater values include:

- Direct loss or disturbance of aquifers and springs due to earthworks and/or placement of the project infrastructure.
- Mine dewatering, resulting in reduced groundwater levels, altered groundwater flow directions, reduced baseflows to streams, and reduced flow in remaining groundwater springs. Groundwater level drawdown may also lead to land subsidence.
- Increased recharge from TSFs, water impoundments, and the waste rock dump leading to groundwater mounding and altered flow directions.
- Reduced groundwater quality due to seepage from TSFs, the Wallah waste rock dump and the open pit (post closure).
- Contamination of aquifers due to waste disposal.

These impacts could result in the reduction or loss of the beneficial uses of groundwater, such as their capacity to support aquatic ecosystems, provide drinking water and supply agricultural.

The remainder of this section discusses these potential impacts.

Direct loss of springs

The project will result in the direct loss (i.e., direct burial) of six known groundwater springs (SWSP01, SWSP04, SWSP06, SWSP07, Spring 01 and Spring 02) due to the construction of TSFs, haul road and Wallah waste rock dump. This includes the loss of three springs that are currently used for potable water (SWSP01, SWSP04 and SWSP07), one of which is in the Nam Pangyun headwaters and provides a substantial portion of the total stream flow (SWSP04). Other, unmapped springs may exist in the area that also contribute flow to the Nam Pangyun and may have the potential to be destroyed.

Figure 6.5 shows the location of project facilities in relation to the known springs.

Groundwater drawdown

In the Bawdwin region, groundwater levels and flow direction are expected to be complex and locally influenced by previous underground mining activities as well as the ongoing dewatering of the underground mine via Tiger Tunnel. Groundwater is likely to be drawn-down from pre-mining conditions to some degree around the existing Bawdwin open cut pit and in areas where the existing underground mine drains groundwater via the Tiger Tunnel.

During mining operations for the project, groundwater will be intercepted by the pit from mining year 5 onwards as the pit deepens below the existing water table (approximately 40 to 60 m below the surface). The resultant groundwater inflows from the surrounding permeable alluvial deposits and fractured rock aquifers (along with captured rainfall runoff) will be dewatered from the pit. Pit dewatering will occur through an in-pit sump dewatering system. Groundwater and surface water pit inflows will gravity drain to in-pit sumps at low points at the base of both the main pit and the south pit. The water will then be pumped out of the in-pit sumps to a sedimentation basin (see Figure 4.30), and subsequently discharged to the Nam Pangyun. Mine water will also continue to discharge to the Nam Pangyun via the Tiger Tunnel, although it may be a reduced volumetric flow rate.

A conceptual model of potential groundwater drawdown impacts is shown in Figure 6.6.

Dewatering the pit will result in localised groundwater level drawdown in the saprolite (where present) and fractured rock aquifers. This will depress groundwater levels further below the current groundwater levels that are currently influenced by historical mine workings at Bawdwin.

Groundwater drawdown may have the following impacts:

1. Reduced base flow to surface water in the Nam Pangyun and reduced discharge from saprolite springs.

2. Altered groundwater flow directions.
3. Ground subsidence due to groundwater drawdown.

These potential impacts are discussed further in the following sections.

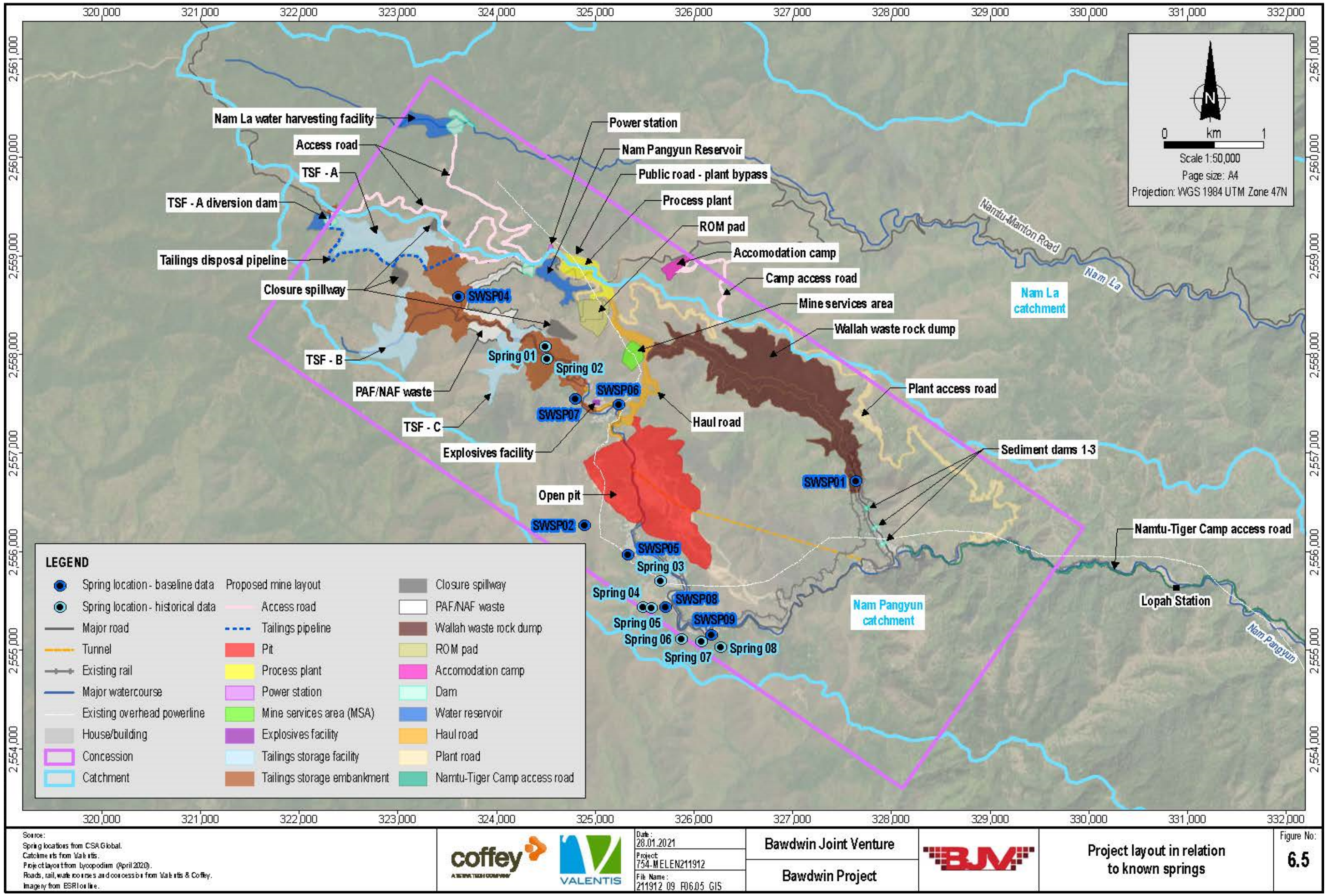


Figure 6.5 Project layout and known springs

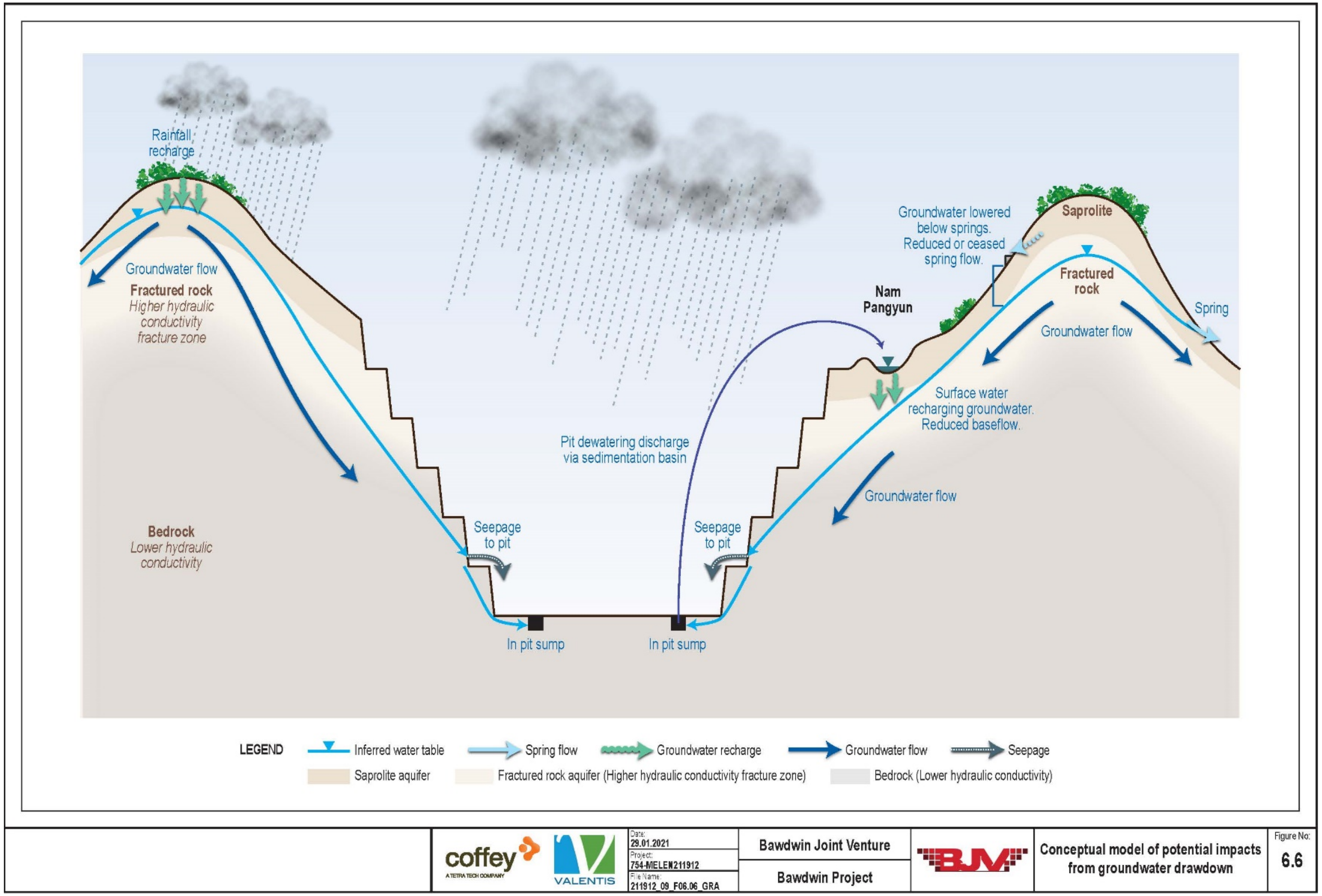


Figure 6.6 Conceptual model of potential impacts from groundwater drawdown

Reduced spring and surface water flow

Surface water flow in the mountainous region of the study area is comprised of three main components;

1. Rainfall runoff.
2. Spring flow from the saprolite aquifer.
3. Groundwater discharge (baseflow) from the fractured rock aquifer.

In the upper and mid-Nam Pangyun catchment the existing groundwater level drawdown associated with historical mine workings has probably reduced baseflow contribution from the fractured rock aquifer to the Nam Pangyun stream between Bawdwin and Tiger Camp. Therefore, flow in the upper and mid-Nam Pangyun catchment is dependent primarily on spring flow particularly during the dry season.

Groundwater drawdown due to proposed mining will further lower the water table and potentially expand the zone where baseflow contribution is reduced. In addition to reduced flow contribution from groundwater, surface water may also seep through the stream bed and recharge the fractured rock aquifer (further reducing the stream flow). This process will already be occurring in the Bawdwin area but may increase during mining.

Groundwater drawdown that extends to the saprolite aquifer may reduce spring discharge rates. Reduced spring flow will probably reduce flow rates in nearby drainages that discharge into the Nam Pangyun (see Figure 6.14) and potentially impact other beneficial uses, such as potable water supply.

A conceptual model of groundwater drawdown impacts on spring flow are shown in

Figure 6.7.

The combined effect of reduced flow from springs, reduced baseflow from the fractured rock aquifer and possible seepage to groundwater may result in reduced water availability to support the aquatic ecosystems and beneficial uses of the Nam Pangyun. These impacts associated with groundwater drawdown are discussed further in Section 6.3.4.

Altered groundwater flow directions

It is expected that an extensive zone of groundwater drawdown currently exists around the historical Bawdwin mine pit as well as the zone south of Bawdwin where the underground mine has been dewatered for over 100 years.

The combined effect of the surrounding steep topography and pre-existing groundwater conditions will result in only minor changes to groundwater flow directions. These potential impacts are not expected to extend outside of the Nam Pangyun catchment and will not substantially alter groundwater flow directions from current conditions. This impact is not discussed further.

Drawdown induced subsidence

Dewatering can lead to ground subsidence (also known as settlement) in some geological settings. This risk typically exists where compressible soils are present. Compressible soils are not known to be present within the zone of predicted groundwater drawdown around Bawdwin. Furthermore, significant groundwater drawdown has already occurred around Bawdwin over the past 100 years without any ground subsidence or damage to original buildings occurring. Further dewatering of the hard rock aquifer is not expected to result in ground settlement and subsidence and this impact is not discussed further.

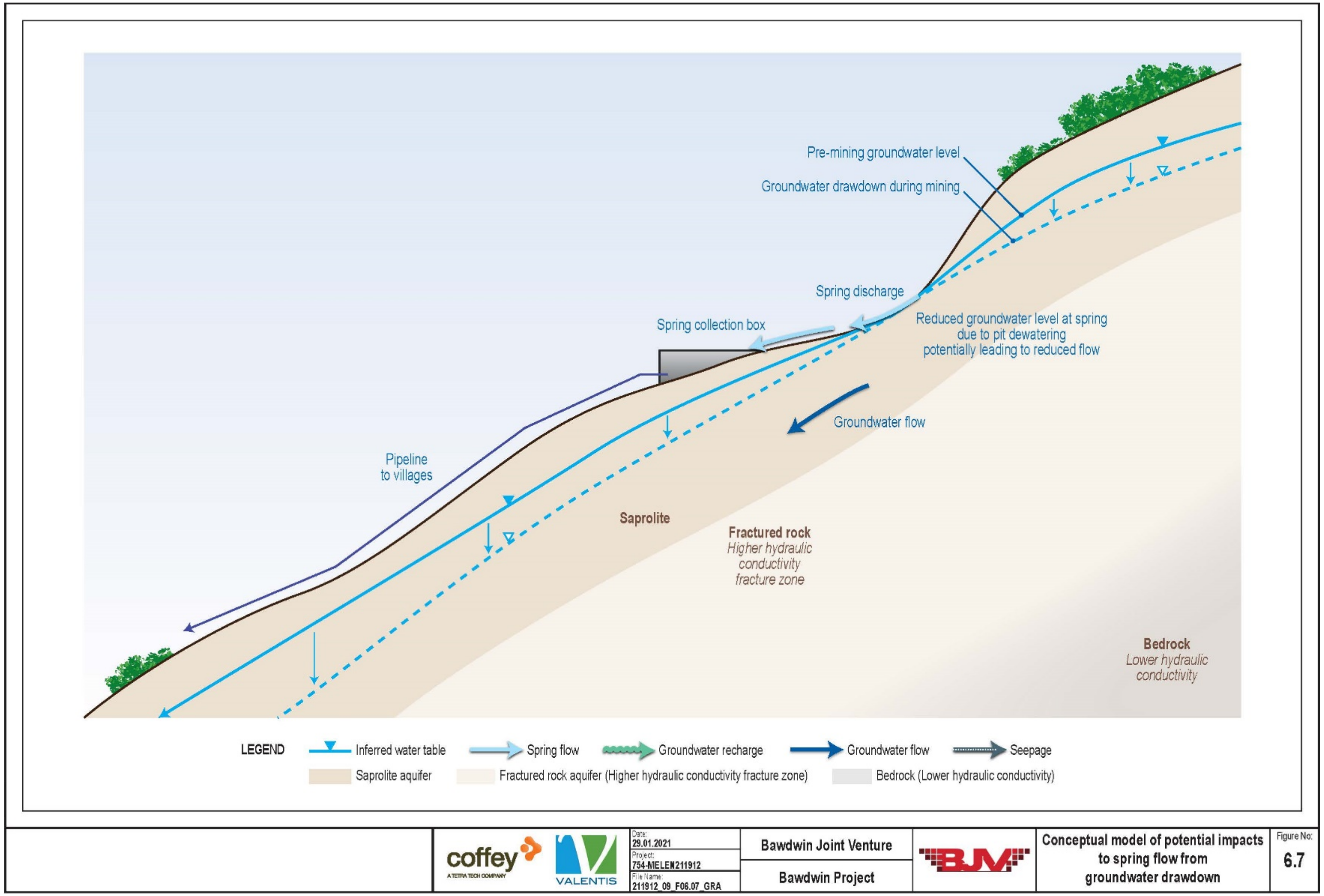


Figure 6.7 Conceptual model of potential impacts to spring flow from groundwater drawdown

Groundwater mounding

Groundwater mounding occurs where an increase in hydraulic head (groundwater pressure) occurs in areas where a locally increased hydraulic load exists. This can be associated with increased groundwater recharge beneath dams or, in the case of a TSF, may occur in areas of high hydraulic loading (i.e., where large volumes of water and tailings material result in increased pressure within the underlying aquifer). Mounding raises the water table in an unconfined aquifer or the pressure in a confined aquifer, and can change the natural groundwater flow directions and velocities.

Tailings storage

The TSFs will be designed to receive and store saturated tailings behind embankments that will eventually raise the hydraulic pressure in the underlying fractured rock aquifer and saprolite aquifer up to 100 m above the natural ground surface in places. Mounding will promote groundwater flow direction down the Nam Pangyun valley where hydraulic gradients will be greatest around and beneath the main valley embankments.

TSF A will be located in a valley that borders the Nam La catchment on its northern edge. Due to the undulating topography of the northern ridgeline, tailings material will gradually approach the final design level of 1,298 m RL for TSF A (the TSF that is positioned against the catchment boundary). These levels approach the natural crest of the valley. This is expected to result in the post mining phreatic surface being at or close to the natural ridgeline, which will result in a high potential for groundwater to flow from TSF A through the saprolite and fractured rock aquifer, and into the Nam La catchment to the north. This may result in increased groundwater discharge to, or emergence of new saprolite springs in the Nam La catchment and increased baseflow to the Nam La stream. Erosion, water logging of the surface and creation of land instability may also result. Such processes could also result in the transport of contaminants to previously uncontaminated aquifers and streams (see Section 6.3.4 and Section 6.4).

A conceptual model of potential impacts tailings storage may have on groundwater is shown on Figure 6.8.

Water reservoirs

The Nam Pangyun reservoir (current 446,860 m^3 capacity) will be expanded and become the primary raw water storage for the Bawdwin mine, with 483,390 m^3 capacity (see Figure 4.29). A degree of groundwater mounding will already exist around the Nam Pangyun reservoir and proposed works are expected to address current leakage and have only a negligible change to mounding. Mounding is expected to be confined to a zone of up to 50 m around the reservoir.

The construction of the Nam La water harvesting facility will result in a new water dam in the Nam La. The dam, although relatively small (1,125,840 m^3), will result in some localised changes to groundwater flow direction, however these will be contained within the Nam La catchment and are likely to have only a negligible effect. Mounding is expected to be confined to <50 m zone around the reservoir.

Due to the negligible impact of the water reservoirs on groundwater monitoring the significance of the impact is not further assessed in Section 6.3.4.

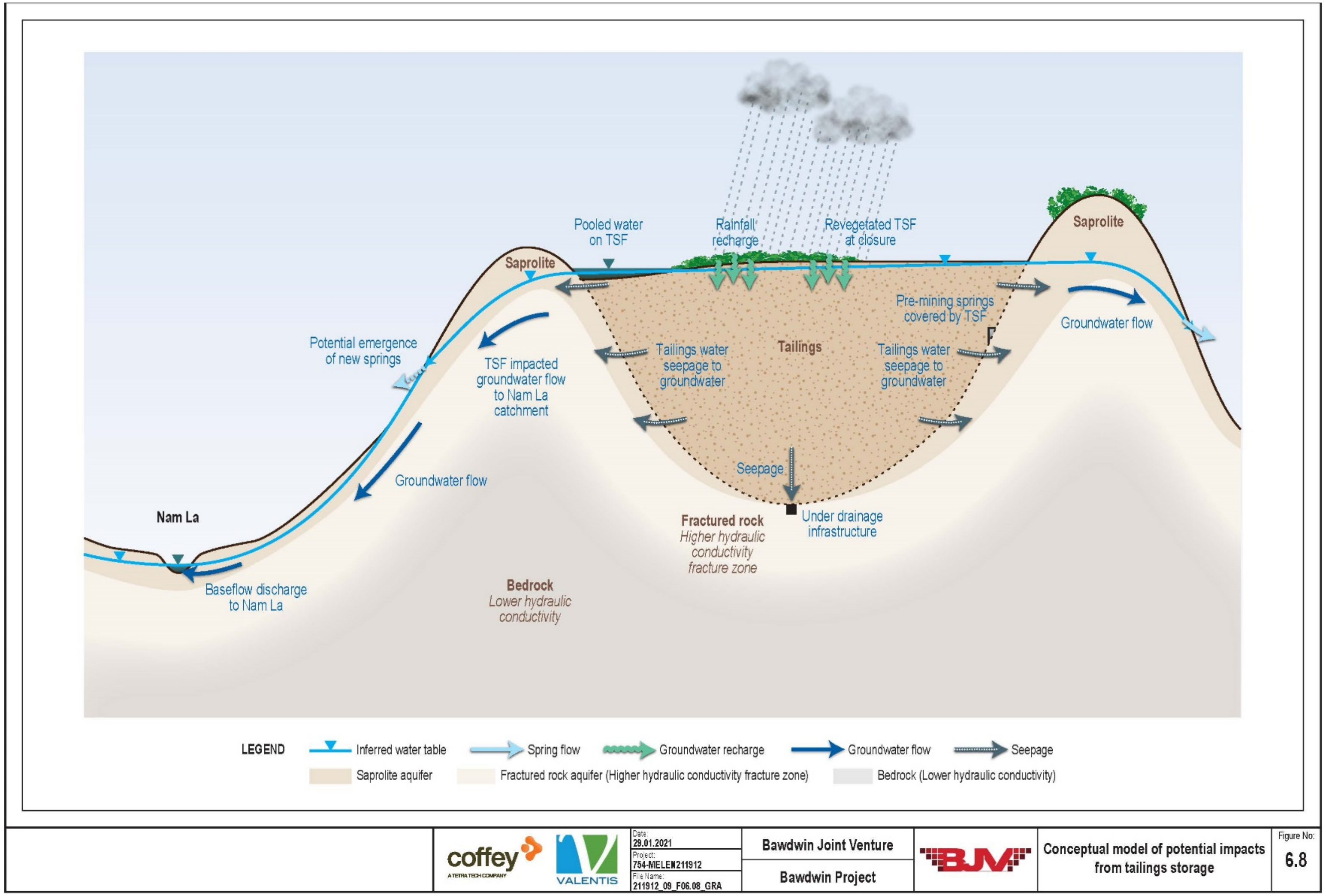


Figure 6.8 Conceptual model of potential impacts from tailings storage

Wallah waste rock dump

At the Wallah waste rock dump, the crushed waste rock will have a higher permeability when compared to the existing ground surface, which is expected to result in increased infiltration of rainfall and saturation of the waste rock above the natural ground surface. This in turn may result in increased groundwater recharge to the underlying aquifer where this water is not completely captured by underdrainage infrastructure. Where increased recharge occurs, it may result in localised changes to groundwater flow within the Wallah Valley and could result in the migration of groundwater to new areas, emergence of new springs, erosion, water logging of the surface and creation of land instability. Such processes could also result in the transport of contaminants to previously uncontaminated aquifers (see Section 6.3.4). A conceptual model of potential impacts the waste rock dump may have on groundwater is shown on Figure 6.9.

Open pit

Groundwater in the vicinity of the proposed pit has been substantially drawn-down by historical open pit and underground mining for over a century. The existing groundwater levels are highly altered from their natural levels. Proposed pit dewatering will cause further groundwater level drawdown during mining.

Reduced groundwater quality

Contamination of groundwater may occur from three key pathways: accidental spills and leaks of hazardous materials that seep into shallow groundwater; leaching of poor-quality water from the TSFs and Wallah waste rock dump during operations; and leaching of poor-quality water from the pit after closure. Accidental spills and leaks of hazardous substances (e.g., liquid hydrocarbons and processing reagents) have the potential to occur throughout the life of the project. Impacts associated with spill and leaks are addressed in Section 7.4.7 and are not addressed further in this section.

Tailings and waste rock

Based on the projected geochemical properties of tailings and waste rock (see sections 4.7.1 and 4.8.1), water of poor quality has the potential to seep from the TSFs and Wallah waste rock dump.

The flotation process that will be used in processing of Bawdwin ore will require the use of flocculants and processing reagents including copper sulfate, zinc sulfate, and intermittent use of sodium cyanide. As such, the water contained in the tailings slurry is predicted to contain residual concentrations of these contaminants. Collecting and redirecting TSF seepage via an underdrain system is a critical design feature. The TSF underdrain water will flow under gravity into a sump and be pumped, via a riser pipe, back into the TSF supernatant pond. However, some of this water entrained in tailings is expected to leach through the unlined TSFs into underlying soils and seep into groundwater. This will increase concentrations of contaminants such as total and dissolved metals, sulphate, and residual reagents in the underlying saprolite and fractured rock aquifers. Combined with the potential changes in groundwater flow as outlined earlier, this could disperse the contaminants to previously unimpacted groundwater systems in the Nam Pangyun valley and to a lesser extent the Nam La valley. There is a low likelihood that contaminated groundwater will flow towards the undisturbed Nam Kong catchment to the west from TSF-B via fractured zones in bedrock or the higher permeability saprolite horizon. This potential migration requires further investigation.

The majority of the waste rock will be stored in the Wallah Gorge waste rock dump. Most rain falling on the waste rock will infiltrate through the dump and collect at the base. This infiltrating water will probably become contaminated by metals and sulfate and may have reduced pH. An underdrainage system for the waste rock dump will collect seepage and discharge it to a series of sediment dams downstream of the dump for treatment. While most of the seepage is likely to be captured, some contaminated seepage may enter the groundwater system beneath the waste rock dump, reducing groundwater quality.

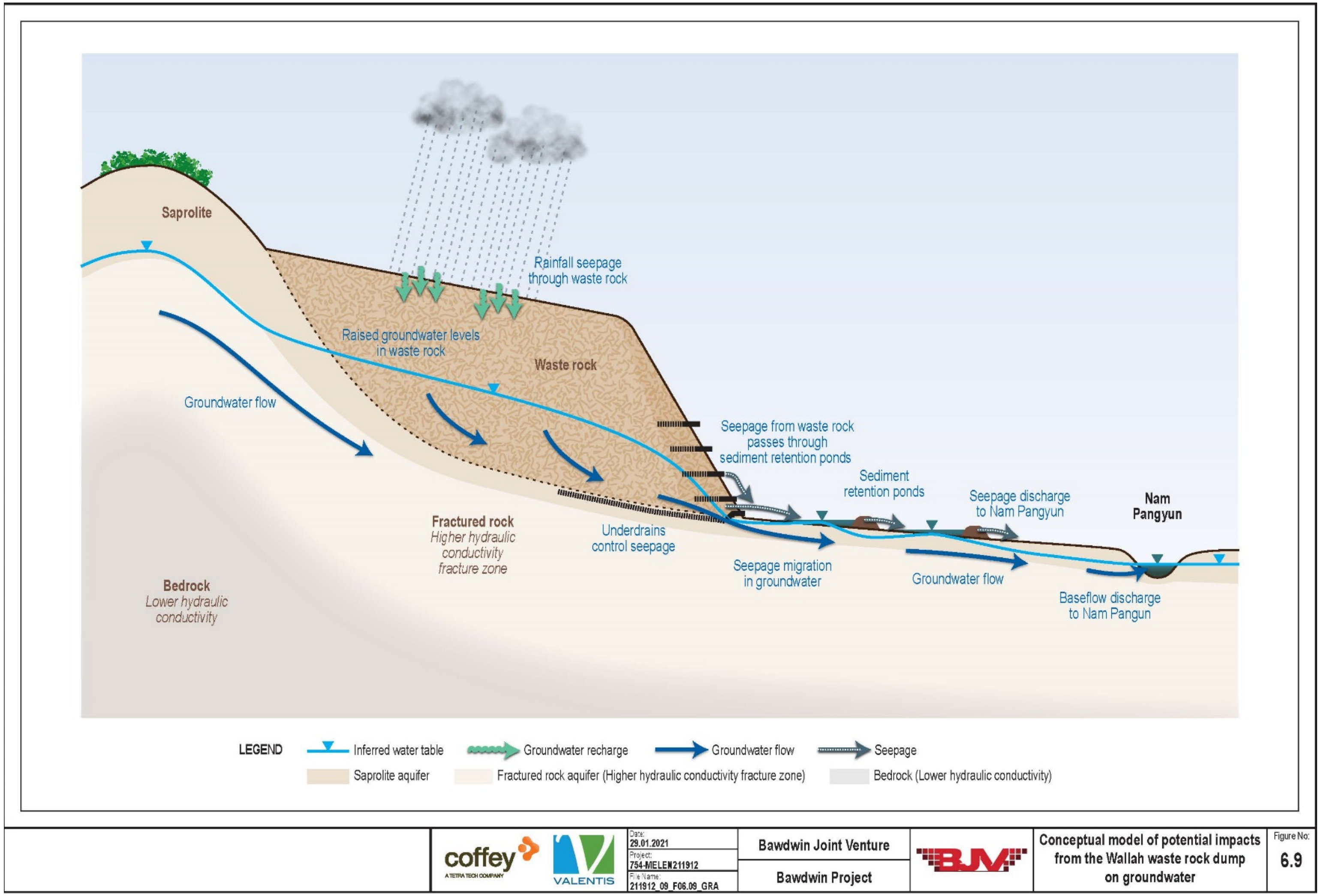


Figure 6.9 Conceptual model of potential impacts from the waste rock dump on groundwater

Open pit

The final pit depth will extend below the current water table. After project closure, and once dewatering ceases, the open pit will gradually fill with water sourced from groundwater inflow and rainfall runoff, forming a pit lake. The pit lake will become larger over time as the water level increases and will be dependent on the effective and permanent sealing of the historical underground adits, shafts and other mine voids that would otherwise allow the pit to freely drain via the Tiger Tunnel (see Chapter 4, Table 4.39).

To accelerate the time required to fill the pit and reduce the potential water quality impacts associated with exposure, oxidation and leaching of minerals in the pit, the Nam Pangyun will be diverted into the open pit. This accelerated filling option is expected to fill the pit within five years.

Groundwater levels in the aquifer surrounding the open pit will recover after cessation of operations as the pit lake develops, with groundwater recovering to levels above the current water table, which has been drawn-down by long term dewatering of the historical underground mine via the Tiger Tunnel. The pit lake is expected to interact with the surrounding groundwater in the fractured rock aquifer and will probably alternate between receiving regional groundwater discharge from the fractured rock aquifer (during dry periods with lower pit lake water levels) and providing groundwater recharge (during wet periods with raised pit lake water levels).

The water-filled pit is predicted to be of poor quality, containing elevated concentrations of some metals, particularly lead and zinc. This water may seep into the fractured rock aquifer. Although groundwater surrounding the pit probably already has reduced water quality due to historical mining activities, it could see a further reduction in water quality due to potential seepage from the flooded open pit.

Waste disposal

The mine will generate a range of general, industrial, liquid and chemical wastes that will be managed in line with Myanmar regulatory requirements or, where absent, international guidance. Hydrocarbon and chemical waste will be collected and disposed offsite. WMM will identify responsible contractors who will purchase and/or collect these materials for secondary uses, as part of a recycling contract. WMM will verify that such materials are being used for their declared purpose once they have been removed from site . Solutions for chemical waste will be developed during the detailed design phase as waste disposal requirements are confirmed.

A Works Approval and Environmental Licence will be sought from the relevant Myanmar authority for a putrescible landfill to allow disposal of wastes that contain organic materials such as food wastes and wastes that will readily bio-degrade. This will include general waste from the camp and offices. No chemical waste or hydrocarbons will be disposed to the landfill. An appropriate location of the landfill site will be assessed during detailed design phase. It will be located over 250 m from residential areas and greater than 500 m from any watercourse or water supply.

Sewage waste will be collected and treated at one of two stand-alone activated sludge bioreactor (ASBR) sewage treatment plants (STPs) that will service each of the process plant and accommodation camp. Treated effluent will be discharged to the environment and the resulting sludge will be buried. The discharge point and site for disposing sludge have not been defined, but will be in line with licence conditions.

The landfill and site of buried sewage sludge may be sources of contamination to the saprolite and underlying fractured rock aquifers if leachate is allowed to seep to groundwater. Contaminants of concern typically include ammonia and other nutrients, alkalinity, total organic carbon, and dissolved metals. Microbiological contamination may also be expected. Depending on the types of waste received, a range of other organic compounds may also be detected.

Summary of sources of potential impact

Table 6.23 provides a summary of potential impacts to groundwater features and their associated values and indicates which phase of the project these are expected to occur.

Table 6.23 Summary of potential groundwater impacts during project construction, operation and closure

Potential Sources of Impact	Construction	Operation	Closure[a]
Direct loss of springs due to placement of project facilities over springs	X	X	X
Dewatering for mining resulting in groundwater drawdown		X	
Construction of new landforms (TSF, and waste rock dump) results in mounding and increased recharge leading to emergence of new springs, erosion, water logging of the surface and creation of land instability		X	X
Contamination of aquifers due to seepage from mine waste storage areas (TSF and waste rock dump) and the pit.		X	X
Contamination of aquifers due to seepage from waste disposal	X	X	X

X = occurring in this phase
[a] includes the period during and after mine closure

6.3.3 Proposed mitigation and management measures

Potential impacts to groundwater values will be managed through development and implementation of the Bawdwin Project Groundwater Management Plan. The management plan will specify measures for the management of impacts to groundwater values within, and in the immediate vicinity of, the project area, and will contain a range of management measures pertaining to project planning and design, inductions and training, contamination management and groundwater monitoring.

Design controls

A design control is an elimination, substitution or engineering control implemented during the project design and/or construction phase with the intent of eliminating impact pathways. Proposed design controls for groundwater management are:

- WMM will comply with the Global Industry Standard on Tailings Management (ICMM et al., 2020) in relation to design, construction, operation, monitoring, management, governance, emergency response and community consultation of the TSF facilities, including associated water quality treatment plant. This will include implementation of construction vs design intent verification, which will ensure that design intent is implemented and continues to be met in the case that site conditions vary from design assumptions. It will also involve preparation and implementation of an operations, maintenance and surveillance manual that outlines critical controls for safe TSF operations and allows tracking.
- Design the dimensions, embankments, benches, and sediment dams associated with the TSFs and waste rock dump based on detailed assessment of site conditions and in line with relevant Australian guidelines and design principles outlined in the Global Industry Standard on Tailings Management (ICMM et al., 2020) and with sufficient factors of safety (see Chapter 4 Project Description). This will involve developing a design that considers the technical, social, environmental and local economic context, the results of risk analysis for TSF failure scenarios, site conditions, water management, mine operations, construction issues and requirements for safe closure.
- Construct and operate the Wallah waste rock dump in accordance with detailed designs and operating manual.
- In line with good practice management principles for acid forming material outlined in the Global Acid Rock Drainage Guide (INAP, 2020), manage potentially acid forming (PAF) material by:
  - Storing potentially acid forming (PAF) material under water in TSF C to reduce oxidation and acid formation.

  - Encapsulating any PAF material to be disposed within the Wallah waste rock dump within an engineered cell to reduce oxidation and acid formation.

- Implement an underdrainage system to capture seepage from the TSFs and Wallah waste rock dump and if required treat water to meet Myanmar draft mining effluent standards before discharge to the Nam Pangyun.
- Line the embankment upstream batter, upstream and downstream structural zones of the TSFs with HDPE to reduce seepage to groundwater.
- Locate the landfill over 250 m from residential areas and greater than 500 m from any watercourse or water supply.

Management measures

A management control is one that may be implemented during construction, operations or closure for the purpose of reducing the consequence and/or likelihood of a potential impact and described below.

Water seepage, collection and management

- Complete groundwater modelling during detailed design to assess and quantify the potential mounding and seepage transport around the TSFs.
- Construct and operate TSFs and waste rock dump in accordance with detailed designs and operating manual. The TSFs will be designed, constructed and operated in line with the Global Industry Standard on Tailings Management (ICMM et al., 2020). This will include implementation of construction vs design intent verification, which will ensure that design intent is implemented and continues to be met in the case that site conditions vary from design assumptions. TSF management in accordance with the Global Industry Standard on Tailings Management will also involve preparation and implementation of an operations, maintenance and surveillance manual that outlines critical controls for safe TSF operations and allows tracking of risk management.
- Implement an underdrainage system to capture seepage from the TSFs and Wallah waste rock dump and if required treat water via series of sediment dams or water treatment plant to meet Myanmar draft mining effluent standards before discharge to the Nam Pangyun.
- Capture and treat mine wastewater to meet regulatory requirements where necessary prior to discharge to meet environment permit conditions.
- Develop and implement a groundwater quality and level monitoring program prior to construction to further establish baseline conditions, identify adverse changes during construction and operation, establish triggers for remedial action, and assess whether drawdown or mounding is consistent with predictions.

Water supply management

- Provide alternative safe drinking water supplies for Bawdwin villages and Tiger Camp if their spring water supplies are impacted by project development.

Hazardous material management

- Train personnel involved in the handling, transportation and storage of hazardous materials in hazardous materials management, transfer procedures and spill prevention and emergency response.
- Implement measures to reduce the potential for accidental leaks and spills to occur, including to:

- Store and handle hazardous materials including fuels, oils and chemicals in accordance with good international practice, including designing appropriately secured and bunded facilities to meet appropriate standards for storage of hazardous materials.
- Establish protocols for handling, transport, transfer, storage and disposal of hazardous materials, including fuel, which comply with all Myanmar regulations and good international practice.
- Develop a risk-based spill prevention and response plan that encompasses project-specific work areas and activities including measures to reduce risks to as low as reasonably practical, for example:
  - Service vehicle and machinery using measures to contain spills (e.g., drip trays) and in appropriate locations (e.g., away from watercourses and drainage lines).
  - Conduct inspections to evaluate the presence and condition of spill prevention measures and replacing measures as required.
  - Conduct regular emergency spill drills to practice timely and effective spill response, involving relevant site personnel.
  - Keep adequate quantities of spill response materials such as absorbent materials and pH buffer solutions adjacent to hazardous material storage areas and in vehicles transporting hazardous materials.
  - Establish arrangements to mobilise additional resources for responding to larger spills and strategies for deployment.
- Design and construct landfill cells in line with Myanmar regulatory requirements or, where absent, international guidance. Landfill cells should be lined and contain leachate and landfill gas management system. Seepage from lined cells will be captured and treated.

Closure

- Progressively rehabilitate the TSFs and waste rock dump and cap them following cessation of operations to reduce infiltration and seepage.
- Divert the Nam Pangyun to fill the open pit rapidly at closure, in order to minimise the potential for oxidation of in-pit PAF and subsequent acid formation and to also minimise the concentration of metals in the pit water (as predicted by CSA, 2020).

6.3.4 Residual impact assessment

This section assesses the residual significance of impacts identified in Section 6.3.2 after implementation of the mitigation and management measures outlined in Section 6.3.3. The magnitude of each residual impact is assessed based on the impact's geographic extent, severity and duration, taking into consideration the existing conditions of the features and their importance, vulnerability and resilience. Table 6.24 presents the criteria used to determine the magnitude of each impact.

Table 6.24 Criteria used to determine the magnitude of impacts to groundwater

	Very low	Low	Medium	High	Very high
Spatial extent	Impact affects a very small area within the project footprint	Impact is entirely within existing disturbance areas Impact affects a localised area	Impact is partly within existing disturbance areas but also within previously undisturbed (or low-level disturbance) areas Impact affects a moderate area	Impact is completely within previously undisturbed (or low-level disturbance) areas Impact affects a widespread area	Impact spatial extent is very high (regional extent)
Severity	Impact is a very minor change from background conditions and will probably recover on its own or require minimal rehabilitation effort. The impact will not reduce the capacity to support aquatic ecosystems and/or beneficial uses.	Impact is a minor change from background conditions and can be straightforwardly remedied or rehabilitated using standard management measures. The impact is unlikely to reduce the capacity to support aquatic ecosystems and/or beneficial uses.	Impact is a medium change from background conditions and can be partly remedied or rehabilitated. Some capacity to support aquatic ecosystems and/or beneficial uses is reduced.	Impact is a high degree of change from existing conditions and is very difficult to rehabilitate. Most of the groundwater feature's capacity to support aquatic ecosystems and/or beneficial uses is reduced.	Impact is a very high degree of change from existing conditions and cannot be rehabilitated. Capacity to support aquatic ecosystems and/or beneficial uses is lost.
Duration	Impact is very short in duration (i.e., days)	Impact is short term (i.e., months or less)	Impact is medium term (1 to 2 years).	Impact is long term (3 to 15 years).	Impact is greater than 15 years or permanent.

Direct loss of springs

The value of springs is associated with the provision of base flow to watercourses and their ability to support beneficial uses of groundwater, such as providing potable water and supporting aquatic ecosystems.

Figure 6.5 shows that six of the 16 known springs will be directly covered by the placement of project facilities. Springs SWSP04, SWSP07, Spring 01 and Spring 02 are located where the TSFs will be constructed, SWSP06 will be covered by the haul road, and SWSP01 is located within the footprint of the Wallah waste rock dump. The current beneficial uses of these springs are outlined in Table 6.25.

Communities currently present in the Bawdwin upper village will be resettled approximately 7 to 9 months after commencement of the project so are unlikely to experience the impact of lost spring resources. Bawdwin lower village will be resettled 40 to 42 months after commencement of the project, or 30 to 32 months after commencement of mining operations. This indicates that this village will experience the impact of lost springs for at least 32 months before being resettled, although the exact timing of loss of each spring is not clear. Tiger Camp village will be resettled approximately 29 to 30 months after commencement of the project, or 19 to 20 months after commencement of mining operations. This indicates that this village will experience the impact of lost springs for at least 20 months before being resettled, although the exact timing of loss of each spring is not clear.

Table 6.25 Current beneficial uses of springs which will be directly covered by project facilities

Spring	Location	Current beneficial use
SWSP01	Beneath Wallah waste rock dump	Source of potable water to Wallah village and Tiger Camp, supports stream flow in Wallah valley.
SWSP04	Beneath TSFs	Source of potable water to Bawdwin, supports stream flow in Nam Pangyun.
SWSP06	Beneath haul road	Beneficial uses unknown, may be a source of potable water to Tiger Camp
SWSP07	Beneath TSFs	Source of potable water to Wallah village and Tiger Camp
Spring 01	Beneath TSFs	Beneficial uses unknown, may be a source of potable water to Wallah village and Tiger Camp
Spring 02	Beneath TSFs	Beneficial uses unknown, may be a source of potable water to Wallah village and Tiger Camp

The burial of these springs by TSFs or the waste rock dump will result in a substantial change to the surface topography and the local groundwater system. In most cases, groundwater levels will raise above the natural ground surface through the tailings or waste rock. The springs will be filled and inundated by the overlying waste storage facilities. Groundwater that may have once discharged to the natural ground surface as a spring would be entrained either as regional groundwater flow through remaining aquifer, or migrate through the overlying fill and be managed as seepage.

The impact to the value of springs as a result of the placement of project facilities will be of **major significance** based on the **high magnitude** of impact and **high sensitivit**y of springs (Table 6.26).

Table 6.26 Residual impact significance summary - loss of capability to support aquatic ecosystems and beneficial uses due to direct loss of springs from placement of project facilities over springs

Value	**Sensitivity of value**			
Springs	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Intrinsic attributes support the use of the groundwater for potable supply, agricultural use, and food production for current Bawdwin villages and Tiger Camp. Currently the springs provide base flow to the Nam Pangyun as well as support the beneficial uses of groundwater and are of high importance.	**Medium** Low groundwater residence times are likely to positively influence recovery provided the impact source is removed, however as springs take a longer time to disperse contaminants than rivers, they are more vulnerable to change. Springs represent a limited number of surface expressions of the saprolite aquifer and are therefore more vulnerable to permanent change and significant degradation.	**Low** Intrinsic properties of the springs are very susceptible to change (such as land clearing and excavation), however will maintain high connectivity to the saprolite aquifer. The overall function of the springs would be permanently altered.	**High**
Impact	**Magnitude of impact**			
Loss of capability to support aquatic ecosystems and beneficial uses due to direct loss of springs from placement of project facilities over springs	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Impacts are limited to small sections of the Nam Pangyun catchment and represent loss of six of the sixteen known springs in the Bawdwin concession area and impact areas that are not currently disturbed.	**Medium** Some springs will be permanently lost, along with the contribution these springs made to aquatic ecosystems or beneficial uses associated with the springs. Nam Pangyun relies on spring flow during dry season and so the impact may reduce flow volumes in the downstream Nam Pangyun.	**Very high** Springs will be permanently lost due to permanent infrastructure. This is deemed a very high duration because the spring resource would be lost if people were to return to the area in the future.	**Medium**
	Residual impact significance			**High**
	Assessment of uncertainty			
	Medium The timing of when each individual spring will be lost during construction is not clear. The duration of this impact has been assumed to commence at the start of operations up until each of these villages are resettled but to continue as a permanent impact because the spring resource would be lost if people decided to return to the area in the future. There is uncertainty as to the dependency of some of the spring resources for water supply.			

Groundwater drawdown

Mine dewatering to remove pit water will result in groundwater drawdown over the life of the mine. This drawdown will be additional to the existing groundwater drawdown in the vicinity of the pit due to historic mining and dewatering. Currently, the underground mine is dewatered to a depth of approximately 200 m below the ground surface level at Marmion Shaft and this level is maintained by continuous pumping and by discharge to the Nam Pangyun via the Tiger Tunnel. At its largest extent, the open pit will be 92 ha in size and 250 m below the existing pit floor and approximately 495 m below the surface elevation.

As outlined in Section 6.3.2, dewatering will occur via a combination of pumping from an in-pit sump and discharge to the Nam Pangyun via a sediment pond and by continuing the discharge of groundwater from the Tiger Tunnel into the Nam Pangyun. Groundwater inflows are expected to increase from an average of 142 m^3/d in year 1 to 670 m^3/d in year 13. In order to dewater the pit in three days following a 100-year 24-hour storm event the pumping rate will range between 12,960 L/s and 21,600 L/s (1,119,744 m^3/d to 1,866,240 m^3/d) depending on the mining year.

Groundwater modelling was undertaken to predict groundwater drawdown throughout the life of the mine (CSA, 2020). The modelling predicted groundwater drawdown contours in the fractured rock aquifer at mining years 7 and 14, which represent the mid and end mining years.

Figure 6.10 and

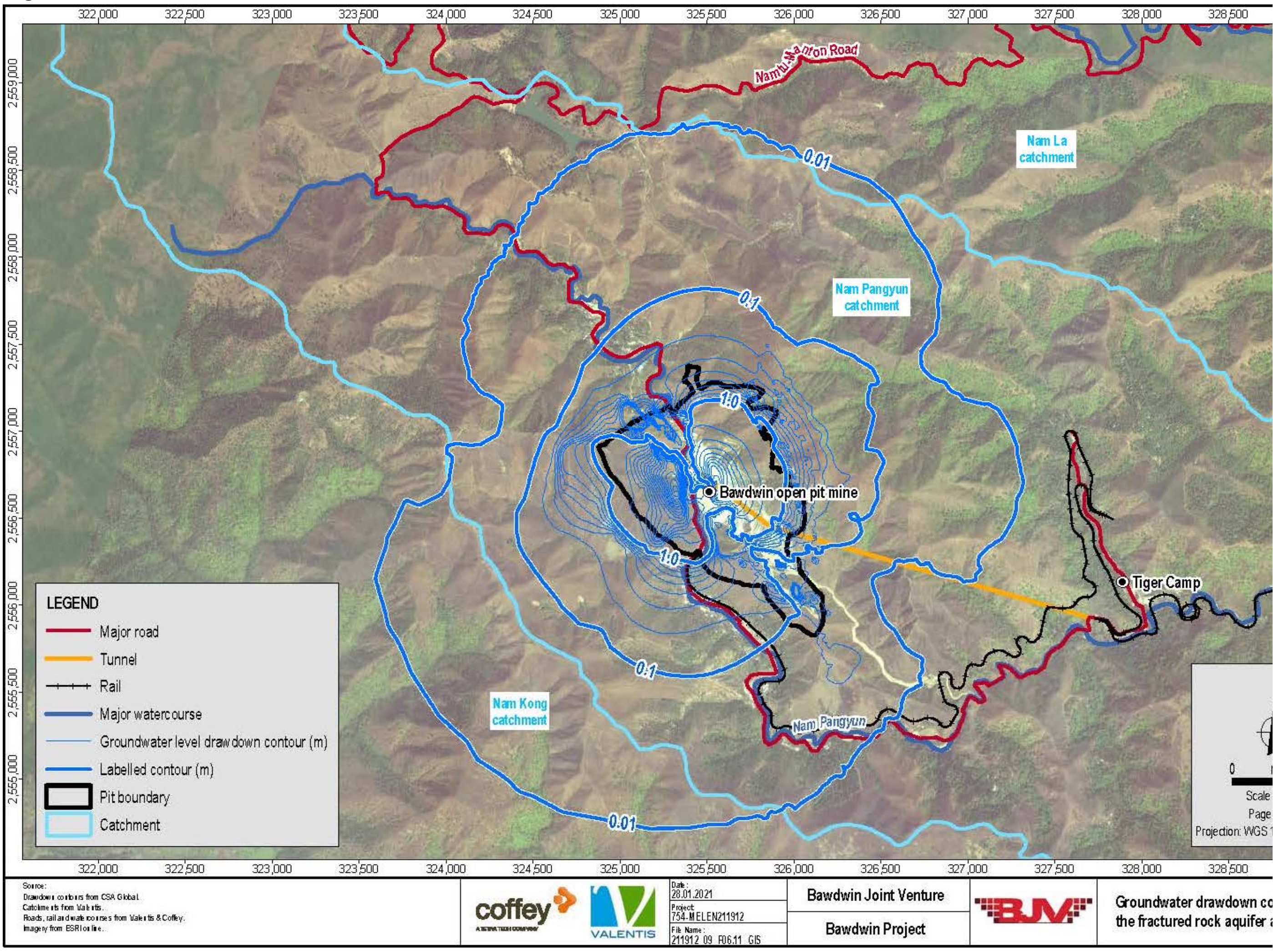


Figure 6.11 present the drawdown contours for years 7 and 14, respectively, as a result of mine dewatering.

The results show that, in years 7 and 14, drawdown from current groundwater levels is primarily constrained to within the immediate vicinity of the pit, which is probably a result of the steep topography, low hydraulic conductivity of the fractured rock aquifer and the recharge from the adjacent Nam Pangyun. In year 7, a maximum drawdown of 8 m is predicted to occur at the base of the pit. Also, during this year, the modelling predicts groundwater levels in the fractured rock aquifer will be drawn down by 10 cm at a distance of up to 1 km from the proposed pit crest. In year 14, a maximum drawdown of 1 m is predicted to occur within and around the periphery of the pit and drawn down by 10 cm at a distance of up to about 2 km from the proposed pit crest. During both years, predicted groundwater drawdown is mostly within the range of 10 cm to 1 m in the area outside the pit through which the Nam Pangyun flows (see

Figure 6.10 and

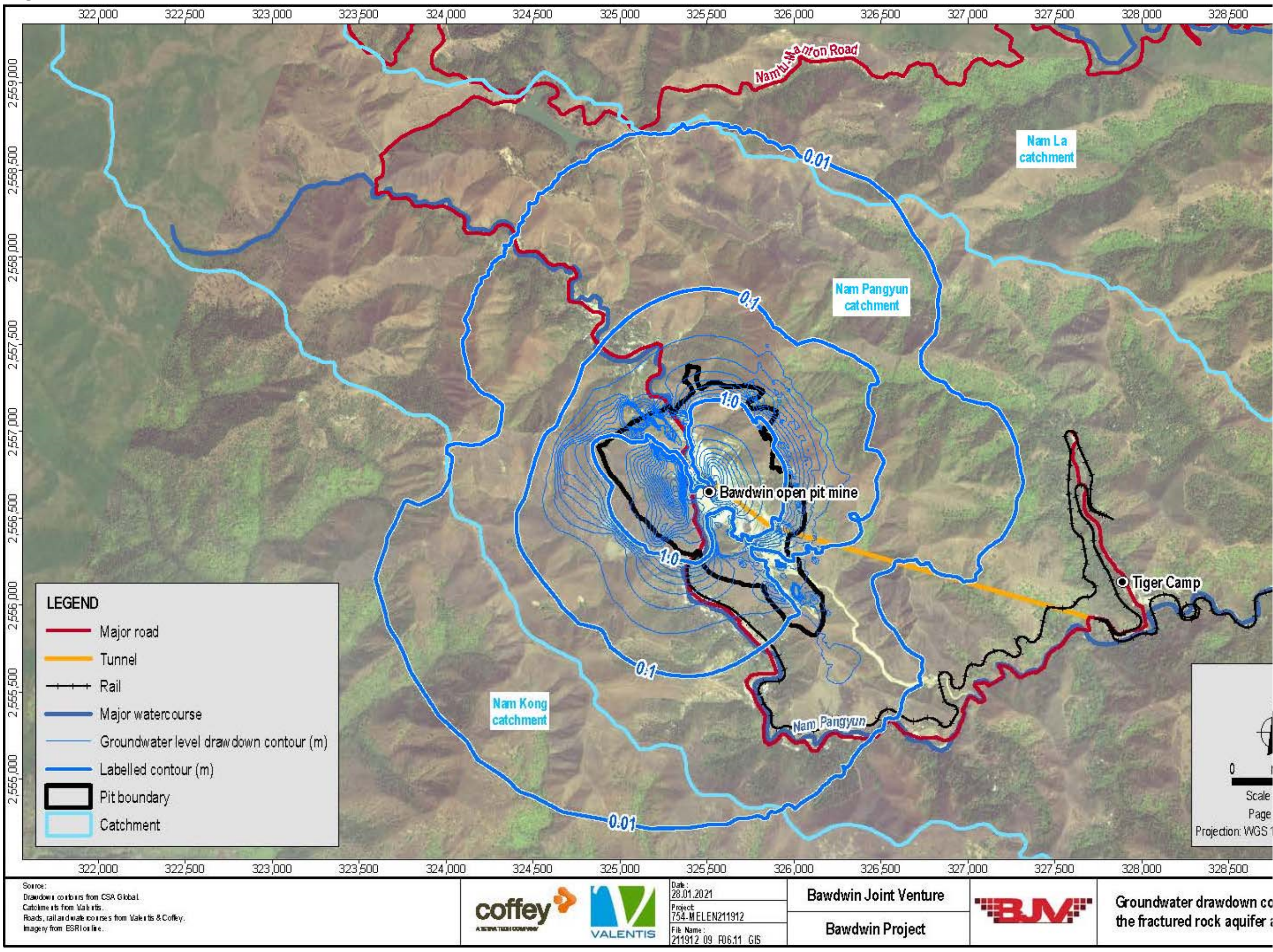


Figure 6.11).

As discussed in Section 6.4, in the vicinity of the pit the Nam Pangyun is 'water losing' (i.e., the river loses water via seepage to the underlying groundwater system) due to existing drawdown, which promotes surface water seepage to groundwater. The same mechanism will occur throughout mining operations while dewatering continues. While further drawdown around the mine is predicted, drawdown levels in the order of 10 cm to 1 m are low in the context of existing natural fluctuations measured in the fractured rock aquifer. Monitoring of existing groundwater levels in fractured bedrock in and around the pit between March 2019 and March 2020 showed that the levels at most sites varied in the order of metres across the monitoring period.

Drawdown of the fractured rock aquifer and subsequent reduced baseflows to the Nam Pangyun due to mine dewatering is of **low significance** based on the **low magnitude** of impact and the **low to medium sensitivity** of the feature (Table 6.27).

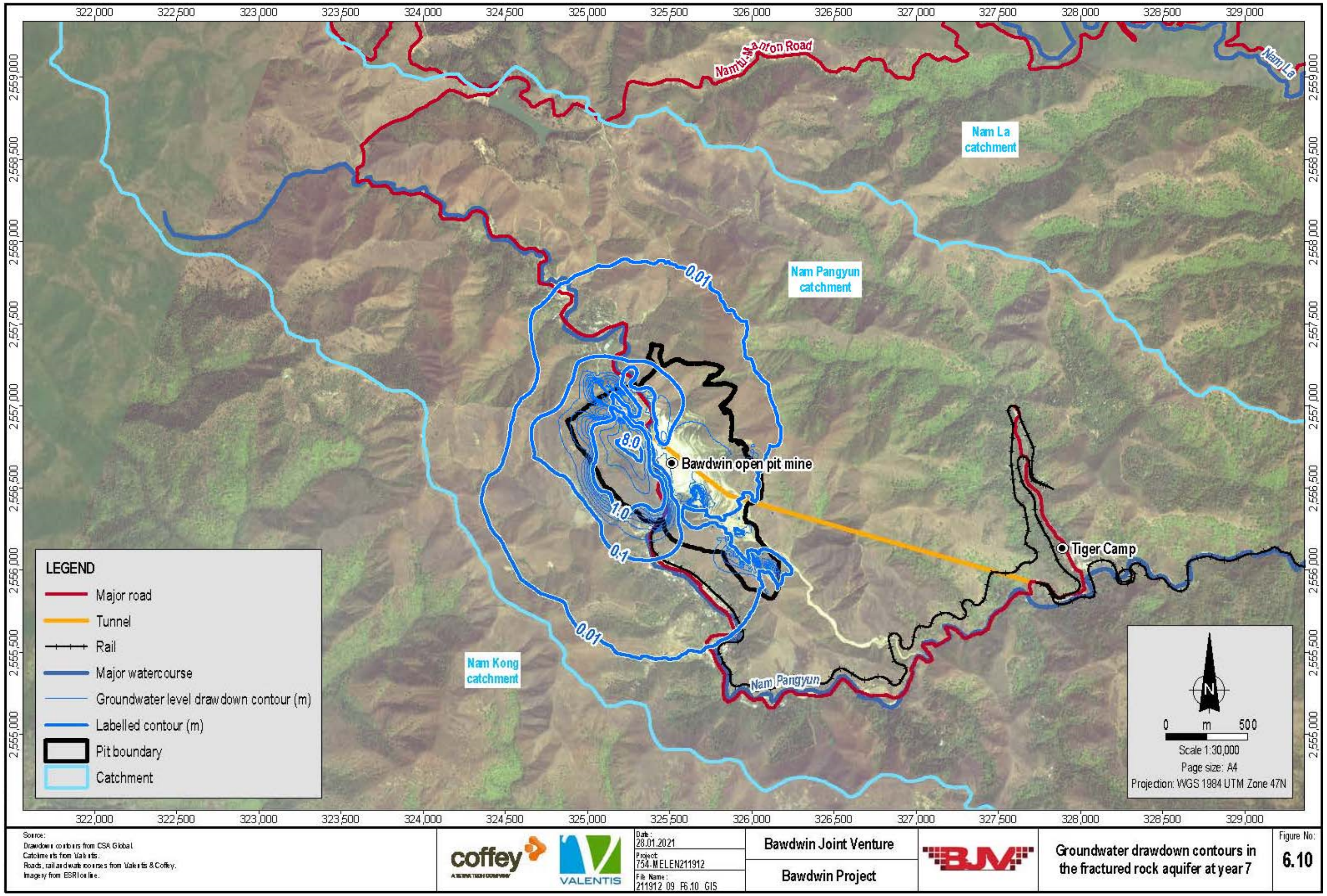


Figure 6.10 Groundwater drawdown contours in the fractured rock aquifer at year 7

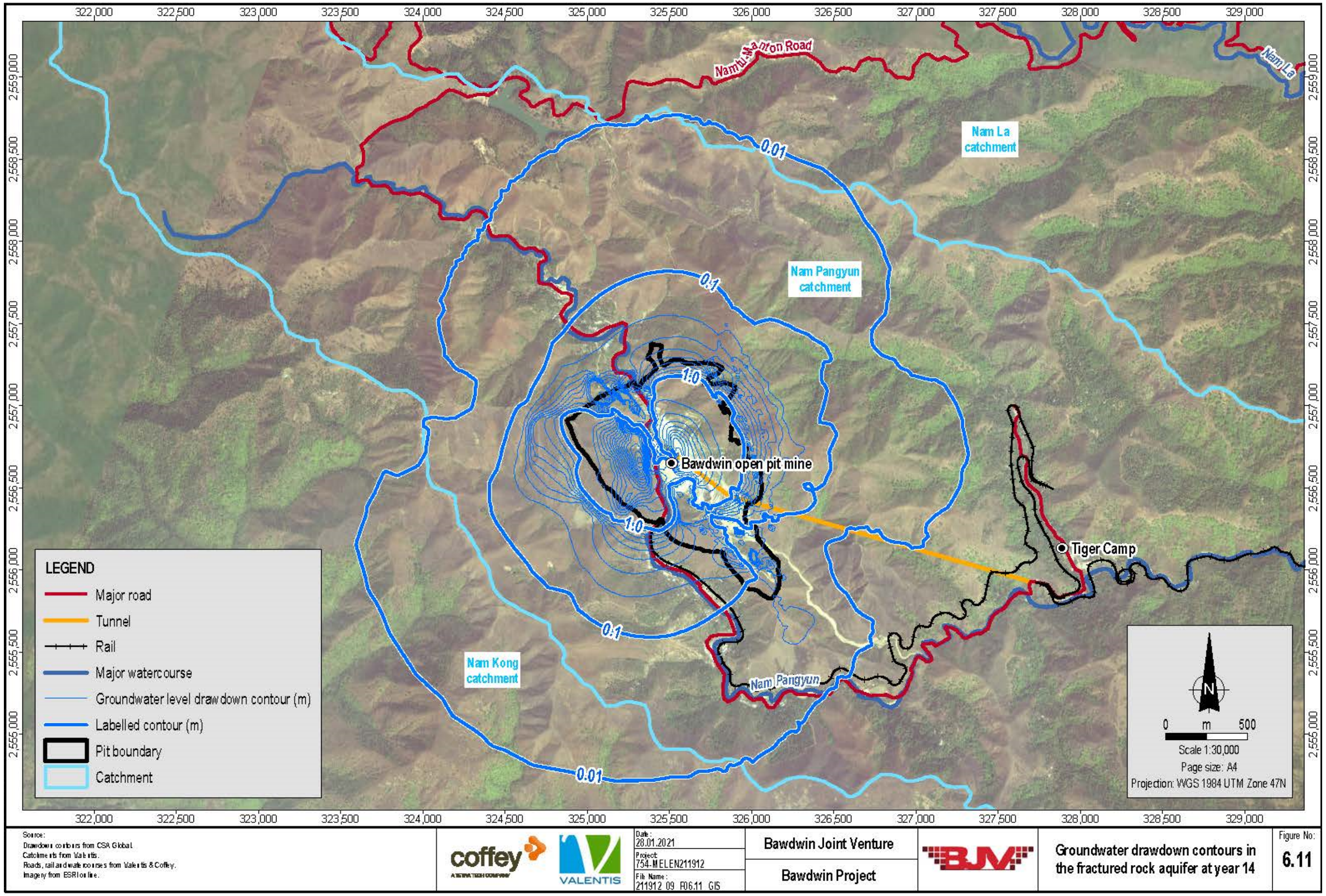


Figure 6.11 Groundwater drawdown contours in the fractured rock aquifer at year 14

Table 6.27 Residual impact significance summary - drawdown of the fractured rock aquifer and subsequent reduced baseflows to the Nam Pangyun due to mine dewatering

Value	**Sensitivity of value**			
Nam Pangyun – fractured rock aquifer	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Attributes of the groundwater system (quality, occurrence, volume, extraction potential) are not suitable for beneficial uses due to natural mineralisation and historical mineral processing activity. Locally, the groundwater system does not support ecosystems. Further downstream the groundwater system supports ecosystems of low ecological importance, and/or groundwater dependent surface water features which are characterised as highly altered from their natural state.	**Medium** Recovery is likely to be slow or only partially successful.	**Medium** Intrinsic properties of the groundwater system are moderately resistant to change. The overall function of the groundwater system could be moderately altered.	**Low to medium**
Impact	**Magnitude of impact**			
Drawdown of the fractured rock aquifer and subsequent reduced baseflows to the Nam Pangyun due to mine dewatering	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Drawdown would only affect a localised and already heavily impacted area around the open pit in the mid-section of the Nam Pangyun.	**Very low** Overall, the predicted levels of drawdown are unlikely to significantly change the baseflow contribution from the fractured rock aquifer and the subsequent loss of water to the Nam Pangyun is expected to be negligible in the context of the Nam Pangyun being an already highly impacted stream.	**High** Drawdown will persist throughout operations but will cease after mine closure when the pit refills with water. The groundwater system will recharge and baseflows to the Nam Pangyun will increase from current volumes	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Medium Groundwater drawdown has been modelled for years 7 and 14; however, this was for the saprolite aquifer. The levels of drawdown for the fractured rock aquifer have not been quantified.			

A key uncertainty associated with this impact assessment rating is that expansion of the pit in the early stages of mine development may intersect with the underground sections of the Nam Pangyun at the northern and southern periphery of the pit prior to the river diversion being installed. While not strictly a drawdown impact, this could reduce the flow in the Nam Pangyun. Investigations would be required to confirm the underground river alignment to ensure that the pit does not intersect it prior to the diversion being installed.

The reduction of water supply to springs due to groundwater drawdown is likely to have a greater impact than reduced baseflow to rivers, given the importance of these features to the community and their lower potential for recovery (i.e., lower resilience). As discussed, six out of the 16 known springs will be directly covered (i.e., removed) by project facilities so those springs that remain and are exposed to drawdown are vulnerable to a relatively high impact. Furthermore, in drier months, some of the minor springs that are higher in the landscape are known to cease flowing (A Witcomb, pers. comm. 2020), which limits the availability of springs to support beneficial uses and ecosystems in the dry season.

The groundwater model predicted drawdown in water levels at known springs in the catchment.

Figure 6.12 displays the groundwater drawdown contours in the saprolite aquifer and

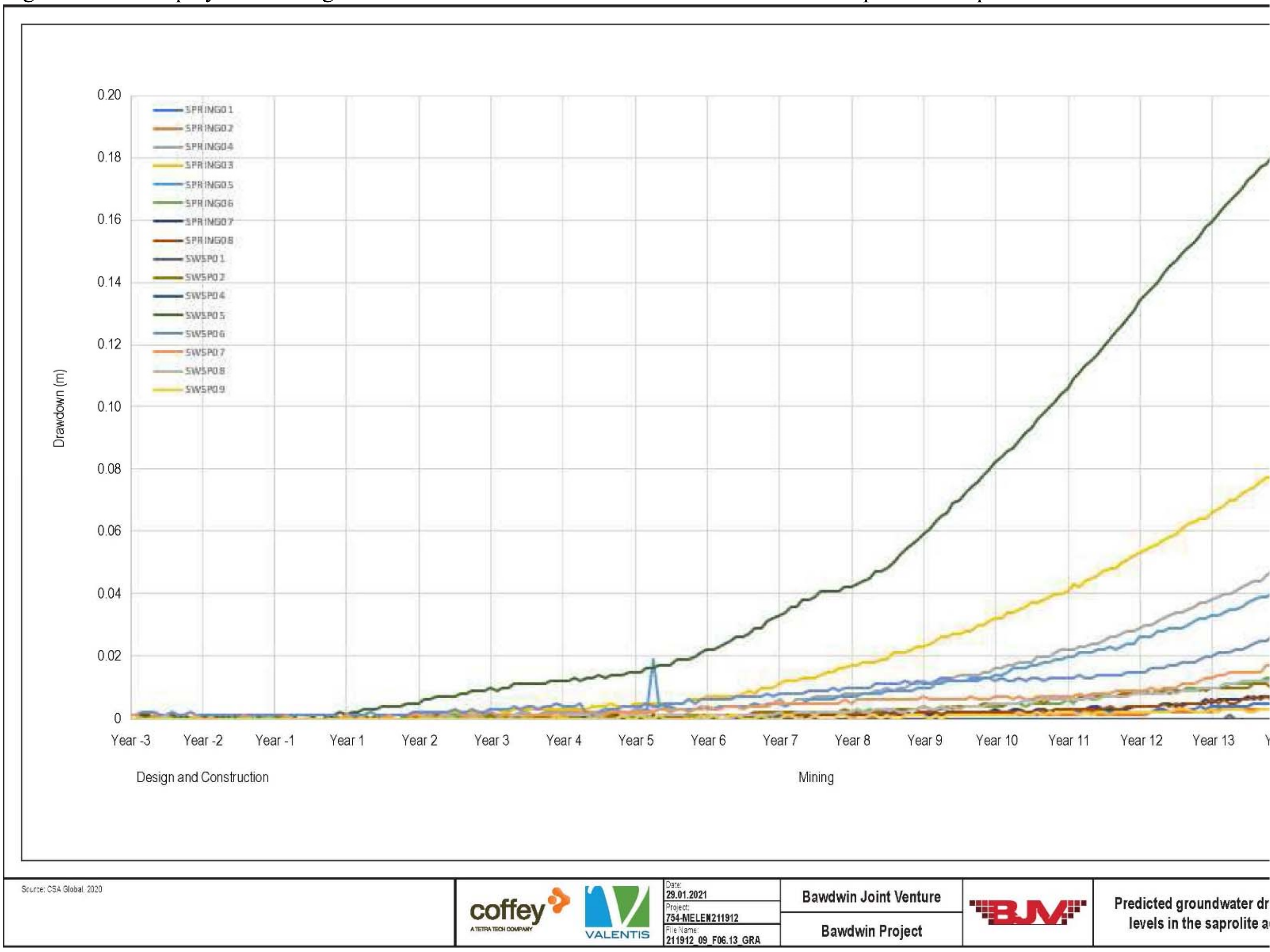


Figure 6.13 presents the predicted drawdown at known springs. The expected drawdown for the six springs that will be lost due to placement of project infrastructure (Springs SWSP01, SWSP04, SWSP06, SWSP07, Spring 01 and Spring 02) are plotted to show the extent of expected drawdown, but it should be noted that the impact of drawdown on these springs is irrelevant as the springs will be directly lost (i.e., buried). The modelling predicted that groundwater drawdown in the saprolite aquifer is largely constrained to the area surrounding the pit, and the water levels at most of the known springs in the Nam Pangyun catchment would be drawn down by less than 5 cm. The exceptions were two springs (sites Spring 03 and SWSP05 shown on

Figure 6.12) where a drawdown, at the end of mine life, of 8 cm is predicted at Spring 03 and a drawdown of 18 cm is predicted at SWSP05. Drawdown in the saprolite and fractured rock aquifers is not expected to extend far (if at all) into the neighbouring catchments, and similar drawdown impacts are not likely to be realised.

The natural range of groundwater level fluctuations near springs have not been measured and so it is not clear whether a reduced level of up to 5 cm (springs SWSP02, SWSP05, SWSP09, Spring 04, Spring 05, Spring 06, Spring 07 and Spring 08), 8 cm (Spring 03) and 18 cm (spring SWSP05) would have a measurable impact on spring flow rates. However, the natural range of groundwater level fluctuation in the saprolite aquifer is expected to be greater than the predicted drawdown due to the highly seasonal nature of rainfall recharge and suspected short groundwater residence times in the aquifer. It is expected that springs drawn down by less than 10 cm would unlikely experience a measurable effect on spring flow.

It is reasonable to expect that where groundwater drawdown between 0.1 m to 1 m occurs at springs, this may temporarily or permanently reduce or halt spring flow. Based on modelling results, material impacts to spring flow due to drawdown are only expected to affect the known spring SWSP05, which supplies potable water to the nearby Bawdwin community. Drawdown greater than 0.1 m is not predicted until Year 10 of mining operations, which will be several years after the Bawdwin villages will have been resettled (see

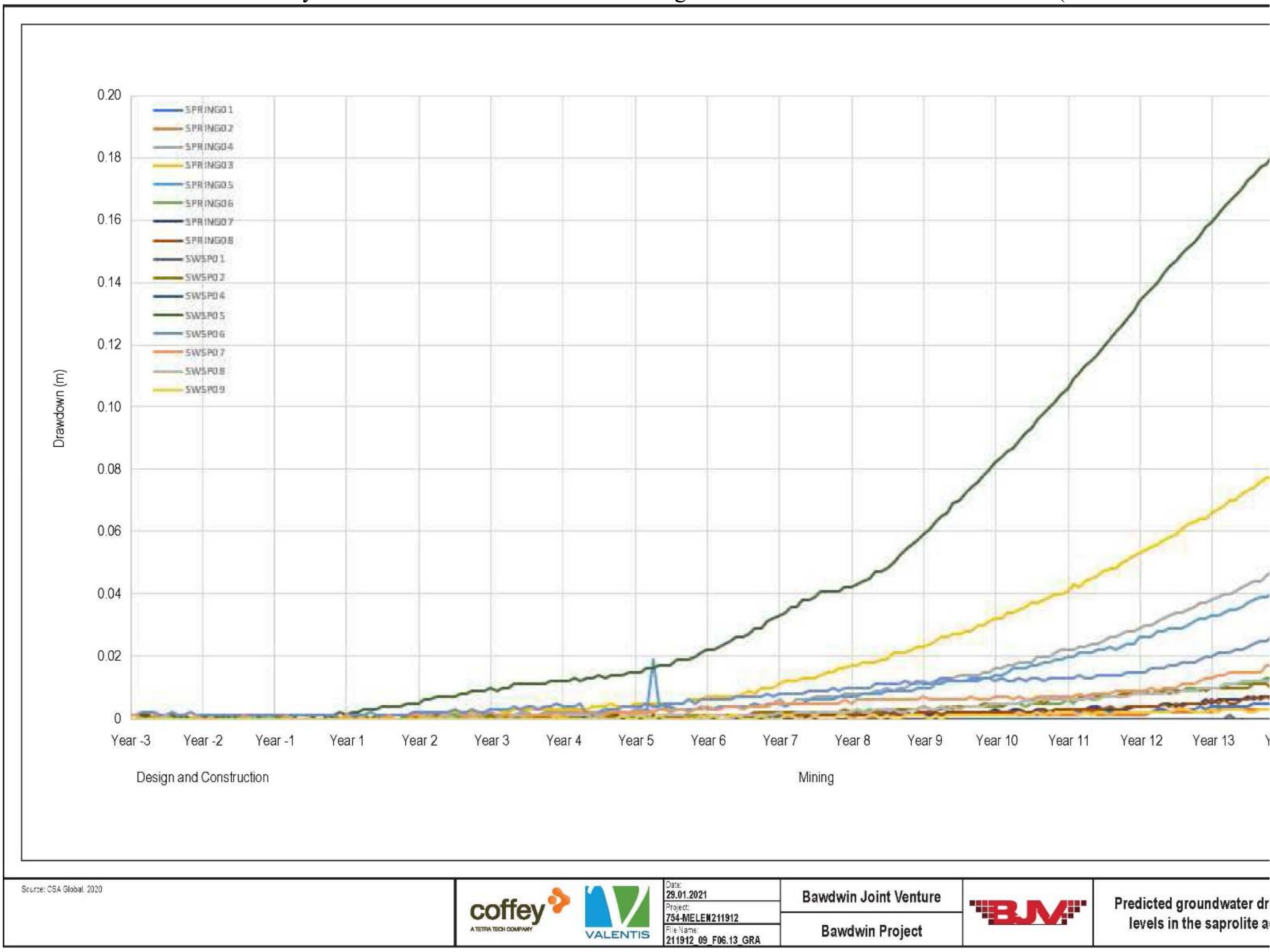


Figure 6.13).

Additional unknown springs that occur in this area would also probably experience materially reduced flows.

Drawdown of 0.1 m to 1 m at spring SWSP05 and potentially other unknown springs is considered to be of **moderate significance** based on the **low magnitude** of impact and the **high sensitivity** of springs (Table 6.28).

Figure 6.12 Predicted groundwater drawdown in the saprolite aquifer (Year 14) and known springs

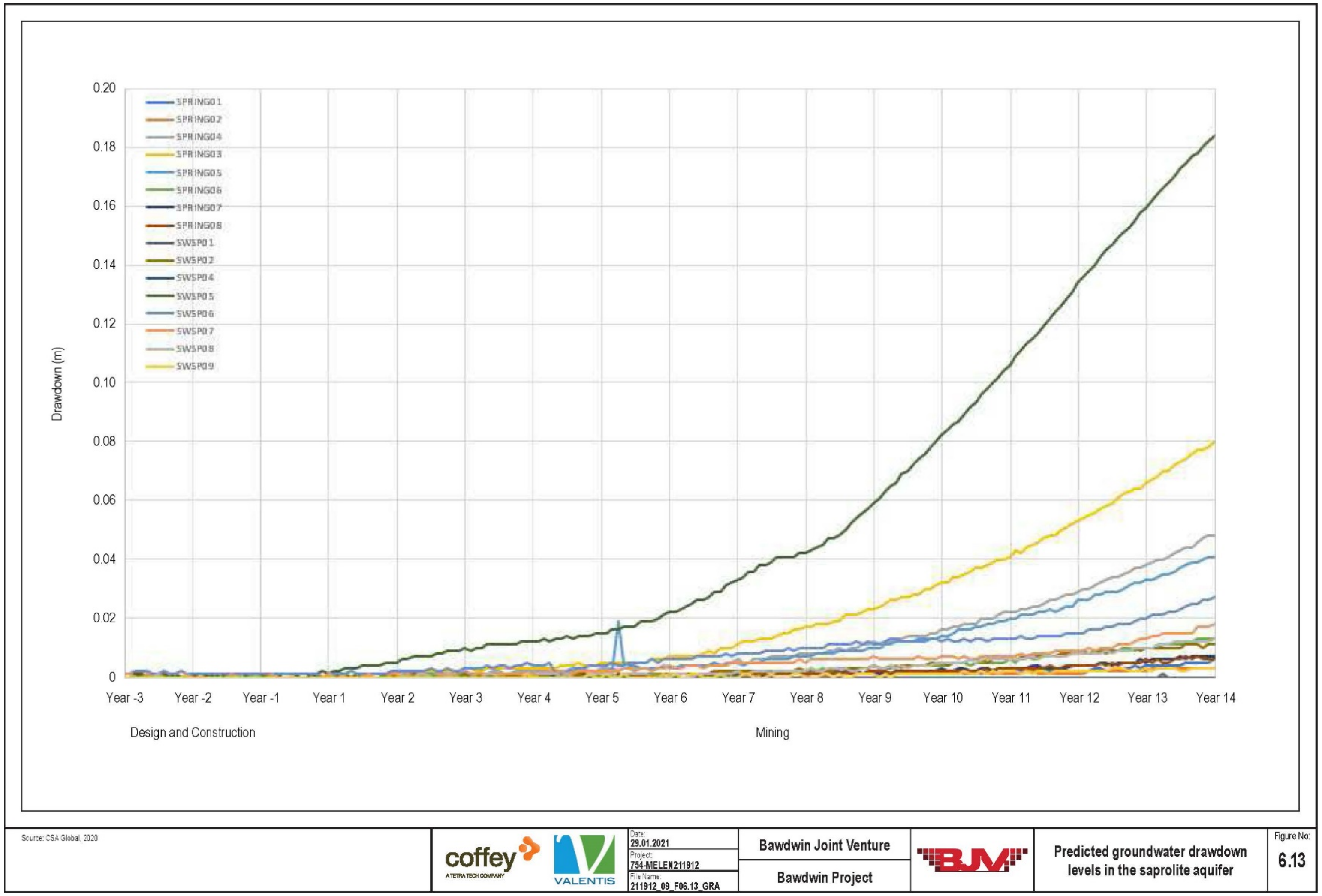


Figure 6.13 Predicted groundwater drawdown levels in the saprolite

Table 6.28 Residual impact significance summary - loss of capability to support aquatic ecosystems and beneficial uses due to reduced spring flow caused by groundwater drawdown

Value	**Sensitivity of value**			
Springs	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Intrinsic attributes support the use of the groundwater for potable supply, agricultural use, and food production for current Bawdwin villages and Tiger Camp. Currently the springs provide base flow to the Nam Pangyun as well as support the beneficial uses of groundwater and are of high importance.	**Medium** Low groundwater residence times are likely to positively influence recovery provided the impact source is removed, however as springs take a longer time to disperse contaminants than rivers, they are more vulnerable to change. Springs represent a limited number of surface expressions of the saprolite aquifer and are therefore more vulnerable to permanent change and significant degradation.	**Low** Intrinsic properties of the springs are very susceptible to change (such as land clearing and excavation), however will maintain high connectivity to the saprolite aquifer. The overall function of the springs would be permanently altered.	**High**
Impact	**Magnitude of impact**			
Loss of capability to support aquatic ecosystems and beneficial uses due to reduced spring flow caused by groundwater drawdown	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Impact is likely to materially affect one known spring (SWSP05)	**Low** There may be reduced water available to support ecosystems and to support extractive beneficial use but the spring would be able to recover. With the resettlement of the Bawdwin and Tiger Camp villages for the project, the productive beneficial uses of the spring will not be realised once the project is in operation. Drawdown of the spring is expected to be less than 10 cm while the communities are still present in the area.	**High** Groundwater levels are expected to recover after project closure.	**Low**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	Low Groundwater drawdown has been modelled for all operational years for the known springs. There is some uncertainty regarding additional as yet unknown springs and the levels to which they may be impacted. As these have not been identified it is assumed additional springs are not of high importance to communities for provision of beneficial uses. It has been conservatively assumed that drawdown of greater than 10 cm could result in a notable reduction in spring flow. The recommended further hydrogeological assessments work will support a refined assessment of what level of drawdown would result in reduction of spring flow.			

Groundwater mounding

Tailings storage

Hydraulic loading due to the TSFs can add significant pressure to the underlying saprolite (where present) and fractured rock aquifers, causing significant groundwater mounding and potential changes to the aquifer hydraulic properties as the underlying aquifer is compressed. While there has been no modelling of groundwater mounding at the three TSFs, it is common to observe altered groundwater flow directions and flow velocities beneath and around similar TSFs. Mounding will probably cause higher hydraulic gradients at some locations in the underlying and surrounding aquifers and, based on the surrounding topography, may promote groundwater to flow in new directions through the fractured bedrock or the more permeable saprolite. Groundwater mounding and changes to groundwater flows are likely to be complex and have not yet been modelled. The following assessment is approached qualitatively and with uncertainty about the magnitude of impact.

The application of design controls, such as an underdrainage system and cut-off drains, will assist with capturing some seepage and control groundwater levels within the main embankments, predominantly to maintain the structural integrity of the embankments. However, significant hydraulic loading (mounding) of the underlying and aquifer can be expected beneath and surrounding the TSFs. The TSFs will not be lined. The permeability of the fractured rock aquifer is expected to reduce with depth (a commonly observed phenomenon in fractured rock aquifers) and the valley walls that contain the TSFs are expected to prevent the mounding effects and the lateral movement of groundwater to surrounding catchments. Two key exceptions are noted:

1. Fracture and fault zones: where present may provide preferential pathways for groundwater movement away from the TSFs.

2. Higher permeability ridge lines: as the TSFs fill towards their final design levels the available thickness of lower permeability or unfractured deep bedrock reduces and the presence of more permeable fractured bedrock and saprolite is expected to increase. Potential for groundwater to mobilise to neighbouring catchments will therefore increase as the tailings surface climbs towards the ridge lines.

A detailed geotechnical and hydrogeological study of the TSF areas is required to identify high hydraulic conductivity zones that may allow movement of groundwater to neighbouring, unimpacted aquifers.

Due to the undulating topography of the northern ridgeline of TSF A, tailings material will be filled to within 5 m to 10 m of the natural ridge in places. This will require construction of saddle dams at two locations. The phreatic surface may be at, or close to, the rehabilitated surface of the filled TSF, and therefore close to the natural ridgeline during operation and permanently, post closure. In the absence of detailed geotechnical investigations and hydrogeological modelling, there is considered to be a high likelihood that a component of groundwater will flow from TSF A (located within the Nam Pangyun catchment) through the saprolite and higher permeability fractured rock aquifers, and into the Nam La catchment to the north. This may result in increased groundwater discharge to Nam La catchment, emergence of new saprolite springs in the Nam La catchment, formation of unstable ground, erosion or waterlogging.

Elsewhere, altered groundwater flow directions and increased flow rates may result in the formation of springs in surrounding sub-catchments, most likely higher in the landscape. It is expected that where the groundwater flow emerges to the surface, areas of waterlogging, erosion and localised land instability will occur, based upon observation of existing emergent springs on steep hillsides within the Bawdwin concession area. In addition, groundwater flow from the aquifers under the TSFs may transport contaminants leached from the TSFs to adjacent and previously undisturbed aquifers (assessed in subsequent sections). It is therefore assumed that formation of new springs does not result in an added beneficial water source.

A combined geotechnical and hydrogeological assessment should be completed during detailed design to identify areas where ground treatment (grouting), cut off walls, or other engineering controls may be required to minimise the effects of mounding or prevent the movement of groundwater into unimpacted catchments (i.e., the Nam La catchment).

While all the impact scenarios and pathways cannot be accurately predicted, the impact of changes to groundwater flow in the Nam Pangyun catchment around the TSFs due to hydraulic loading induced groundwater mounding is considered to be of **low significance** for the fractured rock aquifer, based on the **low magnitude** of impact and the **low to medium sensitivity** of the feature (Table 6.29).

Table 6.29 Residual impact significance summary - changed groundwater flow in the fractured rock aquifer in the Nam Pangyun catchment around the TSFs due to groundwater mounding induced by hydraulic loading

Value	**Sensitivity of value**			
Nam Pangyun – fractured rock aquifer	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Attributes of the groundwater system (quality, occurrence, volume, extraction potential) are not suitable for beneficial uses due to natural mineralisation and historical mineral processing activity. Locally, the groundwater system does not support ecosystems. Further downstream the groundwater system supports ecosystems of low ecological importance and highly altered from their natural state.	**Medium** Recovery is likely to be slow or only partially successful.	**Medium** Intrinsic properties of the groundwater system are moderately resistant to change. The overall function of the groundwater system could be moderately altered.	**Low to medium**
Impact	**Magnitude of impact**			
Changed groundwater flow in the fractured rock aquifer in the Nam Pangyun catchment around the TSFs due to groundwater mounding induced by hydraulic loading	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Impact will affect the portions of the Nam Pangyun catchment where the TSFs have been constructed, but will not extend significant distances beyond the TSFs, limited by the high topographic relief and suspected low hydraulic conductivity at depth.	**Low** The greatest change to groundwater flow within the Nam Pangyun catchment is likely to occur beneath and immediately surrounding the TSFs and around the engineered embankments. Groundwater levels will be controlled by the drainage system to minimise impact severity and are not expected to have significant impacts.	**Very high** Changes to flow caused by mounding are likely to extend post-closure.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	High In the absence of a detailed geotechnical and hydrogeological study of the TSF areas and modelling of changes to groundwater flows due to mounding (which are highly complex processes) the uncertainty is high in terms of impact severity and spatial extent. All the impact scenarios and pathways due to mounding cannot be accurately predicted. The assessment is approached qualitatively and with high uncertainty about the magnitude of impact. A detailed geotechnical and hydrogeological study of the TSF areas is required to identify high hydraulic conductivity zones that may allow movement of groundwater to neighbouring, unimpacted aquifers.			

The impact is considered to be **moderate significance** for the saprolite aquifer, based on the **low magnitude** of impact and the **high sensitivity** of the feature (Table 6.30).

Table 6.30 Residual impact significance summary - changed groundwater flow in the saprolite aquifer in the Nam Pangyun catchment around the TSFs due to groundwater mounding induced by hydraulic loading

Value	**Sensitivity of value**			
Nam Pangyun – saprolite aquifer	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Currently groundwater from the saprolite aquifer has beneficial uses as a potable water supply and supports aquatic ecosystems, and is of high importance.	**Low** Low groundwater residence times are likely to positively influence recovery provided the impact source is removed.	**Low** Intrinsic properties of the groundwater system are very susceptible to change (such as land clearing and excavation). The overall function of the groundwater system would be permanently altered.	**High**
Impact	**Magnitude of impact**			
Changed groundwater flow in the saprolite aquifer in the Nam Pangyun catchment around the TSFs due to groundwater mounding induced by hydraulic loading	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Impact will affect the Nam Pangyun catchment where the TSFs have been constructed, but will not extend significant distances beyond the TSFs, limited by the high topographic relief and limited thickness of the saprolite.	**Low** The greatest change to groundwater flow within the Nam Pangyun catchment is likely to occur beneath and immediately surrounding the TSFs and around the engineered embankments. Changes to groundwater levels and flow beyond the immediate TSF area are likely to be low in the first 32 months of operations while downstream communities at Bawdwin Lower village are still present.	**Very high** Changes to flow caused by mounding are likely to extend post-closure.	**Low**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High In the absence of a detailed geotechnical and hydrogeological study of the TSF areas and modelling of changes to groundwater flows due to mounding (which are highly complex processes) the uncertainty is high in terms of impact severity and spatial extent. All the impact scenarios, pathways and timing due to mounding cannot be accurately predicted. The assessment is approached qualitatively and with high uncertainty about the magnitude of impact. A detailed geotechnical and hydrogeological study of the TSF areas is required to identify high hydraulic conductivity zones that may allow movement of groundwater to neighbouring, unimpacted aquifers.			

Overall, the impact of mounding-induced changes to groundwater flow in the Nam La catchment around the TSFs is considered to be of **low significance** for the fractured rock aquifer, based on the **low magnitude** of impact and the **medium sensitivity** of the feature (Table 6.31), and of based on the **medium magnitude** of impact and the **high sensitivity** of the feature (Table 6.32).

Table 6.31 Residual impact significance summary - changed groundwater flow in the fractured rock aquifer in the Nam La catchment around the TSF-A due to groundwater mounding induced by hydraulic loading

Value	**Sensitivity of value**			
Nam La – fractured rock aquifer	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium Attributes of the groundwater system (quality, occurrence, volume) are suitable for beneficial uses however the reduced extraction potential has resulted in this resource not being exploited for a consumptive beneficial use. The groundwater system supports aquatic and some terrestrial ecosystems of ecological importance. Catchments outside of developed urban centre of Namtu township are largely unaltered from their natural state and will have some dependence on groundwater discharge during dry months.	**Medium** Recovery is likely to be slow or only partially successful.	**Medium** Intrinsic properties of the groundwater system are slightly resistant to change. However, the overall function of the groundwater system remains relatively unchanged.	**Medium**
Impact	**Magnitude of impact**			
Changed groundwater flow in the fractured rock aquifer in the Nam La catchment around the TSF-A due to groundwater mounding induced by hydraulic loading	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Impact may affect parts of the aquifer in the immediately adjacent Nam La catchment, but is unlikely to extend significant distances.	**Low** Changes to groundwater flow and subsequent effects may be controlled by cut-off drains, weep holes or other engineering methods if adverse effects are realised.	**Very high** Changes to flow caused by mounding are likely to extend post-closure.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	High In the absence of a detailed geotechnical and hydrogeological study of the TSF areas and modelling of changes to groundwater flows due to mounding (which are highly complex processes) the uncertainty is high in terms of impact severity and spatial extent. All the impact scenarios and pathways due to mounding cannot be accurately predicted. The assessment is approached qualitatively and with high uncertainty about the magnitude of impact. A detailed geotechnical and hydrogeological study of the TSF areas is required to identify high hydraulic conductivity zones that may allow movement of groundwater to neighbouring, unimpacted aquifers.			

Table 6.32 Residual impact significance summary - changed groundwater flow in the saprolite aquifer in the Nam La catchment around the TSF-A due to groundwater mounding induced by hydraulic loading

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Nam La – saprolite aquifer</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>High
Intrinsic attributes support the use of the groundwater for potable supply (for Namtu township), agricultural use, and food production.
Attributes of the groundwater system are of moderate to high ecological importance, supporting terrestrial and aquatic ecosystems that are characterised as largely undisturbed.</td><td>Low
Low groundwater residence times are likely to positively influence recovery provided the impact source is removed.</td><td>Low
Intrinsic properties of the groundwater system are very susceptible to change. The overall function of the groundwater system would be permanently altered.</td><td>High</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact</th></tr>
<tr><td rowspan="6">Changed groundwater flow in the saprolite aquifer in the Nam La catchment around the TSF-A due to groundwater mounding induced by hydraulic loading</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Low
Impact may affect parts of the aquifer in the immediately adjacent Nam La catchment, but is unlikely to extend significant distances</td><td>Low
Changes to groundwater flow and subsequent effects may be controlled by cut-off drains, weep holes or other engineering methods if adverse effects are realised.</td><td>Very high
Changes to flow caused by mounding are likely to extend post-closure.</td><td>Low</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Moderate</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">High
In the absence of a detailed geotechnical and hydrogeological study of the TSF areas and modelling of changes to groundwater flows due to mounding (which are highly complex processes) the uncertainty is high in terms of impact severity and spatial extent. All the impact scenarios and pathways due to mounding cannot be accurately predicted. The assessment is approached qualitatively and with high uncertainty about the magnitude of impact.
A detailed geotechnical and hydrogeological study of the TSF areas is required to identify high hydraulic conductivity zones that may allow movement of groundwater to neighbouring, unimpacted aquifers.</td></tr>
</table>

Wallah waste rock dump

Increased rainfall infiltration across the waste rock dump will collect towards the base of the dump and cause mounding of groundwater levels in the underlying saprolite aquifer. A series of underdrains will be constructed to promote drainage of the dump and collect some of this seepage. Seepage modelling suggests that the underdrainage system will maintain low phreatic levels within the waste rock dump.

However, some minor mounding is expected towards the base of the waste rock dump that may cause locally altered groundwater flow direction in the saprolite and potentially the fractured rock aquifer. Unlike the TSFs, mounding under the waste rock dumps will not rise to levels that would probably present a risk of groundwater flow to other sub-catchments or cause the formation of new springs. Impacts to groundwater quality are assessed in subsequent sections in more detail.

Overall, the impact of changed groundwater flow in the fractured rock and saprolite aquifers in the Nam Pangyun catchment around the Wallah waste rock dump due to increased recharge at the Wallah waste rock dump and subsequent changes to the landscape is considered to be of **low significance** for the fractured rock aquifer, based on the **low magnitude** of impact and **low to medium sensitivity** of the feature (Table 6.33)

Table 6.33 Residual impact significance summary - changed groundwater flow in the fractured rock aquifer in the Nam Pangyun catchment due to increased recharge at the Wallah waste rock dump

Value	**Sensitivity of value**			
Nam Pangyun – fractured rock aquifer	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Attributes of the groundwater system (quality, occurrence, volume, extraction potential) are not suitable for beneficial uses due to natural mineralisation and historical mineral processing activity. Locally, the groundwater system does not support ecosystems. Further downstream the groundwater system supports ecosystems of low ecological importance and highly altered from their natural state.	**Medium** Recovery is likely to be slow or only partially successful.	**Medium** Intrinsic properties of the groundwater system are moderately resistant to change. The overall function of the groundwater system could be moderately altered.	**Low to medium**
Impact	**Magnitude of impact**			
Changed groundwater flow in the fractured rock aquifer in the Nam Pangyun catchment due to increased recharge at the Wallah waste rock dump	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Impact covers the extent of the waste rock dump within the Wallah Valley	**Low** Minor mounding is expected towards the base of the waste rock dump that may cause locally altered groundwater flow direction in the saprolite and potentially the fractured rock aquifer	**Very high** Changes to flow caused by mounding will last for longer than 15 years	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	High In the absence of a detailed geotechnical and hydrogeological study of the Wallah waste rock dump area and modelling of changes to groundwater flows due to mounding (which are highly complex processes) the uncertainty is high in terms of impact severity and spatial extent. All the impact scenarios and pathways due to mounding cannot be accurately predicted. The assessment is approached qualitatively and with high uncertainty about the magnitude of impact. A detailed geotechnical and hydrogeological study of the waste rock dump area is required to identify high hydraulic conductivity zones that may allow movement of groundwater to neighbouring, unimpacted aquifers.			

Changed groundwater flow in the Nam Pangyun catchment around the Wallah waste rock dump due to increased recharge at the Wallah waste rock dump and subsequent changes to the landscape is considered to be of **moderate significance** for the saprolite aquifer, based on the **low magnitude** of impact and **high sensitivity** of the feature (Table 6.34).

Table 6.34 Residual impact significance summary - changed groundwater flow in the saprolite aquifer in the Nam Pangyun catchment due to increased recharge at the Wallah waste rock dump

Value	**Sensitivity of value**			
Nam Pangyun – saprolite aquifer	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Currently groundwater from the saprolite aquifer has beneficial uses as a potable water supply and supports aquatic ecosystems, and is of high importance.	**Low** Low groundwater residence times are likely to positively influence recovery provided the impact source is removed.	**Low** Intrinsic properties of the groundwater system are very susceptible to change (such as land clearing and excavation). The overall function of the groundwater system would be permanently altered.	**High**
Impact	**Magnitude of impact**			
Changed groundwater flow in the saprolite aquifer in the Nam Pangyun catchment due to increased recharge at the Wallah waste rock dump	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Impact covers the extent of the waste rock dump within the Wallah Valley	**Low** Minor mounding is expected towards the base of the waste rock dump that may cause locally altered groundwater flow direction in the saprolite and potentially the fractured rock aquifer	**Very high** Changes to flow caused by mounding will last for longer than 15 years	**Low**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High In the absence of a detailed geotechnical and hydrogeological study of the Wallah waste rock dump area and modelling of changes to groundwater flows due to mounding (which are highly complex processes) the uncertainty is high in terms of impact severity and spatial extent. All the impact scenarios and pathways due to mounding cannot be accurately predicted. The assessment is approached qualitatively and with high uncertainty about the magnitude of impact. A detailed geotechnical and hydrogeological study of the waste rock dump area is required to identify high hydraulic conductivity zones that may allow movement of groundwater to neighbouring, unimpacted aquifers.			

Open pit

During mining, WMM will largely control groundwater flows in the area of the open pit, with inflows captured and passed through sediment dams before being released to the Nam Pangyun. At the same time, the Tiger Tunnel will continue to capture and discharge groundwater to the Nam Pangyun at Tiger Camp.

At closure, the Tiger Tunnel, underground mine adits and possibly other tunnels (if required) will be plugged to allow groundwater to fill the open pit (see Chapter 4, Table 4.39). Filling of the open pit will be expedited over 5 years by diverting surface water from the Nam Pangyun. After closure, groundwater levels will recover, rising close to the ground surface as the pit lake fills. While not strictly ‘mounding’, groundwater levels will be permanently raised 100 to 200 m higher than pre-mining levels. Although no predictive modelling has been completed, it is assumed that raised groundwater levels could occur over most of the mid-catchment area as the underground mine is flooded. This remains an area of uncertainty (see Section 6.3.6).

Existing groundwater flow directions around Bawdwin is expected to be towards the dewatered underground mine. Raised groundwater levels at are likely to lead to a more natural flow path, where groundwater flows from areas of high topography towards the surface water features in the lower valley. Groundwater-surface water interactions around Bawdwin will probably change, with raised groundwater levels contributing baseflow to the Nam Pangyun post-closure. Groundwater-surface water interaction around the pit lake may be more dynamic depending on the water balance inputs from rainfall, evaporation and stream flow from the upper catchment.

Overall, changes in groundwater flow in the fractured rock aquifer in the Nam Pangyun catchment due to inundation of the open pit at closure will be of **low to moderate significance**, based on the **medium magnitude** of impact and the **low to medium sensitivity** of the feature (Table 6.35).

Table 6.35 Residual impact significance summary - changed groundwater flow in the fractured rock aquifer in the Nam Pangyun catchment due to inundation of the open pit at closure

Value	**Sensitivity of value**			
Nam Pangyun – fractured rock aquifer	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Attributes of the groundwater system (quality, occurrence, volume, extraction potential) are not suitable for beneficial uses due to natural mineralisation and historical mineral processing activity. Locally, the groundwater system does not support ecosystems. Further downstream the groundwater system supports ecosystems of low ecological importance and highly altered from their natural state.	**Medium** Recovery is likely to be slow or only partially successful.	**Medium** Intrinsic properties of the groundwater system are moderately resistant to change. The overall function of the groundwater system could be moderately altered.	**Low to medium**
Impact	**Magnitude of impact**			
Changed groundwater flow in the fractured rock aquifer in the Nam Pangyun catchment due to inundation of the open pit at closure.	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium It is assumed that raised groundwater levels could occur over most of the mid-catchment area as the underground mine is flooded.	**Low** While new springs may be reactivated higher in the landscape as a result of raised groundwater levels, other potentially adverse impacts (e.g., ground instability) are not anticipated.	**Very high** Raising of groundwater levels will be permanent	**Medium**
	Residual impact significance			**Low to moderate**
	Assessment of uncertainty			
	High In the absence of predictive groundwater flow modelling after closure, it is assumed that raised groundwater levels could occur over most of the mid-catchment area as the underground mine is flooded.			

Overall, changes in groundwater flow in the saprolite aquifer in the Nam Pangyun catchment due to inundation of the open pit at closure will be of **moderate significance**, based on the **medium magnitude** of impact and the **medium sensitivity of** the feature (Table 6.36).

Table 6.36 Residual impact significance summary - changed groundwater flow in the saprolite aquifer in the Nam Pangyun catchment due to inundation of the open pit at closure.

Value	**Sensitivity of value**			
	Importance	***Vulnerability***	***Resilience***	***Sensitivity***

Nam Pangyun – saprolite aquifer	**High** Currently groundwater from the saprolite aquifer has beneficial uses as a potable water supply and supports aquatic ecosystems, and is of high importance.	**Low** Low groundwater residence times are likely to positively influence recovery provided the impact source is removed.	**Low** Intrinsic properties of the groundwater system are very susceptible to change (such as land clearing and excavation). The overall function of the groundwater system would be permanently altered.	**Medium**
Impact	**Magnitude of impact**			
Changed groundwater flow in the saprolite aquifer in the Nam Pangyun catchment due to inundation of the open pit at closure.	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium It is assumed that raised groundwater levels could occur over most of the mid-catchment area as the underground mine is flooded.	**Low** While new springs may be reactivated higher in the landscape as a result of raised groundwater levels, other potentially adverse impacts associated with mounding, such as ground instability, waterlogging and erosion are not anticipated.	**Very high** Raising of groundwater levels will be permanent	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High In the absence of predictive groundwater flow modelling after closure, it is assumed that raised groundwater levels could occur over most of the mid-catchment area as the underground mine is flooded.			

Reduced groundwater quality

Notwithstanding implementation of management measures outlined in Section 6.3.3, contamination of groundwater is predicted to occur. Residual impacts are assessed for two pathways: leaching from the TSFs and Wallah waste rock dump during operations and after closure, and leaching from the pit after closure. These are assessed below.

Leaching from TSFs and waste rock dump

The TSFs will store 24 Mt of tailings with high enrichment of metals including arsenic, copper, lead, mercury, silver and zinc. The TSFs will also store high concentrations of sulphide minerals and sulphate, which is a product of oxidation of those minerals. The TSF C will store up to 12.4 Mt of PAF waste rock containing high concentrations of metals including arsenic, antimony, lead, selenium and silver. Over the life of the project 156.3 Mt of waste rock, containing high metals content, will be produced. Most waste rock will be stored in a single waste dump within the Wallah Gorge.

Distilled water extracts performed on the tailings and waste rock showed that water from these mine wastes is of poor quality with numerous metals being elevated above drinking water standards and ambient aquatic ecosystem protection criteria (Knight Piésold, 2020).

Process wastewater will also be stored in the TSFs, in the form of entrained water within the tailings mass and supernatant water (tailings pool). In addition to elevated total and dissolved metals and sulphate, the TSF supernatant water and its leachate are expected to contain residual cyanide from processing wastewater. The concentration of weak acid dissociable (WAD) (the bioavailable portion) cyanide in the tailings stream is expected to be low (i.e., below baseline ranges in ambient waters in Nam Pangyun upper catchment and below Myanmar Emission Guidelines for Mining) for most of the time. However, the concentration may potentially be elevated (i.e., above the Myanmar Emission Guideline for Mining and above the concentrations in ambient waters in the

Nam Pangyun upper catchment) during periods where sodium cyanide is used in processing to improve mineral selectivity. Knight Piésold (2020) predicted the maximum free cyanide concentration of tailings supernatant to be 0.14 mg/L, which is above the Myanmar Emission Guideline for Mining standard of 0.1 mg/L. Further assessment is required to predict the concentrations of total cyanide, free cyanide and WAD cyanide in the TSF supernatant water under a range of scenarios and to predict cyanide levels of fugitive seepage from the TSF.

Seepage from the TSFs is expected to steadily increase during the first five years of operations with monthly seepage rates peaking in Year 10 and Year 11 with approximately 40,000 m^3 (54.8 m m^3/h) of seepage predicted. TSF seepage estimates over the life of operations are presented in Figure 4.28 in Section 4.8.5.

The TSF designs include an underdrainage system that will collect seepage. Although, geochemical modelling of the seepage water quality has not been conducted, the seepage is expected to be of poor water quality, probably containing concentrations of metals, sulphate and potentially cyanide above Myanmar drinking water standards and/or above ANZ ambient aquatic ecosystem protection guidelines. Further assessment is needed to predict the contaminant concentrations in the leachate compared to the Myanmar mining effluent standards.

The underdrainage system will facilitate a reduction in pressure at the engineered TSF embankments and will reduce the rate of seepage into the underlying groundwater. However, it is expected that some seepage to the surrounding groundwater will still occur. As a result, it is expected that the water quality of the saprolite and fractured rock aquifers will be adversely impacted in some areas.

Baseline monitoring of two saprolite groundwater monitoring sites, SWSP04 and SWSP06, between 2017 and 2019 showed evidence of some existing elevated levels of metals and sulphate in the aquifer under the proposed TSF location (see Section 5.2). Site SWSP04 had maximum dissolved concentrations of aluminium, cadmium, copper and zinc above the ANZ ambient water quality guidelines and maximum sulphate concentration above the Myanmar drinking water standards. Site SWSP06 had maximum and average concentrations of aluminium, cobalt, copper, lead, nickel and zinc above the ANZ ambient water quality guidelines and maximum concentrations of aluminium, copper, iron, lead, manganese and nickel above the Myanmar drinking water standards. Site SWSP07, (although only sampled once) showed only lead to be above the Myanmar drinking water standards with all other metals below the ANZ ambient water quality guidelines and Myanmar drinking water standards. Cyanide was not detected in any sampling from these four sites.

The baseline results indicate that existing elevated contaminant concentrations are more prevalent in the saprolite aquifer closer to the pit (site SWSP06), with groundwater quality being higher at the two sites further from the pit (SWSP07 and SWSP04). Notwithstanding, the existing groundwater quality in the saprolite beneath the proposed TSF location is relatively good compared to the groundwater quality of the fractured rock aquifer in the pit area (see subsection below). There is no available water quality data from the fractured rock aquifer in the TSF area; however, it is assumed that its water quality is relatively good being upstream of the groundwater flow towards the pit area and being locally recharged by the overlying relatively good-water-quality saprolite aquifer.

Seepage from the TSFs into the underlying saprolite and fractured rock aquifers is expected to increase concentrations of dissolved and total metals, sulphate and cyanide in those aquifers above background concentrations. Modelling will be needed to confirm whether seepage may also potentially raise the concentrations of total metals, sulphate and cyanide within the aquifers above Myanmar drinking water standards and ANZ ambient water quality guidelines for ecosystem protection.

For the purposes of this assessment it is assumed that at least some metals and sulphate will increase to above the drinking water standards and the ANZ guidelines in at least part of the aquifer system. As outlined above, upon closure, the TSFs will be capped with a low permeability layer to reduce infiltration and long-term seepage. However, seepage will still continue after closure, albeit at a slower rate.

The contamination of the fractured rock aquifer in the Nam Pangyun catchment due to leaching of contaminants from the TSFs will be of **moderate to high significance**, based on the **high magnitude** of impact and the **low to medium sensitivity** of the feature (Table 6.37). This assessment has a high degree of uncertainty particularly in relation to impact severity and spatial extent (i.e., degree of change of water quality and how far this extends throughout aquifers) since geochemical modelling of the seepage water quality has not been conducted and the rate of seepage that is not collected in the TSF under drainage system has not been determined.

Table 6.37 Residual impact significance summary - contamination of groundwater in the fractured rock aquifer in the Nam Pangyun catchment due to seepage from the TSFs

Value	**Sensitivity of value**			
Nam Pangyun – fractured rock aquifer	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Attributes of the groundwater system (quality, occurrence, volume, extraction potential) are not suitable for beneficial uses due to natural mineralisation and historical mineral processing activity. Locally, the groundwater system does not support ecosystems. Further downstream the groundwater system supports ecosystems of low ecological importance, and/or groundwater dependent surface water features which are characterised as highly altered from their natural state.	**Medium** Recovery is likely to be slow or only partially successful.	**Medium** Intrinsic properties of the groundwater system are moderately resistant to change. The overall function of the groundwater system could be moderately altered.	**Low to medium**
Impact	**Magnitude of impact**			
Contamination of groundwater in the fractured rock aquifer in the Nam Pangyun catchment due to seepage from the TSFs	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Impact will affect the portions of the Nam Pangyun catchment where the TSFs are constructed and once it reaches aquifer may extend downgradient albeit limited by suspected low hydraulic conductivity at depth.	**High** Relatively good quality groundwater may be affected by contaminants and reduce the suitability and existing use of the groundwater to support aquatic ecosystems and beneficial uses.	**Very high** The reduction in water quality in fractured rock aquifers would probably be a long term impact (during operations and for many years after project closure)	**High**
	Residual impact significance			**Moderate to High**
	Assessment of uncertainty			
	High Geochemical modelling of the seepage water quality has not been conducted. It has been assumed that at least some metals, sulphate and potentially cyanide will increase to above the drinking water standards and the ANZ guidelines in at least part of the aquifer system. There is particularly high uncertainty in relation to impact severity and spatial extent (i.e., degree of change of water quality and how far this extends throughout aquifers). Rate of seepage that is not collected in the TSF under drainage system has not been determined. Baseline monitoring of groundwater from the fractured rock aquifer in the vicinity of the TSF has not been conducted. Assessment qualitatively assumes relatively good water quality in this aquifer given its distance upstream of historic mining.			

The contamination of the saprolite aquifer in the Nam Pangyun catchment due to leaching of contaminants from the TSFs will be of **major significance**, based on the **high magnitude** of impact and the **high sensitivity** of the feature (Table 6.38). This assessment has a high degree of uncertainty particularly in relation to impact severity and spatial extent (i.e., degree of change of water quality and how far this extends throughout aquifers) since geochemical modelling of the seepage water quality has not been conducted and the rate of seepage that is not collected in the TSF under drainage system has not been determined. However, it is assumed that at least some metals, sulphate and potentially cyanide will increase to above the drinking water standards and the ANZ guidelines in at least part of the aquifer system.

Table 6.38 Residual impact significance summary - contamination of groundwater in the saprolite aquifer in the Nam Pangyun catchment due to seepage from the TSFs

Value	**Sensitivity of value**			
Nam Pangyun – saprolite aquifer	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Currently groundwater from the saprolite aquifer has beneficial uses as a potable water supply and supports aquatic ecosystems, and is of high importance.	**Low** Low groundwater residence times are likely to positively influence recovery provided the impact source is removed.	**Low** Intrinsic properties of the groundwater system are very susceptible to change (such as land clearing and excavation). The overall function of the groundwater system would be permanently altered.	**High**
Impact	**Magnitude of impact**			
Contamination of groundwater in the saprolite aquifer in the Nam Pangyun catchment due to seepage from the TSFs	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Impact will affect the portions of the Nam Pangyun catchment where the TSFs are constructed and once it reaches aquifer may extend downgradient albeit limited by suspected low hydraulic conductivity at depth.	**High** Relatively good quality groundwater (and associated springs and surface water features) may be affected by contaminants and materially reduce the suitability and existing use of the groundwater to support aquatic ecosystems and beneficial uses. Changes to groundwater quality and flow beyond the immediate TSF area are likely to be low in the first 32 months of operations while downstream communities at Bawdwin Lower village are still present.	**Very high** The reduction in water quality in the saprolite aquifers would probably be a long-term impact (during operations and for many years after project closure)	**High**
	Residual impact significance			**Major**
	Assessment of uncertainty			
	High Geochemical modelling of the seepage water quality has not been conducted. It has been assumed that at least some metals, sulphate and potentially cyanide will increase to above the drinking water standards and the ANZ guidelines in at least part of the aquifer system. There is particularly high uncertainty in relation to impact severity and spatial extent (i.e., degree of change of water quality and how far this extends throughout aquifers). Rate of seepage that is not collected in the TSF under drainage system has not been determined.			

The contamination of the springs in the Nam Pangyun catchment due to leaching of contaminants from the TSFs will be of **major significance**, based on the **high magnitude** of impact and the **high sensitivity** of the feature (Table 6.39). This assessment has a high degree of uncertainty particularly in relation to impact severity and spatial extent (i.e., degree of change of water quality and this impacts springs in the Nam Pangyun catchment) since geochemical modelling of the seepage water quality has not been conducted and the rate of seepage that is not collected in the TSF under drainage system has not been determined. However, it is assumed that at least some metals, sulphate and potentially cyanide will increase to above the drinking water standards and the ANZ guidelines in at least part of the aquifer system and springs.

Table 6.39 Residual impact significance summary - contamination of spring discharge in the Nam Pangyun catchment due to seepage from the TSFs

Value	**Sensitivity of value**			
Springs	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Intrinsic attributes support the use of the groundwater for potable supply, agricultural use, and food production for current Bawdwin villages and Tiger Camp. Currently the springs provide base flow to the Nam Pangyun as well as support the beneficial uses of groundwater and are of high importance, however, once Bawdwin and Tiger Camp villages have been resettled their importance will be reduced to medium.	**Medium** Low groundwater residence times are likely to positively influence recovery provided the impact source is removed, however as springs take a longer time to disperse contaminants than rivers, they are more vulnerable to change. Springs represent a limited number of surface expressions of the saprolite aquifer and are therefore more vulnerable to permanent change and significant degradation.	**Low** Intrinsic properties of the springs are very susceptible to change (such as land clearing and excavation), however will maintain high connectivity to the saprolite aquifer. The overall function of the springs would be permanently altered.	**High**
Impact	**Magnitude of impact**			
Contamination of spring discharge in the Nam Pangyun catchment due to seepage from the TSFs	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Impact will affect the portions of the Nam Pangyun catchment where the TSFs are constructed and once it reaches aquifer may extend downgradient albeit limited by suspected low hydraulic conductivity at depth.	**High** Relatively good quality groundwater (and associated springs and surface water features) may be affected by contaminants and materially reduce the suitability and existing use of the groundwater to support aquatic ecosystems and beneficial uses (such as drinking water).	**Very high** The reduction in water quality in the saprolite and fractured rock aquifers would probably be a long-term impact (during operations and for many years after project closure)	**High**
	Residual impact significance			**Major**
	Assessment of uncertainty			
	High Geochemical modelling of the seepage water quality has not been conducted. It has been assumed that at least some metals, sulphate and potentially cyanide will increase to above the drinking water standards and the ANZ guidelines in at least part of the aquifer system. There is particularly high uncertainty in relation to impact severity and spatial extent (i.e., degree of change of water quality and how far this extends throughout aquifers). Rate of seepage that is not collected in the TSF under drainage system has not been determined.			

Overall, the impact of contamination of the fractured rock aquifer in the Nam La catchment due to leaching of contaminants from the TSFs will be of **high significance**, based on the **high magnitude** of impact and the **medium sensitivity** of the feature (Table 6.40). This assessment has a high degree of uncertainty particularly in relation to impact severity and spatial extent (i.e., degree of change of water quality and how far this extends throughout aquifers) since geochemical modelling of the seepage water quality has not been conducted and the rate of seepage that is not collected in the TSF under drainage system has not been determined. However, it is assumed that at least some metals, sulphate and potentially cyanide will increase to above the drinking water standards and the ANZ guidelines in at least part of the aquifer system.

Table 6.40 Residual impact significance summary - contamination of groundwater in the fractured rock aquifer in the Nam La catchment due to seepage from the TSFs

Value	**Sensitivity of value**			
Nam La – fractured rock aquifer	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium Attributes of the groundwater system (quality, occurrence, volume) are suitable for beneficial uses however the reduced extraction potential has resulted in this resource not being exploited for a consumptive beneficial use. The groundwater system supports aquatic and some terrestrial ecosystems of ecological importance. Catchments outside of developed urban centre of Namtu township are largely unaltered from their natural state and will have some dependence on groundwater discharge during dry months.	**Medium** Recovery is likely to be slow or only partially successful.	**Medium** Intrinsic properties of the groundwater system are slightly resistant to change. However, the overall function of the groundwater system remains relatively unchanged.	**Medium**
Impact	**Magnitude of impact**			
Contamination of groundwater in the fractured rock aquifer in the Nam La catchment due to seepage from the TSFs	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	High The impact may extend from Nam Pangyun to the Nam La catchment, affecting previously unimpacted aquifers, springs and surface waters.	**High** Relatively good quality groundwater (and associated springs and surface water features) may be affected by contaminants and materially reduce the suitability and existing use of the groundwater to support aquatic ecosystems and beneficial uses.	**Very high** The reduction in water quality in the saprolite and fractured rock aquifers would probably be a long-term impact (during operations and for many years after project closure)	**High**
	Residual impact significance			**High**
	Assessment of uncertainty			
	High Geochemical modelling of the seepage water quality has not been conducted. It has been assumed that at least some metals, sulphate and potentially cyanide will increase to above the drinking water standards and the ANZ guidelines in at least part of the aquifer system. There is particularly high uncertainty in relation to impact severity and spatial extent (i.e., degree of change of water quality and how far this extends throughout aquifers). Rate of seepage that is not collected in the TSF under drainage system has not been determined. Baseline monitoring of groundwater from the fractured rock aquifer in the Nam La catchment has not been conducted. Assessment qualitatively assumes relatively good water quality in this aquifer given its distance from historic mining.			

The impact of contamination of the saprolite aquifer in the Nam La catchment due to leaching of contaminants from the TSFs will be of **major significance** for the saprolite aquifer, based on the **high magnitude** and the **high sensitivity** of the feature (Table 6.41). This assessment has a high degree of uncertainty, particularly in relation to impact severity and spatial extent (i.e., degree of change of water quality and how far this extends throughout aquifers), since geochemical modelling of the seepage water quality has not been conducted and the rate of seepage that is not collected in the TSF under drainage system has not been determined. However, it is assumed that at least some metals, sulphate and potentially cyanide will increase to above the drinking water standards and the ANZ guidelines in at least part of the aquifer system.

Table 6.41 Residual impact significance summary - contamination of groundwater in the saprolite aquifer in the Nam La catchment due to seepage from the TSFs

Value	**Sensitivity of value**			
Nam La – saprolite aquifer	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Intrinsic attributes support the use of the groundwater for potable supply (for Namtu township), agricultural use, and food production. Attributes of the groundwater system are of moderate to high ecological importance, supporting terrestrial and aquatic ecosystems that are characterised as largely undisturbed.	**Low** Low groundwater residence times are likely to positively influence recovery provided the impact source is removed.	**Low** Intrinsic properties of the groundwater system are very susceptible to change. The overall function of the groundwater system would be permanently altered.	**High**
Impact	**Magnitude of impact**			
Contamination of groundwater in the saprolite aquifer in the Nam La catchment due to seepage from the TSFs	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	High The impact may extend from Nam Pangyun to the Nam La catchment, affecting previously unimpacted aquifers, springs and surface waters.	**High** Relatively good quality groundwater (and associated springs and surface water features) may be affected by contaminants and materially reduce the suitability and existing use of the groundwater to support aquatic ecosystems and beneficial uses (such as drinking water).	**Very high** The reduction in water quality in the saprolite and fractured rock aquifers would probably be a long-term impact (during operations and for many years after project closure)	**High**
	Residual impact significance			**Major**
	Assessment of uncertainty			
	High Geochemical modelling of the seepage water quality has not been conducted. It has been assumed that at least some metals, sulphate and potentially cyanide will increase to above the drinking water standards and the ANZ guidelines in at least part of the aquifer system. There is particularly high uncertainty in relation to impact severity and spatial extent (i.e., degree of change of water quality and how far this extends throughout aquifers). Rate of seepage that is not collected in the TSF under drainage system has not been determined. Baseline monitoring of groundwater from the saprolite aquifer in the Nam La catchment has not been conducted. Assessment qualitatively assumes relatively good water quality in this aquifer given its distance from historic mining.			

Poor quality leachate is also expected to seep from the Wallah waste rock dump, which will contain waste rock with high metals content. Seepage from the waste rock dump is predicted to vary from 175 to 897 m^3 per month, varying between wet and dry seasons; with seepage rates predicted to be consistent across each year of the project operations with 7,700 m^3 of seepage per annum. An underdrainage system will be implemented to collect seepage flows and discharge the seepage to the sediment dams downstream of the dump. During operations the seepage will be treated prior to its disposal from the sediment dams when the water quality is very poor during low rainfall periods. Seepage modelling shows that the underdrainage system is expected to maintain low phreatic levels within the waste rock dump, however some waste rock dump seepage into the underlying groundwater is expected to occur during operations and after closure. This is expected to result in increased dissolved and total metals concentrations in the underlying saprolite and possibly fractured rock aquifers that may mobilise beyond the engineered seepage control measures and discharge to surface water features downstream.

Baseline monitoring of saprolite groundwater at one site, SWSP01 (see Section 5.2) between 2018 and 2019 showed maximum iron, lead and manganese concentrations to be above the Myanmar drinking water standards and maximum concentrations of dissolved copper and zinc to be above ANZ ambient water quality guidelines. Average concentrations of all metals were below the drinking water standards and, with the exception of zinc, were all below the ANZ water quality guidelines. This indicates generally good water quality of the saprolite groundwater in the area of the proposed Wallah waste rock dump.

TSF C has been designed to store and encapsulate the PAF waste rock. The Wallah waste rock dump is expected to contain non-acid forming (NAF) material, but there is a possibility that some PAF material may be placed within NAF material in the dump. Based on the small expected volumes of PAF waste rock and selective management of PAF material, it is not expected that generation of acid mine drainage (and consequent increased levels of dissolved metal concentrations) from the waste rock dump will occur. Ongoing testing of waste material against geochemical criteria will be required to allow identification and segregation of PAF and NAF material. Although AMD should be prevented from occurring within the waste rock dump, the NAF material is still expected to leach metals under neutral pH conditions.

Geochemical modelling and seepage modelling of the waste rock dump leachate and seepage has not been undertaken to date, therefore the changes to groundwater quality and the spatial extent of these changes have not been quantified. However, changes to groundwater quality have been assessed based on the understanding of baseline groundwater conditions, and expected contaminants in the TSFs and Wallah waste rock dump.

The contamination the fractured rock aquifer in the Nam Pangyun catchment due to leaching of contaminants from the Wallah waste rock dump will be of **moderate to high significance**, based on the **high magnitude** of impact and the **low to medium sensitivity** of the feature (Table 6.42). This assessment has a high degree of uncertainty because there has been no predictive geochemical modelling of the spatial extent of contaminant concentrations in receiving aquifers. However, it is assumed that at least some metals will increase to above the drinking water standards and the ANZ guidelines in at least part of the aquifer system.

Table 6.42 Residual impact significance summary - contamination of groundwater in the fractured rock aquifer in the Nam Pangyun catchment due to seepage from the waste rock dump

Value	**Sensitivity of value**			
Nam Pangyun – fractured rock aquifer	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Attributes of the groundwater system (quality, occurrence, volume, extraction potential) are not suitable for beneficial uses due to natural mineralisation and historical mineral processing activity. Locally, the groundwater system does not support ecosystems. Further downstream the groundwater system supports ecosystems of low ecological importance and highly altered from their natural state.	**Medium** Recovery is likely to be slow or only partially successful.	**Medium** Intrinsic properties of the groundwater system are moderately resistant to change. The overall function of the groundwater system could be moderately altered.	**Low to medium**
Impact	**Magnitude of impact**			
Contamination of groundwater in the fractured rock aquifer in the Nam Pangyun catchment due to seepage from the waste rock dump	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Impact is expected to affect a localised area within Wallah Valley. Groundwater in the fractured bedrock aquifer is expected to follow the local catchment topography towards the valley floor, discharging to the Wallah Valley creek. Groundwater flow paths (transporting seepage) are expected to be relatively short and contained within the valley.	**High** The impact of seepage from the waste rock dump on the background groundwater quality will be high given that it will contain high concentrations of metals (compared to discharge criteria), sulfate and potentially low pH. Existing groundwater is probably relatively good in this area given its location away from historic mining activity.	**Very high** Impact will be long term to permanent, lasting beyond mine closure	**High**
	Residual impact significance			**Moderate to high**
	Assessment of uncertainty			
	High Geochemical modelling of the seepage water quality has not been conducted. It has been assumed that at least some metals will increase to above the drinking water standards and the ANZ guidelines in at least part of the aquifer system. There is particularly high uncertainty in relation to impact severity and spatial extent (i.e., degree of change of water quality and how far this extends throughout aquifers). Rate of seepage that is not collected in the waste rock dump under drainage system has not been determined. Baseline monitoring of groundwater from the fractured rock aquifer in the vicinity of the waste rock dump site has not been conducted. Assessment qualitatively assumes relatively good water quality in this aquifer given its distance from historic mining.			

The contamination of the saprolite aquifer in the Nam Pangyun catchment due to leaching of contaminants from the Wallah waste rock dump will be of **major significance** based on the **high magnitude** of impact and the **high sensitivity** of the feature (Table 6.43). This assessment has a high degree of uncertainty because there has been no predictive geochemical modelling of the spatial extent of contaminant concentrations in receiving aquifers. However, it is assumed that at least some metals will increase to above the drinking water standards and the ANZ guidelines in at least part of the aquifer system.

Table 6.43 Residual impact significance summary - contamination of groundwater in the saprolite aquifer in the Nam Pangyun catchment due to seepage from the waste rock dump

Value	**Sensitivity of value**			
Nam Pangyun – saprolite aquifer	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Currently groundwater from the saprolite aquifer has beneficial uses as a potable water supply and supports aquatic ecosystems, and is of high importance.	**Low** Low groundwater residence times are likely to positively influence recovery provided the impact source is removed.	**Low** Intrinsic properties of the groundwater system are very susceptible to change (such as land clearing and excavation). The overall function of the groundwater system would be permanently altered.	**High**
Impact	**Magnitude of impact**			
Contamination of groundwater in the saprolite aquifer in the Nam Pangyun catchment due to seepage from the waste rock dump	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Impact is expected to affect a localised area within Wallah Valley. Groundwater in the saprolite aquifer is expected to follow the local catchment topography towards the valley floor, discharging to the Wallah Valley creek. Groundwater flow paths (transporting seepage) are expected to be relatively short and contained within the valley.	**High** The impact of seepage from the waste rock dump on the background groundwater quality will be high given that it will contain high concentrations of metals (compared to discharge criteria), sulfate and potentially low pH.	**Very high** Impact will be long term to permanent, lasting beyond mine closure	**High**
	Residual impact significance			**Major**
	Assessment of uncertainty			
	High Geochemical modelling of the seepage water quality has not been conducted. It has been assumed that at least some metals will increase to above the drinking water standards and the ANZ guidelines in at least part of the aquifer system. There is particularly high uncertainty in relation to impact severity and spatial extent (i.e., degree of change of water quality and how far this extends throughout aquifers). Rate of seepage that is not collected in the waste rock dump under drainage system has not been determined. Baseline monitoring of groundwater from the fractured rock aquifer in the vicinity of the waste rock dump site has not been conducted. Assessment qualitatively assumes relatively good water quality in this aquifer given its distance from historic mining.			

Leaching from the pit after closure

After project closure, the pit will be filled with surface and groundwater inflows to form a permanent pit lake after about five years. The pit lake water will have elevated concentrations of total and dissolved metals due to mobilisation from the pit mineralogy and inputs from the captured TSF seepage and the metal-rich groundwater from the Tiger Tunnel. It is assumed that the pit will be filled with water rapidly enough to avoid potential formation of acid due to exposure of PAF material in the pit walls. Test work has indicated that the majority of

PAF waste rock comprises Bawdwin Tuff, which hosts the majority of the mineralisation (Knight Piésold, 2020). However, further investigation is required to assess the acid forming behaviour of the pit material during project closure.

Post-closure pit water quality modelling conducted by CSA (2020) predicted concentrations of six metals (based on the most likely potential contaminants of concern to the environment) in the final pit water. These results are shown in Table 6.44 along with the Myanmar mining effluent standards and drinking water standards for reference. As the results are for total metals, they are not compared to ANZ ambient water quality guidelines which are relevant to dissolved metals. The table also compares the final pit water quality to background baseline ranges from the saprolite aquifer (sites SWSP02 and SWSP05) and the fractured rock aquifer (sites GWTT01, GWTT02, GWTT03, GWTT04, GWTT05 and GWTT06) in and around the pit area. This provides only an indication of water quality in pit seepage because it does not account for changes in water quality due to interactions with existing contaminated groundwater in underground workings, and it does not account for leachate interaction with underlying mineralogy as it seeps from beneath the pit. Further, the pit water quality data only addresses some of the metals which are expected to be present in seepage to groundwater and the data does not include dissolved metals concentrations, which are of more concern to water quality changes due to their bioavailability.

Table 6.44 Predicted pit lake metals concentrations at closure

Parameter	Myanmar standards		Measured baseline ranges		Predicted pit concentrations	
	Mining effluent standards (mg/L)	Drinking water standards (mg/L)	Saprolite[a] (min-max, mg/L)	Fractured rock[b] (min-max, mg/L)	Final main pit, mg/L (CSA, 2020)	Final small pit, mg/L (CSA, 2020)
Arsenic	0.1	0.05	0 - 0.0021	0.0112 – 2.01	0.0016	0.0080
Cadmium	0.05	0.003	0 – 0.004	0.0031 – 0.619	0.0016	0.0072
Copper	0.3	2	0 – 0.006	0.002 – 0.632	0.1003	0.0682
Lead	0.2	0.01	0 – 0.057	0.038 – 3.82	0.1184	0.5019
Nickel	0.5	0.07	0 all samples	0.021 – 16.4	0.0334	0.0179
Zinc	0.5	N/A	0 – 0.062	0.284 - 583	0.2919	0.8753

[a] Data from sites SWSP02 and SWSP05 between 2018 and 2019
[b] Data from sites GWTT01, GWTT02, GWTT03, GWTT04, GWTT05 and GWTT06 between 2018 and 2019
Data presented is for total (unfiltered) metals
Data below detection levels are presented as zero

Table 6.44 shows that the predicted final pit concentrations of these metals in the main pit lake are all within the Myanmar mining effluent standards and drinking water standards, except lead which is predicted to exceed the drinking water standard. Concentrations of all metals in the final main pit lake are predicted to be within the baseline ranges measured for the fractured rock aquifer in the pit area. Water from the pit lake is unlikely to impact on the saprolite aquifer which is typically at higher elevations on the mid and upper slopes of the surrounding valleys, however, with the exception of copper and lead, all concentrations in the main pit lake are predicted to be within background range measured at the closest saprolite aquifer monitoring sites to the pit area.

Predicted concentrations in the final small pit show that all of these metals, except lead and zinc, will be below the Myanmar mining effluent standards and drinking water standards. All of the concentrations of these metals are predicted to be above the baseline ranges for the saprolite aquifer but below the ranges for the fractured rock aquifer. The saprolite aquifer is present on the mid and upper slopes of the valleys and is unlikely to be affected by any seepage from the pit after closure.

It is noted that the mine pit may intersect historical underground mine workings in later years, which will be plugged to allow a pit lake to be established upon closure. Depending on how this is undertaken, water in the filled pit could interact with poor quality water residing in the underground mine workings and result in pit water quality that is worse than modelled. The future mine closure plans and future revisions of geochemical modelling for the pit lake should consider and address this risk.

The assessment of groundwater quality change due to seepage from the pit is associated with a high degree of uncertainty because seepage through the underlying mineralogy, particularly after groundwater interactions with existing underground workings and zones of poor water quality, may have notably different (potentially poorer) water quality than that predicted for pit water outlined in Table 6.44. Predictive modelling of seepage quality has not been conducted to accurately predict contaminant concentrations in seepage from the pit. Given the seepage will be influenced by pit mineralogy and inputs from the captured TSF seepage and the metal-rich groundwater from the Tiger Tunnel, it is expected that the seepage will be of poor quality.

Surrounding groundwater levels are likely to recover to levels that will promote groundwater to discharge as baseflow to the Nam Pangyun, potentially delivering poor quality groundwater to the Nam Pangyun.

Overall, the contamination of the fractured rock aquifer in the Nam Pangyun catchment due to seepage from the pit after closure will be of **moderate significance**, based on the **medium magnitude** of impact and **low to medium sensitivity** of this value (Table 6.45). This assessment has a high degree of uncertainty as noted in preceding paragraphs.

Table 6.45 Residual impact significance summary - contamination of groundwater in the fractured rock aquifer in the Nam Pangyun catchment due to leaching from the pit after closure

Value	**Sensitivity of value**			
Nam Pangyun – fractured rock aquifer	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Attributes of the groundwater system (quality, occurrence, volume, extraction potential) are not suitable for beneficial uses due to natural mineralisation and historical mineral processing activity. Locally, the groundwater system does not support ecosystems. Further downstream the groundwater system supports ecosystems of low ecological importance, and/or groundwater dependent surface water features which are characterised as highly altered from their natural state.	**Medium** Recovery is likely to be slow or only partially successful.	**Medium** Intrinsic properties of the groundwater system are moderately resistant to change. The overall function of the groundwater system could be moderately altered.	**Low to medium**
Impact	**Magnitude of impact**			
Contamination of groundwater in the fractured rock aquifer in the Nam Pangyun catchment due to leaching from the pit after closure	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium While groundwater contaminant transport modelling has not been conducted the low hydraulic conductivity of the fractured rock aquifer will confine migration of groundwater. Groundwater is expected to report to the Nam Pangyun.	**Medium** Seepage from the pit is expected to be of poor quality. Changes to the groundwater quality from pit seepage are expected to be medium in the context of the existing high contamination in the Nam Pangyun catchment and low aquatic ecosystem value and limited associated beneficial uses of this section of catchment.	**Very high** It is likely that pit seepage would occur over a long period after closure, although modelling would be needed to confirm the duration	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High In the absence of quantitative modelling of groundwater quality, accurate predictions of groundwater quality changes cannot be made. However, given the long-running mining activity and existing contamination of the fractured rock aquifer (and the mid and downstream Nam Pangyun) it is not expected that the severity, magnitude and significance would be higher than medium.			

Detailed water quality modelling (including a broad suite of metals and potential for acid formation) of the post-closure phase is required to confirm this assessment. Also, modelling of post-closure water impacts is required to understand whether plugging of underground adits during pit lake development results in potential for reactivation of unknown springs between Bawdwin and Tiger Camp and discharge of contaminated water.

Waste disposal

Sewage waste will be collected and treated at one of two stand-alone activated sludge bioreactor (ASBR) sewage treatment plants (STPs). The STPs will discharge treated effluent to the Nam Pangyun and sludge waste will be buried. The burial of sludge waste has the potential to contaminate groundwater. The site for sewage sludge burial has not yet been selected, however will be located away from watercourses, and within the Nam Pangyun catchment. The sludge burial cell design will be appropriately lined and progressively capped to minimise infiltration and seepage of contaminants to groundwater.

The solid waste landfill (which will contain domestic waste, paper and cardboard packaging, plastic packaging, construction waste, used tyres and old equipment) will be a potential source of leachate that may contaminate the saprolite and underlying fractured rock aquifers. Contaminants of concern for landfill leachate typically include ammonia and other nutrients, alkalinity, total organic carbon, and dissolved metals. Microbiological contamination may also be expected. Depending on the types of waste received, a range of other organic compounds may also be present.

Contamination of the fractured rock aquifer in the Nam Pangyun catchment from waste disposal sites, when retained in the Nam Pangyun catchment, will be of **low to moderate significance**, based on the **low magnitude** of impact and the **low to medium sensitivity** of the feature (Table 6.46).

Table 6.46 Residual impact significance summary - contamination of groundwater in the fractured rock aquifer in the Nam Pangyun catchment due to waste disposal

Value	**Sensitivity of value**			
Nam Pangyun – fractured rock aquifer	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Attributes of the groundwater system (quality, occurrence, volume, extraction potential) are not suitable for beneficial uses due to natural mineralisation and historical mineral processing activity. Locally, the groundwater system does not support ecosystems. Further downstream the groundwater system supports ecosystems of low ecological importance, and/or groundwater dependent surface water features which are characterised as highly altered from their natural state.	**Medium** Recovery is likely to be slow or only partially successful.	**Medium** Intrinsic properties of the groundwater system are moderately resistant to change. The overall function of the groundwater system could be moderately altered.	**Low to medium**
Impact	**Magnitude of impact**			
Contamination of groundwater in the fractured rock aquifer in the Nam Pangyun catchment due to waste disposal	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Impact will be localised around the waste disposal sites if contamination occurs	**Low** Waste will be stored in engineered facilities that will be lined to collect seepage for subsequent treatment. Any seepage leaching through to groundwater is expected to be minor.	**Very high** Impact will be long term, with effects lasting after closure of the mine	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Low Although the site for sewage sludge burial has not yet been selected and contaminants of concern for landfills have been assumed based on typical contaminants in landfills, the landfill facilities will be lined and contamination managed by standard measures. There is low likelihood the residual impact significance would change after confirming these uncertainties.			

Contamination of the saprolite aquifer in the Nam Pangyun catchment from waste disposal sites, when retained in the Nam Pangyun catchment, will be of **moderate significance** for the saprolite aquifer, based on the **low magnitude** of impact and the **high sensitivity** of the feature (Table 6.47).

Table 6.47 Residual impact significance summary - contamination of groundwater in the saprolite aquifer in the Nam Pangyun catchment due to waste disposal

Value	**Sensitivity of value**			
Nam Pangyun – saprolite aquifer	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Currently groundwater from the saprolite aquifer has beneficial uses as a potable water supply and supports aquatic ecosystems, and is of high importance.	**Low** Low groundwater residence times are likely to positively influence recovery provided the impact source is removed.	**Low** Intrinsic properties of the groundwater system are very susceptible to change (such as land clearing and excavation). The overall function of the groundwater system would be permanently altered.	**High**
Impact	**Magnitude of impact**			
Contamination of groundwater in the saprolite aquifer in the Nam Pangyun catchment due to waste disposal	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Impact will be localised around the waste disposal sites if contamination occurs	**Low** Waste will be stored in engineered facilities that will be lined to collect seepage for subsequent treatment. Any seepage leaching through to groundwater is expected to be minor.	**Very high** Impact will be long term, with effects lasting after closure of the mine	**Low**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	Low Although the site for sewage sludge burial has not yet been selected and contaminants of concern for landfills have been assumed based on typical contaminants in landfills, the landfill facilities will be lined and contamination managed by standard measures. There is low likelihood the residual impact significance would change after confirming these uncertainties.			

Summary of residual impact assessment

Table 6.48 provides a summary of the residual impacts and their significance.

Table 6.48 Summary of assessment of residual impacts to groundwater

Impact	Value impacted and sensitivity (see Section 5.2.4)	Impact phase	Impact magnitude	Key management measures	Impact significance	Justification for impact significance	Uncertainty
Loss of capability to support aquatic ecosystems and beneficial uses due to direct loss of springs from placement of project facilities over springs	Springs • High sensitivity	Construction, operations, closure	High magnitude • Medium spatial extent • Medium severity • Very high duration	• Resettle Bawdwin and Tiger Camp communities that currently use groundwater fed water sources.	High	Permanent loss of six of the 16 known springs. Impact includes reduced surface water flows and potential impact to beneficial uses as water supply sources prior to resettlement of communities which use spring water. The springs provide flow to Nam Pangyun during dry conditions so direct loss of these springs may reduce downstream surface water flows in a localised area.	Medium • The timing of when each spring will be lost is not clear • The dependency of each spring resource for water supply is not clear for all springs.
Drawdown of the fractured rock aquifer and subsequent reduced baseflows to the Nam Pangyun due to mine dewatering	Nam Pangyun – Fractured rock aquifer • Low to medium sensitivity	Operations	Low magnitude • Low spatial extent • Very low severity • High duration	• Resettle Bawdwin and Tiger Camp communities that currently use groundwater fed water sources.	Low	Drawdown levels are low in the context of natural fluctuations and are unlikely to significantly influence baseflow contribution. Will recover due to increased recharge when the pit is inundated after closure.	Medium • Drawdown levels for the fracture rock aquifer have not been quantified
Loss of capability to support aquatic ecosystems and beneficial uses due to reduced spring flow caused by groundwater drawdown	Springs • High sensitivity	Operations	Low magnitude • Low spatial extent • Low severity • High duration	• Resettle Bawdwin and Tiger Camp communities that currently use groundwater fed water sources.	Moderate	Likely to materially impact one known spring (SWSP05) and potentially other unknown springs. Impacts limited due to resettlement of communities which use springs.	Low • There may be currently unknown springs impacted

Impact	**Value impacted and sensitivity (see Section 5.2.4)**	**Impact phase**	**Impact magnitude**	**Key management measures**	**Impact significance**	**Justification for impact significance**	**Uncertainty**
Changed groundwater flow in the saprolite and fractured rock aquifers around the TSFs due to hydraulic loading induced groundwater mounding	Nam Pangyun – fractured rock aquifer • Low to medium sensitivity	Operations and post-closure	Low magnitude • Low spatial extent • Low severity • Very high duration	• Line the embankment upstream batter, upstream and downstream structural zones of the TSFs with HDPE to reduce seepage to groundwater. • Revegetation and rehabilitation measures • Underdrainage, seepage and water management measures • Resettle Bawdwin and Tiger Camp communities that currently use groundwater fed water sources.	Low	Significant mounding expected under and around the TSFs which are located in the Nam Pangyun catchment. The impact would probably be permanent, but the extent and severity limited by the high topographic relief, suspected low hydraulic conductivity at depth and the drainage system.	High • Absence of a detailed geotechnical and hydrogeological study of the TSF areas • Absence of groundwater modelling • Impact scenarios and pathway due to mounding cannot be accurately predicted
	Nam Pangyun – saprolite aquifer • High sensitivity	Operations and post-closure	Low magnitude • Low spatial extent • Low severity • Very high duration		Moderate	Mounding expected under and immediately around the TSFs which are located in the Nam Pangyun catchment. The impact will extend post closure, but the extent and severity is limited by the high topographic relief, limited thickness of the saprolite and the drainage system.	High • Absence of a detailed geotechnical and hydrogeological study of the TSF areas • Absence of groundwater modelling • Impact scenarios and pathways due to mounding cannot be accurately predicted
	Nam La – Fractured rock aquifer • Medium sensitivity	Operations and post-closure	Low magnitude • Low spatial extent • Low severity • Very high duration		Low	TSF A is located south of the Nam La catchment and mounding around the TSF may cause groundwater to flow north into the catchment, but is unlikely to extend significant distances. Changes may extend post closure but may be controlled with implementation of management measures.	High • Absence of a detailed geotechnical and hydrogeological study of the TSF areas • Absence of groundwater modelling • Impact scenarios and pathway due to mounding cannot be

Impact	Value impacted and sensitivity (see Section 5.2.4)	Impact phase	Impact magnitude	Key management measures	Impact significance	Justification for impact significance	Uncertainty
Changed groundwater flow in the saprolite and fractured rock aquifers around the TSFs due to hydraulic loading induced groundwater mounding	Nam La – Saprolite aquifer • High sensitivity	Operations and post-closure	Low magnitude • Low spatial extent • Low severity • Very high duration	• Line the embankment upstream batter, upstream and downstream structural zones of the TSFs with HDPE to reduce seepage to groundwater. • Revegetation and rehabilitation measures • Underdrainage, seepage and water management measures • Resettle Bawdwin and Tiger Camp communities that currently use groundwater fed water sources.	Moderate	TSF A is located south of the Nam La catchment and mounding around the TSF may cause groundwater to flow north into the catchment, but is unlikely to extend significant distances. Changes may extend post closure but may be controlled with implementation of management measures.	accurately predicted
Changed groundwater flow in the saprolite and fractured rock aquifers due to increased recharge at the Wallah waste rock dump	Nam Pangyun – Fractured rock aquifer • Low to medium sensitivity	Operations, closure	Low magnitude • Low spatial extent • Low severity • Very high duration	• Revegetation and rehabilitation measures • Underdrainage and water seepage, collection and management measures	Low	Despite management measures, increased recharge may cause minor mounding and locally altered flow direction in the waste rock dump area within the Wallah Valley.	High • Absence of a detailed geotechnical and hydrogeological study of the Wallah waste rock dump area • Absence of modelling of changes to groundwater flows due to mounding • Impact scenarios and pathways due to mounding cannot be accurately predicted
	Nam Pangyun – Saprolite aquifer • High sensitivity	Operations, closure	Low magnitude • Low spatial extent • Low severity • Very high duration		Moderate		

Impact	Value impacted and sensitivity (see Section 5.2.4)	Impact phase	Impact magnitude	Key management measures	Impact significance	Justification for impact significance	Uncertainty
Changed groundwater flow in the saprolite and fractured rock aquifers in the Nam Pangyun catchment due to inundation of the open pit at closure.	Nam Pangyun – Fractured rock aquifer • Low to medium sensitivity	Closure	Medium magnitude • Medium spatial extent • Low severity • Very high duration	• Designing hydraulic plugs to seal historical underground mine workings that may be encountered during open pit mining. • Develop and implement mine closure plan	Low to moderate	Groundwater levels will be permanently raised 100 m to 200 m higher than pre-mining levels, which may cause changes in flow and groundwater-surface water interaction. Impacts are likely to be limited to the mid Nam Pangyun catchment. No communities will be living in this area at the time due to resettlement.	High • Absence of predictive groundwater flow modelling after closure
	Nam Pangyun – Saprolite aquifer • High sensitivity	Closure			Moderate		

Impact	Value impacted and sensitivity (see Section 5.2.4)	Impact phase	Impact magnitude	Key management measures	Impact significance	Justification for impact significance	Uncertainty
Contamination of groundwater in the saprolite and fractured rock aquifers due to seepage from the TSFs	Nam Pangyun – Fractured rock aquifer • Low to medium sensitivity	Operations, closure	High magnitude • Medium spatial extent • High severity • Very high duration	• Actively manage and control runoff and potential leachate of poor water quality. • Line the embankment upstream batter, upstream and downstream structural zones of the TSFs with HDPE to reduce seepage to groundwater. • Revegetation and rehabilitation measures • Water seepage, collection and management measures • Store potentially acid forming (PAF) material under water and under additional non-acid-generating waste (e.g., tailings) in TSF C to avoid oxidation and acid formation and AMD seepage to groundwater • Develop and implement a groundwater quality and level monitoring program (see Section 6.3.5 Monitoring) • Groundwater modelling • Actively manage and control runoff and seepage of poor water quality.	Moderate to high	Greater levels of seepage are likely to enter groundwater in the Nam Pangyun catchment due to the location of the TSFs. However there is an existing degree of contamination from existing and historical sources. Groundwater mounding may disperse groundwater (and contaminants) to new, potentially unimpacted areas, reducing the suitability and use of groundwater to support aquatic ecosystems and beneficial uses. Impact may continue for years after project closure.	High • Absence of geochemical modelling of seepage • Uncertainty surrounding severity and spatial extent (i.e., degree of change of water quality and how far this extends throughout aquifers). • Rate of seepage that is not collected in the TSF under drainage system has not been determined • Absence of baseline monitoring of groundwater in the fractured rock aquifer near the TSF
	Nam Pangyun – Saprolite aquifer • High sensitivity	Operations, closure	High magnitude • Medium spatial extent • High severity • Very high duration		Major		
	Nam Pangyun – Springs • High sensitivity	Operations, closure	High magnitude • Medium spatial extent • High severity • Very high duration		Major		
	Nam La – Fractured rock aquifer • Medium sensitivity	Operations, closure	High magnitude • High spatial extent • High severity • Very high duration		High	Contaminants may enter Nam La catchment due to changes in flow direction caused by the project. The degree of change in groundwater quality will be higher in the Nam La catchment due to the relatively	High • Absence of geochemical modelling of seepage • Uncertainty surrounding severity and spatial extent (i.e., degree of change of water quality

Impact	Value impacted and sensitivity (see Section 5.2.4)	Impact phase	Impact magnitude	Key management measures	Impact significance	Justification for impact significance	Uncertainty
	Nam La – Saprolite aquifer • High sensitivity	Operations, closure	High magnitude • High spatial extent • High severity • Very high duration	• Cap and progressively rehabilitate the waste rock dump upon closure to reduce infiltration and seepage. • Implement an underdrainage system to capture seepage from the waste rock dump and divert the captured seepage downstream for treatment (during operations) and discharge into a series of sediment dams prior to discharge into the Nam Pangyun	Major	good groundwater quality. Impact may continue for years after project closure and materially reduce the suitability and existing use of the groundwater to support aquatic ecosystems and beneficial uses.	and how far this will extend throughout aquifers). • Rate of seepage that will not be collected in the TSF under drainage system has not been determined • Absence of baseline monitoring of groundwater
Contamination of groundwater in the saprolite and fractured rock aquifers in the Nam Pangyun catchment due to seepage from the waste rock dump	Nam Pangyun – Fractured rock aquifer • Low to medium sensitivity	Operations, closure	High magnitude • Medium spatial extent • High severity • Very high duration		Moderate to high	Impact will affect a localised area within Wallah Valley where the existing groundwater quality is generally good. Impact may continue for years after project closure and result in high concentrations of metals, sulfate and potentially low pH. The contaminated groundwater is expected to report to surface water features down gradient.	High • Absence of geochemical modelling of seepage • Uncertainty surrounding severity and spatial extent (i.e., degree of change of water quality and how far this will extend throughout aquifers). • Rate of seepage that will not be collected in the WRD under drainage system has not been determined • Absence of baseline monitoring of groundwater in the fractured rock aquifer near the WRD
	Nam Pangyun – Saprolite aquifer • High sensitivity	Operations, closure	High magnitude • Medium spatial extent • High severity • Very high duration		Major		

Impact	**Value impacted and sensitivity (see Section 5.2.4)**	**Impact phase**	**Impact magnitude**	**Key management measures**	**Impact significance**	**Justification for impact significance**	**Uncertainty**
Contamination of groundwater in the fractured rock aquifer in the Nam Pangyun catchment due to leaching from the pit after closure	Nam Pangyun – Fractured rock aquifer • Low to medium sensitivity	Closure	Medium magnitude • Medium spatial extent • Medium severity • Very high duration	• Fill the open pit rapidly after closure using the diverted Nam Pangyun in order to minimise the potential for oxidation of in-pit PAF and subsequent acid formation. • Designing hydraulic plugs to seal historical underground mine workings that may be encountered during open pit mining. • Develop and implement mine closure plan	Moderate	Seepage from the pit is expected to be poor quality and have a moderate impact after closure in the context of existing contamination, low aquatic ecosystem value and limited beneficial uses. The low hydraulic conductivity of the aquifer around the pit is likely to limit the spatial extent. Modelling is required to confirm the extent, severity and duration of the impact.	High • Absence of quantitative modelling of groundwater quality
Contamination of groundwater in the Nam Pangyun due to waste disposal	Nam Pangyun – Fractured rock aquifer • Low to medium sensitivity	Construction, operations and closure	Low magnitude • Low spatial extent • Low severity • Very high duration	• Design and construct landfill cells in line with Myanmar regulatory requirements or, where absent, international guidance. Landfill cells should be lined and contain leachate and landfill gas management system.	Low	The size of waste disposal sites will be relatively small compared to the waste rock and tailing waste disposal sites and impacts will be localised to around the waste disposal sites. Landfills can provide ongoing source of groundwater contamination in the order of 50 years, however with the use of engineered facilities any seepage to groundwater is expected to be minor	Low • Sewage sludge burial site has not been selected • Contaminants of concern have been assumed based on typical contaminants in landfills • Low likelihood the residual impact significance would change once these uncertainties confirmed
	Nam Pangyun – Saprolite aquifer • High sensitivity	Construction, operations and closure	Low magnitude • Low spatial extent • Low severity • Very high duration		Moderate		

6.3.5 Monitoring

A project wide environmental and social management plan (ESMP) (Attachment 4) that will be implemented outline the management, monitoring, auditing and reporting processes and requirements for specific environmental aspects including groundwater during construction, operation and decommissioning of the project.

A groundwater monitoring program will be developed and implemented to monitor groundwater level and quality on an ongoing basis to confirm and inform models and predicted changes and allow early detection of contamination to aquifers. Groundwater quality will be analysed to ensure all groundwater discharge complies with relevant legislation and permits and to confirm modelling results. The project will monitor runoff, leachate and discharge sources to ensure the contaminants are below the Myanmar draft mining effluent standards and to allow early detection of contamination issues and instances of non-compliance.

The monitoring program will include:

- Waste rock dump: the installation of monitoring bores, including at least two pairs of groundwater monitoring bores installed to monitor groundwater downstream of the waste rock dump sediment dams.
- TSFs: the installation of monitoring bores down gradient of primary embankments and saddle dams and at locations where groundwater modelling indicates potential for groundwater migration to neighbouring catchments.
- Waste disposal sites: the installation of perimeter groundwater monitoring bores.
- Process plant: the installation of a network of groundwater monitoring bores within the plant area and on downgradient slopes (both Nam La and Nam Pangyun). Both shallow and deep monitoring bores should be considered based on local hydrogeological assessment.
- Open pit: the installation of perimeter groundwater monitoring bores.

A combination of the existing boreholes and new boreholes will be used to monitor groundwater levels during operations to detect levels of drawdown and changes to groundwater flow. Monitoring of groundwater levels and flows needs to capture and address potential impacts from groundwater mounding and identify whether the project is causing contaminants to be transported through the groundwater system, including to neighbouring catchments. The groundwater monitoring programme should monitor for the formation of new springs, changes to topography and dispersal of leached contaminants from the TSFs.

6.3.6 Uncertainties and further work

This section outlines the key uncertainties associated with the impact assessment and outlines recommended further work to address uncertainties.

The uncertainties and further work required to address these uncertainties is outlined in Table 6.49.

Table 6.49 Uncertainties and further work in respect of groundwater impacts

Uncertainty	Further work	Purpose	Assumption
Groundwater level data has not been collected for the saprolite aquifer. The full extent and thickness of the saprolite aquifer is not well defined.	Conduct hydrogeological investigations (including drilling and monitoring well installation) to determine the presence, thickness and aquifer conditions of the saprolite aquifer. Hydrogeological investigations should focus on areas where the saprolite aquifer may provide a preferential pathway for contaminant transport (e.g. surrounding TSFs, WRD, processing plant).	To better understand the impact pathways to the saprolite aquifer.	Assumptions of baseline groundwater levels and flow conditions have been made. The full extent and thickness of the saprolite aquifer has been inferred in many parts of the study area based on a general description of weathering and observations of exposed bedrock during site inspections as well as review of geology.
High uncertainty regarding the predicted extent of drawdown due to project dewatering. Limited hydraulic testing was undertaken in proximity to the pit. There is the potential for drawdown to extend greater distances than predicted where higher hydraulic conductivity exists away from the pit, although this is an unlikely scenario.	Conduct updated groundwater modelling to assess the impacts of the TSFs on groundwater, and predict levels of drawdown	To better understand the predicted levels of groundwater drawdown due to the project.	Impacts of groundwater drawdown have been assessed using professional judgement to predict spatial extent, severity and duration of impact.
The degree of spring flow reduction as a result of groundwater drawdown is a noted uncertainty.	Conduct revised modelling when additional hydraulic testing (away from the pit) and results of the hydrogeological investigation of the saprolite aquifer are available	To better understand the predicted reduction in spring flow due to the project.	It has been conservatively assumed that drawdown of greater than 10 cm could result in a notable reduction in spring flow. The recommended further hydrogeological assessments work will support a refined assessment of potential impacts

Uncertainty	Further work	Purpose	Assumption
The geographic extent of groundwater mounding around the TSFs and waste rock dump, and the extent of associated changes in groundwater flows is uncertain as groundwater modelling has not been completed.	Conduct groundwater modelling during detailed design. This will include predictive modelling of possible changes in groundwater flow rate and direction. The modelling will assess whether neighbouring catchments will be affected by changes in groundwater levels or quality and assess whether subsequent formation of unstable ground, erosion and waterlogging could occur	To better understand mounding and seepage transport around the TSFs and waste rock dump. To identify likely contaminant transport pathways, including the potential for contaminated groundwater discharges to watercourses. To determine the potential, albeit with a low likelihood, for groundwater to flow towards the undisturbed Nam Kong catchment to the west from TSF-A via fractured zones in bedrock	The impact assessment has made assumptions that mounding could cause groundwater flow and seepage to migrate to new catchments, although the specific pathways were not predicted.
The predicted quality of seepage from the waste rock dump, TSFs and pit during operations and after closure is currently uncertain, but is likely to be of poor quality requiring careful consideration of post closure management options.	Conduct kinetic testing on the waste rock to better understand potential for acid formation under a variety of wet and dry conditions. Conduct geochemical modelling to predict concentrations of contaminants in seepage from the waste rock dump, TSFs and open pit.	To quantify changes to groundwater quality and allow understanding of how contaminant concentrations in seepage compare to Myanmar mining effluent guidelines.	The impact assessment has assumed that the samples assessed in the DFS Tailings and Waste Rock Management DFS Design Report are representative of material to be stored in the TSF and waste rock dump. The results of the testwork were reviewed in order to inform assessment of expected contaminants in seepage; although, quantitative predictions of their concentrations are not possible without geochemical modelling. The impact assessment assumed that rapid filling of the pit lake would minimise acid formation. Acid formation was not assessed. Groundwater quality impacts due to seepage have been assessed using professional judgement to predict spatial extent, severity and duration of impact.

Uncertainty	Further work	Purpose	Assumption
Behaviour of groundwater flow and changes to groundwater quality after closure of the pit.	Model water quality, including pH, TDS, total metals, dissolved metals and the potential for acid formation from seepage from the pit and underground mine workings into the groundwater system after closure. Water quality modelling should consider the implications of plugging Tiger Tunnel on pit water quality during filling and long term. Conduct numerical groundwater modelling to assess the proposed closure scenario and predict post-closure groundwater flow directions and contaminant transport pathways from the pit land and inundated underground mine during and after filling. Groundwater modelling should seek to predict changes in baseflow contribution to the Nam Pangyun (to inform post-closure hydrology, erosion and flood conditions) and identify areas where new springs may emerge as groundwater returns to levels higher than pre-mining conditions.	To determine whether plugging underground adits could reactivate unknown springs and discharge contaminated water To investigate the effect of accelerated filling of the pit in terms of downstream flow and water quality (including avoidance of acid formation), and the effect of groundwater mounding around the pit.	The impact assessment has assumed groundwater levels will recover after closure; although the timing is not able to be predicted at this stage. Post-closure impacts due to changes to groundwater flow and quality have been assessed using professional judgement to predict spatial extent, severity and duration of impact.

Uncertainty	Further work	Purpose	Assumption
The existing and predicted water quality of the fractured rock aquifer around the TSFs is largely unknown. Groundwater quality in the fractured rock aquifer within the Nam Pangyun catchment has potential to be contaminated by historical mining activities. Existing groundwater contamination may potentially be mobilised to groundwater receptors and surrounding unimpacted catchments.	Conduct a hydrogeological assessment of proposed TSF locations including groundwater quality assessment.	To better understand existing and predicted groundwater quality in the fractured rock aquifer around the TSFs.	Assumptions on existing fractured rock aquifer water quality have been made based on the location in respect to the mine, the groundwater flow direction and groundwater quality of the saprolite aquifer.
Locations of fracture/fault and high permeability weathered zones in aquifers under the TSFs.	Conduct a detailed geotechnical/hydrogeological investigation of the footprints of the TSFs.	To identify fracture/fault zones and high permeability weathered zones that may provide preferential seepage transport pathways, including to neighbouring catchments. If such high permeability zones are identified that may lead to a high risk of a groundwater flow or quality impact, the construction design should consider engineered options (such as grouting high permeability fault zones) to minimise transport pathways	Groundwater flow and quality impacts due to mounding and seepage have been assessed using professional judgement to predict spatial extent, severity and duration of impact.

Uncertainty	Further work	Purpose	Assumption
The feasibility of establishing a pit lake, including successfully plugging existing tunnels and adits, has not yet been demonstrated. The establishment of the pit lake will need to consider and address water interaction with the historical underground tunnels and potential points of discharge. The tunnels may need to be plugged and groundwater from the underground tunnels may impact both water quality in the pit lake and final groundwater levels around Bawdwin.	Review underground workings from historical maps Locate and map all obvious Chinese era adits Identify potential pathways for water to escape as the pit lake is filled Conduct hydrogeological investigations to support mine closure plans	To better understand the feasibility and associated impacts associated with forming the pit lake at closure.	Groundwater impacts at closure have been assessed using professional judgement to predict spatial extent, severity and duration of impact. Groundwater flow and quality changes have not been quantified; although it has been assumed groundwater interaction with poor quality water in existing tunnels and adits will occur and result in poor quality seepage.
Locations of project landfills are uncertain.	Identify a suitable location for the project landfill, develop landfill designs in accordance with best practice guidelines and develop appropriate operational control measures.	To confirm that landfills are sited and designed appropriately so that potential impacts to groundwater are minimised.	Specific locations of landfills have not been assumed. Although the site for sewage sludge burial has not yet been selected, it has been assumed the landfill facilities will be lined and contamination managed by standard measures resulting in low significance residual impact. Contaminants of concern for landfills have been assumed based on typical contaminants in landfills associated with mining.

6.4 Surface water impact assessment

This section assesses the project impacts to the surface water values identified in Section 5.3.

Section 5.3 described the levels of importance, vulnerability and resilience associated with each other surface water values in the study area.

6.4.1 Approach to impact assessment

The impact assessment approach adopted in this section is a 'significance assessment'. A significance assessment of surface water impacts involves:

- Identifying the nature of the impact to a surface water value (e.g., physical disturbance and loss of associated value).
- Determining the magnitude of the impact through an assessment of the spatial extent, severity and duration of the impact.
- Assessing the significance of the residual impact (i.e., with assumed successful implementation of avoidance and management measures). The significance (very low, low, medium, high or major) of the impact to a surface water value is determined by considering the importance, vulnerability and resilience of the surface water value (as assessed in Section 5.3) and the predicted magnitude of the impact to the value. Impact magnitude (very low, low, medium, high or very high) is determined based on the spatial extent, severity and duration of the impact.

A significance assessment has been used to assess the magnitude of change to surface water values. As there are no compliance criteria for ambient water quality in Myanmar, Australian and New Zealand water and sediment quality guidelines for aquatic ecosystem protection (ANZ, 2018) are referred to in order to provide context for assessment of impacts to water quality. The Myanmar mining effluent standards outlined in the Myanmar draft national environmental quality (emission) guidelines (MOECAF, 2014) are referred to in this section as a framework for assessing effluent discharge water quality. Reference is also made to the Myanmar National Drinking Water Quality Standards (NWRC, 2014), to provide context on their suitability for such use and their existing level of contamination.

Impacts to the surface water values are assessed in the context of the existing condition of the values. Surface water features in the Project area have been significantly impacted by previous mining activities. The existing surface water environment is described in detail in Section 5.3. When assessing impacts on surface water features, consideration is given to the existing level of impact (for example, already disturbed habitats or water quality already in exceedance ANZ guidelines for ecosystem protection).

Context for impact assessment

The project has the potential to adversely impact the surface water features identified in Section 5.3 and displayed on Figure 6.14 and Figure 6.15. These are the:

- **Nam Pangyun:** Almost all project infrastructure is located within the Nam Pangyun catchment (Figure 6.15). To enable assessment of impacts it has been divided into three reaches:
  - **Upper Nam Pangyun**: The upper Nam Pangyun catchment is defined as the headwaters of the Nam Pangyun down to the point immediately upstream of the existing open pit. This reach is partially degraded with moderate water quality. One site in the upper catchment had several dissolved metal concentrations consistently exceeding ANZ ambient water quality guidelines. The upper Bawdwin villages discharge sewage into this section of the catchment.
  - **Mid Nam Pangyun:** The mid Nam Pangyun catchment is defined as from the open pit down to just upstream of the Tiger Tunnel discharge point. This reach is characterised by poor water quality, with very high dissolved metal concentrations well above ANZ guidelines for ambient water quality

(cadmium, cobalt, copper, lead, nickel and zinc). Bawdwin villages discharge sewage into this section of the catchment.

- **Lower Nam Pangyun:** The lower Nam Pangyun catchment is defined as the Tiger Tunnel discharge point down to the confluence with Myitnge River. This reach is characterised by very poor water quality, dissolved metal concentrations (cadmium, cobalt, copper, lead, manganese, nickel and zinc) regularly well above ANZ ambient water quality guidelines. The lower Nam Pangyun has experienced significant streambed aggradation over centuries of waste disposal and erosion upstream and ongoing disturbance from artisanal mining. Tiger Camp villages discharge sewage into this section of the catchment.

- **Nam La**: This is a relatively unimpacted stream which has relatively good water quality compared to the Nam Pangyun; although, there is a degree of impact, shown by consistently high turbidity and total lead concentrations above Myanmar drinking water standards and dissolved zinc concentrations above ANZ ambient water quality guidelines. This river provides drinking water to parts of Namtu.
- **Myitnge River**: Includes the section of the Myitnge River from upstream of Namtu to downstream of the confluence with the Nam Pangyun. In this reach, the river passes former ore processing and smelting facilities, and tailings disposal areas which contribute to a small increase of dissolved metals. Downstream of the confluence with Nam Pangyun the water quality in the Myitnge River is notably affected, with numerous metals being elevated with respect to ANZ ambient water quality guidelines.

The sensitivity of these features is dependent on their value and uses. Watercourses provide aquatic habitats and beneficial uses, such as a source of drinking water, and water to support agricultural and industrial activities. Section 5.7 outlines the aquatic ecosystems supported by each of the watercourses. As the Nam Pangyun downstream of the open pit (i.e., mid and lower catchment) is a highly modified watercourse with poor water quality, it has little capacity to support aquatic ecosystems or provide water for beneficial uses, and consequently has low vulnerability to impact. Upstream of the open pit mine, the Nam Pangyun is less impacted and has a higher capacity to support ecosystems and beneficial uses. The upper catchment therefore has a higher vulnerability to impact.

Compared to the Nam Pangyun, the Nam La is less modified and is more capable of supporting aquatic ecosystems and a range of beneficial uses. Drinking water is currently supplied to nearby communities through the Nam La flume, and water is also used for agriculture, irrigation, and industrial use. Nam La is a high sensitivity feature due to these associated values and uses of water and the fact that is the only one of the three major rivers in the region that is largely un-impacted by mining activities.

The Myitnge River is a major watercourse which supports aquatic ecosystems and provides a source of water for consumptive, recreation, agricultural, irrigation and industrial uses. Further downstream of the study area the Myitnge River supports hydroelectric power. The Myitnge River is a high sensitivity due to these values and existing beneficial uses, even though it also receives impacts from mining activity the Nam Pangyun catchment.

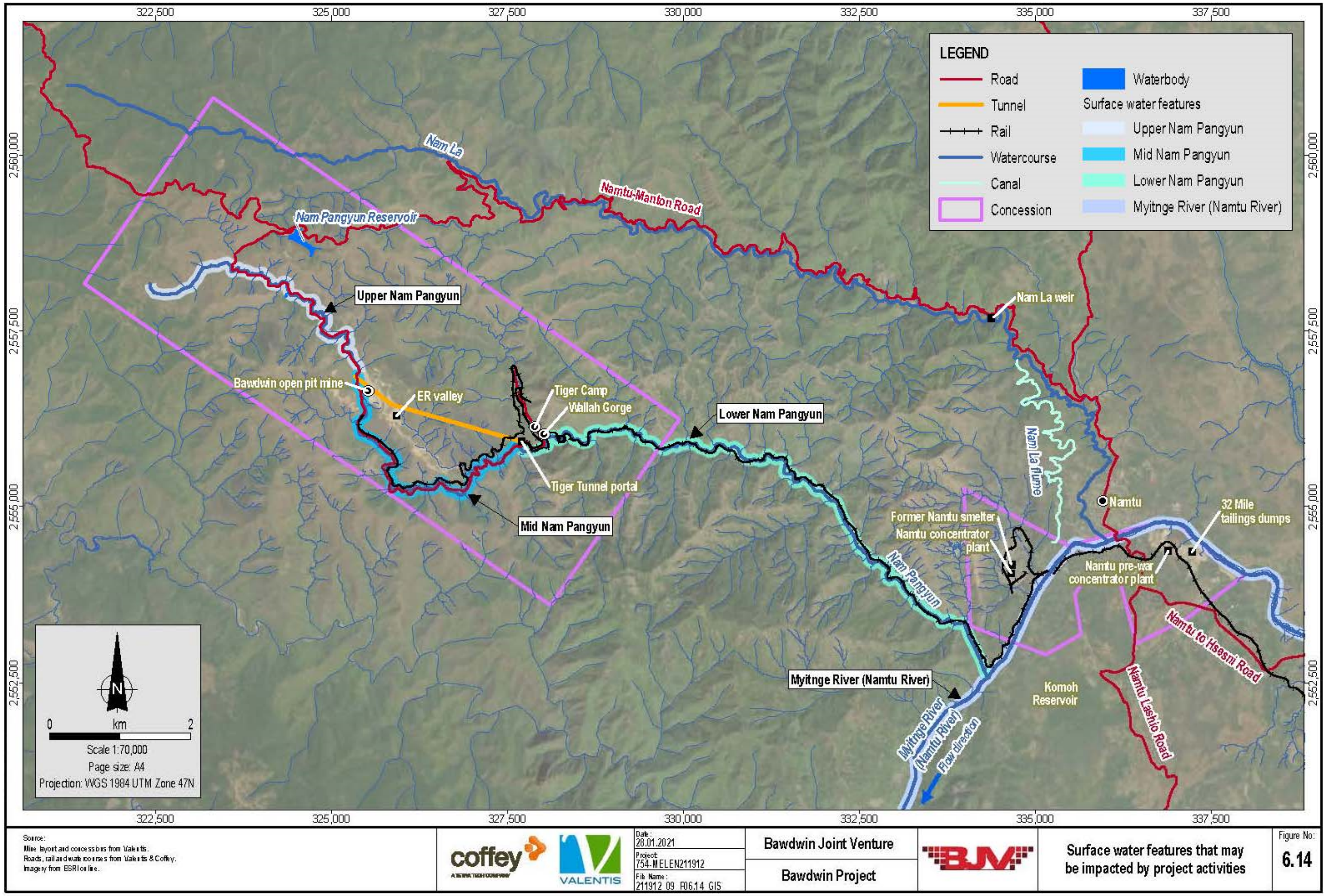


Figure 6.14 Surface water features that may be impacted by project activities

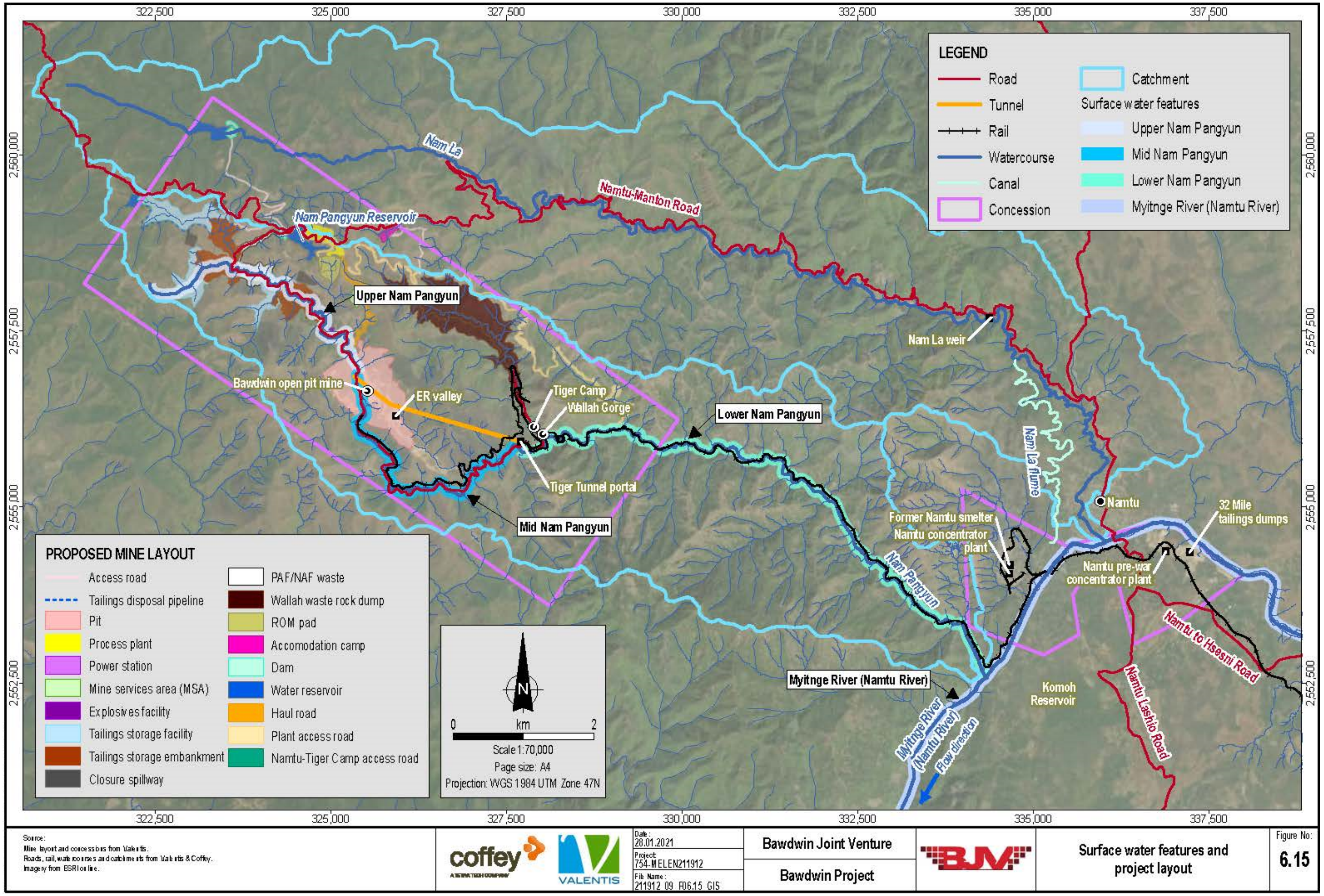


Figure 6.15 Surface water features and project layout

6.4.2 Sources of potential impact

Potential impacts to surface water features include:

- Physical disturbance of surface water habitats caused by construction of project infrastructure, modification of drainage channels, construction of roads and water crossings and diversion of the Nam Pangyun during operations. The impact pathways include:
    - In-stream erosion, sediment deposition and aggradation.
    - Direct physical loss of the surface water feature (or parts of it).
- Changes to surface water flow:
    - Diversion of the Nam Pangyun through the open pit mine during operations.
    - Increased seepage of water from the Nam Pangyun to the underlying rock due to dewatering around the mine pit during operations.
    - Reduced stream flow due to water abstraction from the Nam Pangyun and Nam La for project use during construction and operations.
    - Reduced stream flow due to damming or diverting tributary catchments where mine infrastructure is proposed.
    - Changes to landform and surface drainage during construction, operations and after closure.
    - Altered flood conditions due to changed catchment hydrology and infrastructure placement.
- Reduced water quality. Potential causes of water quality degradation include:
    - Leachate and disposal of excess water from mine waste storage facilities (TSFs and WRD).
    - Contaminated runoff from sites including construction areas, mine waste storage facilities (during operations and after closure), ore stockpiles and processing facilities, and the open pit after closure.
    - Discharge of project effluents and dewatering water.
    - Altered stream flow leading to reduced dilution of historical mine effluent.
    - Runoff containing elevated total suspended solids (TSS) and turbidity due to site erosion.
- Reduced bed sediment quality in downstream surface waters due to mobilisation of waste rock material and contaminated soils containing high metals concentrations.

Physical disturbance

Disturbances to surface water features may occur due to direct physical loss of stream habitat due to placement of project elements and sedimentation of the stream beds from sediment-laden runoff. Major elements causing direct loss of stream habitat are the TSFs and open pit. The risk of downstream sedimentation impacts will be most pronounced during construction of project infrastructure, such as site earthworks, roads, watercourse crossings and embankments; particularly following heavy rainfall events and erosion of disturbed land. Sedimentation risks for the Nam Pangyun will continue during operations as the pit develops and more land surface is disturbed for mine waste facilities.

Approximately 3 km of the Nam Pangyun in the upper catchment will be situated beneath the TSFs and turned into an underdrain to control seepage beneath the TSF. Approximately 750 m of the Nam Pangyun in the mid catchment will be diverted within the open pit footprint and will be converted to a concrete-lined channel with flow directed to the natural Nam Pangyun flow downstream of the pit.

Sediment-laden runoff from project-disturbed land within the catchments may increase levels of TSS, turbidity and metals associated with the particulate matter in receiving waters. This can result in reduced water clarity (and reduced photosynthesis of plants); direct smothering of aquatic flora, fauna and habitat; and introduction of particulate contaminants into the streams. Section 6.2 describes the higher risk areas of site erosion around project construction areas. Constructed landforms such as TSFs and the waste rock dump and cut and fill areas for newly constructed roads (particularly in steeper areas) will be particularly prone to erosion. The rate of land disturbance will be highest during the construction period due to the extensive ground preparation works required for construction of buildings and infrastructure.

Changes to surface water flow

The primary activities resulting in changes to surface water flow are the Nam Pangyun river diversion, damming and abstraction of water from Nam Pangyun and Nam La for project use, dewatering around the pit and changes to landform and drainage around project facilities and disturbance areas. Altered hydrology has the potential to result in reduced availability of surface water to support downstream beneficial uses and aquatic ecosystems and alter flood risks.

Nam Pangyun river diversion

The open pit will intersect with the Nam Pangyun, requiring the river to be diverted during project operations in year 8 of mining operations. This will involve diverting the flow from where the river meets the northern side of the pit, through an in-pit channel, and reconnecting to the existing river channel on the south side of the pit (Figure 6.16) (CSA, 2020). The diversion will consist of a concrete-lined channel, 2 m in depth, 6 m in width, extending 970 m along the length of the pit (CSA, 2020). During the construction of the diversion, flows may be reduced downstream of this area until the diversion is established and lined. If flows to the downstream Nam Pangyun are not adequately managed, the diversion has the potential to reduce surface water supply to the mid and lower Nam Pangyun catchment.

Water abstraction

Reliable water supply is important for the Project in order to operate the process plant, suppress dust and provide potable water. Storage of raw water is critical to maintain supply year-round, particularly during the dry season when stream flows are lower. The main sources of raw water for the Project are:

- Nam Pangyun.
- Nam La.

The Nam La will be the primary raw water source with a water harvesting dam constructed on the headwaters of the Nam La. Most water will be abstracted during the wet season with continued flows passing via a spillway. To supplement supply, a diversion dam, the ‘Water Harvesting Facility’, will also be used to collect water from the Nam Pangyun upstream of the tailings storage facility C (TSF C) (see Figure 4.29 in Chapter 4 Project Description) and stored in the Nam Pangyun Reservoir. Water abstraction has the potential to reduce available flows to support beneficial uses and aquatic ecosystems, particularly during the dry season.

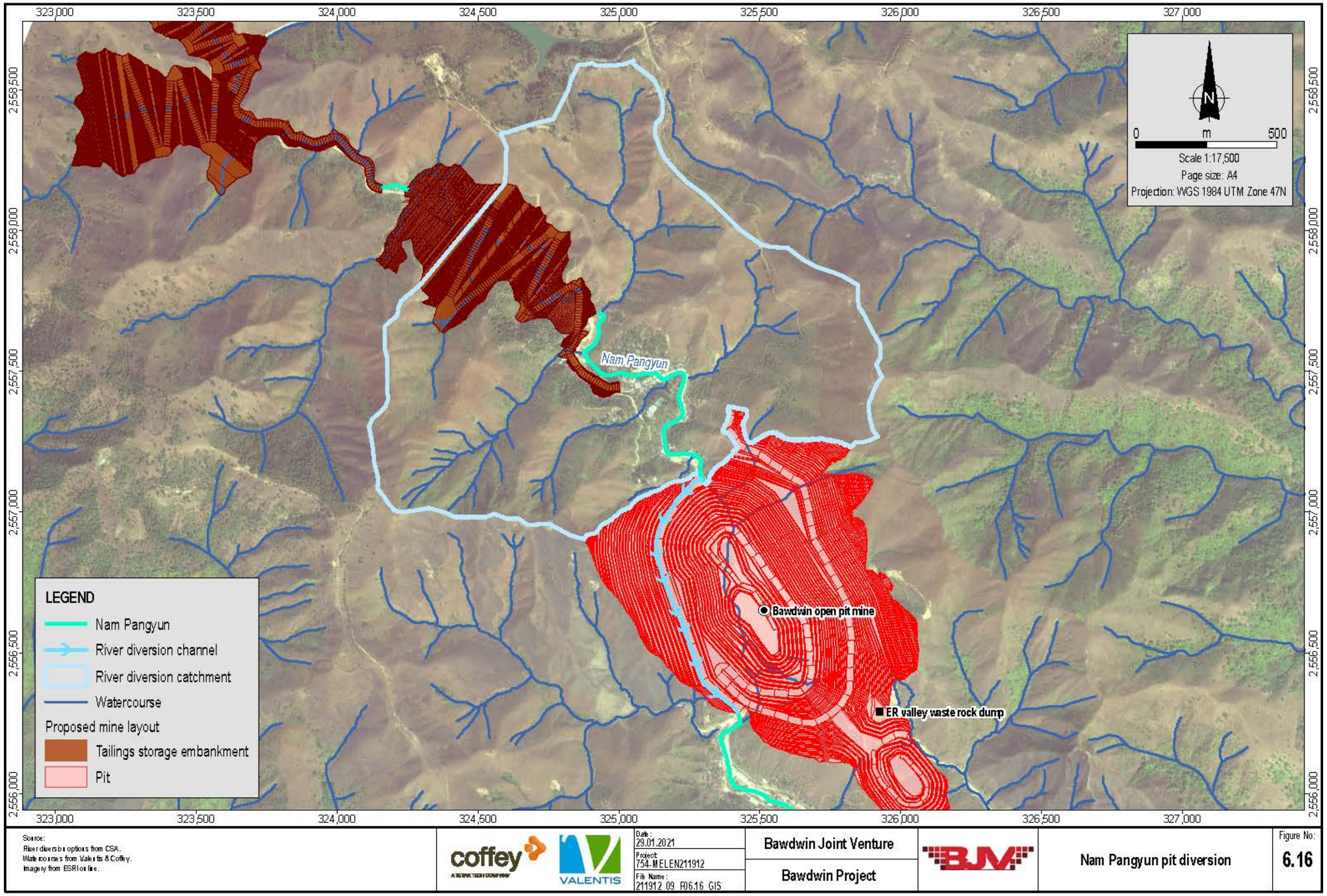


Figure 6.16 Nam Pangyun pit diversion

In addition to the direct abstraction of water from the Nam La and Nam Pangyun, dewatering during mining will reduce the groundwater table level around the open pit, which may reduce the surface flow of the Nam Pangyun in the mid catchment. The water table in the area is already depressed from years of previous mining and dewatering activity and it is expected that further decline in the water table will increase the seepage of the Nam Pangyun into underlying bedrock during operations (WMM, 2020). This has the potential to reduce flows to the mid and lower Nam Pangyun, particularly during drier periods where flow is driven by groundwater baseflow. This is assessed in detail in Section 6.4.4.

Landform and drainage changes

Changes to landforms will result in changes to drainage in and around the project footprint including construction areas and locations of project infrastructure. The key aspects of the project that will change the landform and drainage are the TSFs, the Wallah waste rock dump and the open pit. The three TSF embankments (A, B and C; see figures 4.25 and 4.26) will reduce the Nam Pangyun upstream catchment by about 70% (CSA, 2020), substantially changing the natural hydrology of the catchment. The Wallah waste rock dump will release overflows in a controlled manner to the Wallah Valley stream (a tributary to the Nam Pangyun), via three downstream sediment settlement dams.

The changes to landform and drainage in the upper and mid Nam Pangyun catchments have the potential to reduce water flow to existing surface water features. Also, the drainage changes are expected to alter catchment hydrology potentially leading to increased erosion, increased deposition of suspended sediments and turbidity downstream, and reduced water quality. These impacts to water quality are discussed further later in this subsection and in Section 6.4.4. Altered catchment hydrology may also change flood risk through the catchment.

Post closure, the open pit will receive surface water inflow and groundwater recharge. The likely closure strategy is that the historical underground mine workings will be sealed, including construction of a plug in the Tiger Tunnel, and the Nam Pangyun will be diverted into the pit to expedite filling. The resulting permanent lake feature would directly and permanently change the form of the Nam Pangyun in the upper and mid catchment.

Most mining construction activities will not substantially alter the post-closure water balance between the Nam Pangyun and neighbouring catchments. However, the current TSF engineering design for closure incorporates an engineered spillway that will discharge some surface water runoff from the revegetated TSF-A (and TSF-B that will report to TSF-A) into the Nam La catchment. Controlled release via the TSF-A spillway will increase runoff to the Nam La catchment and establish a possible pathway for contaminant release to this relatively less impacted section of the catchment (discussed further in the reduced water quality subsection).

Flood risk

The project is located in a mountainous area with steep slopes and a climate that has significant wet season rainfall, this results in high runoff and a rapid rise in stream water levels, which can result in floods.

Within the upper and mid-catchments of the Nam Pangyun, flooding is predominantly limited to a narrow zone around the Nam Pangyun stream which results in high flow velocities through the valley during flood events. These high flows transport sediments through the catchment.

Construction of TSFs in the upper catchment will result in wider, shallower flow paths with several water impoundments preventing the release of runoff from rainfall events that are within the design criteria of the structure. Larger storm events that exceed the design criteria will result in discharge via the engineered spillways and contribute flow to the downstream catchment.

Areas of locally increased flood risk may exist around newly constructed infrastructure such as roads, pipelines and other infrastructure.

The engineering design for closure of the TSF complex incorporates an engineered spillway that will discharge some surface water runoff from the Nam Pangyun catchment (from TSF-A and TSF-B) into the Nam La catchment. This change to the water balance will increase the volume of runoff to the Nam La catchment during high rainfall events and may alter the downstream flood risks in the Nam La catchment.

Reduced water quality

Contaminated seepage and runoff

Water quality of surface water features may be reduced due to seepage or runoff from contaminated sites including the TSFs (which includes tailings along with discharged wastewater from the process plant) and Wallah waste rock dump, the mine pit, and from mine dewatering. Accidental spills and leaks of hazardous materials have the potential to impact water quality. Accidental spills and leaks of hazardous materials are assessed in Chapter 7 Hazard and Risk, as these are considered to be unplanned events following the implementation of avoidance and management measures; these aspects are not considered further in this chapter.

Reduced water quality will be due to increased concentrations of metals (dissolved and particulate), sulfate, TSS, turbidity and acidity. Runoff carrying suspended matter from erosion of disturbed areas may increase levels of TSS, turbidity and particulate metals in receiving waters. Leachate from the TSFs is likely to contain elevated dissolved metals concentrations and sulfate and may contain residual cyanide from the processing waste stream (Knight Piésold, 2020; CSA, 2020). Leachate from the Wallah waste rock dump is predicted to contain elevated dissolved metals. Surface water releases from the downstream sediment dams will also contain elevated metals concentrations.

Most construction activity will take place within the Nam Pangyun catchment around the headwaters north of Bawdwin, at Bawdwin and Tiger Camp and in the Wallah Valley. Construction of a new access road will also extend through the lower catchment from Namtu to Tiger Camp. Construction activities will have increased risk of sediment laden and potentially contaminated runoff entering the Nam Pangyun and the a less extent the Nam La. Construction of the Processing Plant north of Bawdwin will take place on the catchment divide between the Nam Pangyun and Nam La. Similar water quality risks may exist for the Nam La during construction.

Mine dewatering

Rainfall runoff, groundwater ingress and drainage from the historical underground mine workings (including Tiger Tunnel) will report to the open pit during operations. The pit will be maintained dry during operations through a series of in pit sumps and pumps which will collect accumulated water and discharge it to the Nam Pangyun via a sedimentation pond.

The water discharged from the open pit and sedimentation pond will be a mixture of groundwater with very high concentrations of metals (as characterised by the existing Tiger Tunnel discharge) and rainfall runoff with high TSS. Water quality testing of Tiger Tunnel discharge during baseline monitoring indicated that existing concentrations of total arsenic, cadmium, iron, lead, nickel and zinc exceeding Myanmar mining emissions guidelines. The volume and quality of water produced by the dewatering system will vary with rainfall events and the increasing depth of mining over the life of the mine, but this variability has not been quantified. Passive discharge of contaminated groundwater from the Tiger Tunnel, as per the current situation (i.e., into the Nam Pangyun), will occur throughout operations.

Reduced water quality may be detrimental to aquatic flora and fauna and reduce suitability for downstream beneficial uses. This is more likely to occur in the upper catchment where the Nam Pangyun has relatively good existing water quality and habitat and potential for beneficial uses. As the mid and lower Nam Pangyun has very poor existing water quality and highly degraded habitat, further reduced water quality is less likely to result in loss of values associated with the river (i.e., ability to support ecosystems and beneficial uses). Contaminants may be toxic to aquatic ecosystems, particularly metals which are prone to bioaccumulation in the aquatic ecosystem food chain, such as lead and zinc. This section only addresses water quality impacts to beneficial uses and aquatic ecosystems. Potential water quality impacts to human health are described in Section 6.11.

Process water

The flotation process that will be used in processing of Bawdwin ore will require the use of flocculants and processing reagents including copper sulfate, zinc sulfate, and intermittent use of sodium cyanide. Process water will be treated to filter fine particles and reduce concentrations of residual reagents and will thereafter be discharged to the TSF entrained in the tailings slurry.

A supernatant pool will form in the TSF basin, comprising tailings water, residual process water and incident rainfall. The pool will be actively managed to keep its extent with operational limits and to create tailings beaches, which will allow tailings to dry and will also act to reduce infiltration of water into the TSF embankment. The

TSF design includes freeboard to accommodate a 1:100-year wet season and extreme storage allowance of 1:100-year 72-hour flood. Each TSF will include a spillway designed to accommodate a probable maximum flood event.

During operations in the wet season, excess TSF pond water will be treated to reduce fine particles, residual processing reagents and metals to meet Myanmar discharge guidelines and will be discharged to the Nam Pangyun. Notwithstanding treatment to Myanmar discharge guidelines, the discharge of treated TSF pond (supernatant) water may result in levels of heavy metals, sulfate and residual reagents including cyanide entering the Nam Pangyun watercourse that are elevated.

Dust suppression

Over 400,000 m^3 per year of groundwater from the Marmion Shaft will be extracted for dust suppression in the open pit and haul roads. This water contains high metals (antimony, arsenic, cadmium, lead, manganese, nickel and zinc) concentrations as shown by groundwater monitoring (CSA, 2020). This may be due to the influence of historically deposited tailings in nearby underground workings. The long-term use of poor-quality water for dust suppression may result in increased accumulation of metals in surface soils, which may be mobilised by surface runoff, delivering elevated metals concentrations to the Nam Pangyun.

Post closure water quality impacts

After project closure, three key project elements (open pit, TSFs and Wallah WRD) will provide ongoing potential sources of contamination to the surrounding environment, including to surface waters.

At closure the open cut pit will naturally fill with groundwater and rainwater to become a pit lake, but the closure strategy will require diversion of the Nam Pangyun into the pit to accelerate filling and limit potential weathering of acid forming material in the pit. With this augmented inflow the pit will fill within 5 years of closure, after which the pit lake may subsequently release flows to the downstream Nam Pangyun catchment, depending on seasonal inflows of surface and groundwater and seepage and evaporation rates.

In addition, seepage from the TSFs and the Wallah waste rock dump is likely to continue for some time after capping of those facilities during closure (Knight Piésold, 2020; CSA, 2020). Seepage from these facilities may introduce high metals concentrations into the Nam Pangyun, which may in turn report to the Myitnge River.

The current TSF design assumes a component of runoff from the capped TSF-A (and TSF-B that will report to TSF-A) will be released via an engineered spillway to the Nam La catchment during periods of high rainfall. This spillway introduces a potential pathway for release of water to the Nam La. The quality of water released via the spillway has not been predicted, but may include concentrations of TSS and total and dissolved metals above background conditions in the Nam La.

Another potential pathway for the discharge of contaminated water to the Nam La is by seepage from the TSF into groundwater, which may subsequently enter the Nam La aquifers. There is high uncertainty surrounding this pathway due to the lack of groundwater modelling, however most of the seepage will be captured and treated within the Nam Pangyun catchment.

Reduced stream bed sediment quality

As there are no Myanmar guidelines for stream sediment quality, the Australia and New Zealand sediment quality guidelines have been used to inform the impact assessment. These provide default guideline values (DGVs) which indicate the concentrations below which there is a low risk of biological effects occurring, and upper guideline values (GV-high), which provide an indication of concentrations at which toxicity related effects would be expected. Concentrations of contaminants between the DGV and GV-high indicate that toxic effects are possible but further investigation would be required to confirm.

As discussed in Section 5.3, all sites in the Nam Pangyun catchment have existing metals concentrations (most commonly antimony, arsenic, lead, mercury, silver and zinc) which exceed ANZ DGVs, and often GV-highs. High existing metal concentrations in these sediments are due to a combination of long-running historic mining activity and natural elevation in regional mineralogy. Mobilisation of waste rock material or contaminated soils entering watercourses can deposit and increase the concentrations of contaminants (e.g., metals) in the streambed sediments. This exposes benthic biota to potentially increased ecotoxicity. The addition of further metal-laden sediments into the watercourses due to mining activities has the potential to increase sediment ecotoxicity above the already impacted sediments in the Nam Pangyun, and potentially as far downstream as the Myitnge River.

No existing streambed sediment quality data from Nam La are available; however, due to the limited presence of waste rock/slag in the stream, and the comparatively better water quality than the Nam Pangyun, it is assumed that the streambed sediment quality is relatively good compared to the Nam Pangyun. During construction and operation of the mine, the mining activities and waste disposal will occur within the Nam Pangyun catchment and are unlikely to impact the Nam La with the exception of potential TSF seepage pathways and the TSF-A closure spillway. Water discharging from the TSF-A spillway may include elevated concentrations of TSS and particulate metals that may impact Nam La stream bed sediments post closure.

Summary of sources of potential impact

Sources or mechanisms for potential impacts to the capacity of surface water features to support aquatic ecosystems and/or beneficial uses are summarised in Table 6.50, along with the relevant phases of the project these are expected to occur.

Figure 4.30 presents a schematic of the project water balance, including runoff and seepage to be managed and all project discharges. Figure 4.30 and 4.21 show the locations of all the project sediment dams. These discharge sources and sediment dams are referred to throughout this section.

Table 6.50 Summary of sources of potential impact during project construction, operation and closure

Potential impacts	Construction	Operation	Closure
Sediment-laden runoff and sedimentation leading to physical disturbance (in-stream erosion, sediment deposition and aggradation)	X	X	X
Construction of mine infrastructure (TSF) and diversion of Nam Pangyun leading to physical disturbance (direct physical loss) of surface water habitats	X	X	X
Diversion of Nam Pangyun leading to altered surface water flow		X	X
Mine pit dewatering leading to seepage from the Nam Pangyun to underlying rock		X	
Abstraction from Nam La and Nam Pangyun leading to reduced surface water flows	X	X	
Runoff and seepage from contaminated sites (including TSFs and WRD) causing reduced surface water quality	X	X	X
Discharge of poor-quality water from mine dewatering causing reduced surface water quality		X	
Accidental spills and leaks causing reduced water quality	X	X	X
Mobilisation of waste rock material and contaminated soil leading to reduced streambed sediment quality	X	X	X

X = occurring in this phase

6.4.3 Proposed mitigation and management measures

Project impacts to surface water features will be reduced by to a combination of avoidance (i.e., by designing the project in a way that removes the impact pathway) and management (i.e., by implementing controls to minimise the effects on the environment).

The project design and management controls are outlined below.

Design controls

A design control is an elimination, substitution or engineering control implemented during the project design and/or construction phase with the intent of eliminating impact pathways. Proposed design controls for surface water management are:

- In line with good practice management principles for acid forming material outlined in the Global Acid Rock Drainage Guide (INAP, 2020), manage potentially acid forming (PAF) material by:
  - Storing potentially acid forming (PAF) material water in TSF C to reduce oxidation and acid formation, or,
  - Encapsulating any PAF material to be disposed within the Wallah waste rock dump within an engineered cell to reduce oxidation and acid formation.
- Incorporate flood risk assessments and scour assessments in the engineering design of river crossings and infrastructure.
- Install downstream sedimentation dams in each disturbed catchment/drainage area in order to facilitate the settlement of suspended sediment from runoff and reduce coarse sediments from entering natural drainage

systems. The sediment dams will be designed to retain fine sands and coarser particles up to a 1:100 year ARI flow event.

- Design the dimensions, embankments, benches, and sediment dams associated with waste rock dump based on detailed assessment of site conditions and in line with relevant Australian guidelines and international good practice standards and with sufficient factors of safety (see Chapter 4 Project Description).
- Design the dimensions, embankments, and sediment dams associated with the TSFs based on detailed assessment of site conditions and in line with relevant Australian guidelines and international best practice standards and with sufficient factors of safety (see Chapter 4 Project Description).
- Use low permeability, erosion-resistant material for capping of TSFs and waste rock dump embankments and the final landforms at closure to reduce erosion of these features and increase their long-term stability.
- Identify geochemically suitable(e.g., inert and non-elevated levels of heavy metals) materials for capping of TSFs and waste rock dump embankments and final landforms at closure and conduct testwork on materials to confirm suitability, such that runoff water quality meets discharge guidelines and preserves values and beneficial uses of downstream environment.
- Design the Namtu – Tiger Camp access road with suitable permanent stormwater controls such as diversion drains, batter chutes and sediment basins.
- Consider potential for flow accumulation and increased flood risk when designing and locating mine infrastructure.
- Maintain hydraulic connectivity along linear infrastructure corridors for pipelines and roads (e.g., install appropriately sized culverts and drains where required).
- Design and construct watercourse crossings so that they will not divert streamflow out of the stream channel and down the road alignment.
- Design the Namtu – Tiger Camp access road with suitable erosion and sediment controls such as check dams and sediment fences. Schedule road construction works to take place during the dry season.
- Design an appropriate water management system that meets applicable regulatory discharge criteria. This will be used to treat discharge from the TSFs and captured seepage from the waste rock dump.
- Store and handle hazardous materials including fuels, oils and chemicals in accordance with good international practice, including designing appropriately secured and bunded facilities to meet appropriate standards for storage of hazardous materials.
- Develop diversion drains around areas of clearing and disturbance to separate clean and dirty water.
- Line the Nam Pangyun river diversion with concrete to reduce erosion and seepage.

Management controls

A management control is one that may be implemented during construction, operations or closure for the purpose of reducing the consequence and/or likelihood of a potential impact. Proposed management controls for surface water management are listed below.

Hydrology and water supply

- Establish a minimum passing flow threshold at the point of water extraction from the Nam La, in consultation with key stakeholders, that preserves potable water supply requirements for Namtu and maintains minimum environmental flows.
- Extract water from the Nam La only when the minimum passing flow threshold can be maintained.
- Where practicable, divert upstream surface water flows from undisturbed catchment areas around the project and discharge into downstream surface water drainage lines.
- Maintain adequate base water supply for Namtu from the Nam La. This may be achieved by establishing infrastructure to divert small spring flows of suitable quality to the Nam La flume during periods of low flow.

Sediment and erosion control

The following key measures will be implemented under a project sediment and erosion management plan:

- Plan for construction on or near natural drainage lines to be undertaken in the dry season, where practicable.
- Implement and maintain erosion and sediment controls, including site specific measures as necessary. Typical controls include:
    - Locate and design infrastructure to limit runoff to watercourses.
    - Install structures to intercept sediment-laden surface runoff to reduce sediment delivery to watercourses.
    - Install diversion drains to intercept uncontaminated surface runoff around facilities and divert away from cleared areas, where practicable.
    - Stockpile spoil and/or topsoil materials away from watercourses (i.e., maintain a minimum of 10 m from watercourse banks), where practicable.
    - Stabilise areas that will be exposed for a substantial period of time using measures such as temporary grass or hydromulch.
    - Grade access roads adjacent to watercourses to drain away from watercourses.
    - Install specific soil stabilisation measures on side hill cuts to prevent slumping and/or erosion.
    - Minimise the extent, and time, that ground surfaces and stockpiles are exposed through staged works wherever possible.
    - Progressively rehabilitate disturbed areas.
    - Schedule major earthworks in dry season where feasible.
    - Discharge water in a manner that prevents scouring and erosion.
- Cover and stabilise exposed areas susceptible to erosion (due to project disturbance) using appropriate materials such as, vegetation debris, jute netting, geogrid matting, or mulch.
- Stabilise minor landslips and other areas of landform instability (e.g., soil binders, synthetic matting and engineered structures).
- Install landform and soil stabilisation measures on side hill cuts to reduce slumping and/or erosion.
- Inspect and, if required, empty sediment dams prior to the start of wet season to remove retained sediment and prevent it from being remobilised and also to restore capacity of the sediment dams. Residual sludge

from the sediment dams will be collected by a liquid-waste truck and driven to the process plant for disposal into the tailings pumping system.

- Discharge water and wastewater in a manner that minimises scouring and erosion.

Water seepage, collection and management

- Implement an underdrainage system to capture seepage from the TSFs and Wallah waste rock dump and if required treat water via series of sediment dams or water treatment plant for treatment to meet Myanmar draft mining effluent standards before discharge to the Nam Pangyun
- Prior to discharge to the downstream environment, TSF supernatant water (including captured seepage), seepage/run-off from the Wallah waste rock dump and water from pit dewatering will be treated as necessary so that the water quality meets the required discharge criteria. Capture surface runoff from the waste rock dump in a series of sediment dams to reduce the concentration of TSS to a level suitable for treatment with a microfiltration system.
- Treat discharge water from the waste rock dump sediment dams with a microfiltration system, which will remove fine particles and some heavy metals from the water before it is discharged into the Wallah stream and eventually the Nam Pangyun. The discharge will be treated so that contaminant concentrations meet Myanmar mining effluent standards.
- Intercept and divert runoff from disturbed mine areas, stockpiles and waste disposal areas into sediment dams.
- Capture disturbed catchment runoff through a diversion channel downstream of earthworks during construction in the Nam La catchment and allow sediment to settle.
- Discharge wastewater in a manner that avoids or reduces impacts on local users.
- Prior to its use, check that the quality of water used for dust suppression does not represent a health risk to workers or the community via direct contact or inhalation of aerosols and will not lead to increased contamination of soils or rainfall runoff.
- Treat water produced from pit dewatering activities so that TSS concentrations meet Myanmar mining effluent criteria.

Hazardous material management

- Implement measures to reduce the potential for accidental leaks and spills to occur, as outlined in Chapter 7 Hazard and Risk.
- Prepare and implement an emergency response plan that includes measures for containing and cleaning up spillage of cyanide reagents.

TSF management

- WMM will comply with the Global Industry Standard on Tailings Management (ICMM et al., 2020) in relation to design, construction, operation, monitoring, management, governance, emergency response and community consultation of the TSF facilities, including associated water quality treatment plant. This will include implementation of Construction vs Design Intent Verification (CDIV), which will ensure that design intent is implemented and continues to be met in the case that site conditions vary from design assumptions. It will also involve preparation and implementation of an Operations, Maintenance and Surveillance (OMS) Manual that outlines critical controls for safe TSF operations and allows tracking.
- Construct and operate Wallah waste rock dump in accordance with detailed designs and operating manual.

- Design the dimensions, embankments, benches, and sediment dams associated with the TSFs and waste rock dump based on detailed assessment of site conditions and in line with relevant Australian guidelines and design principles outlined in the Global Industry Standard on Tailings Management (ICMM et al., 2020) and with sufficient factors of safety (see Chapter 4 Project Description). This will involve developing a design that considers the technical, social, environmental and local economic context, the results of risk analysis for TSF failure scenarios, site conditions, water management, mine operations, construction issues and requirements for safe closure.

Closure

- Divert the Nam Pangyun to fill the open pit rapidly after closure, in order to minimise the potential for oxidation of in-pit PAF and subsequent acid formation and to also minimise the concentration of metals in the pit water (as predicted by CSA, 2020).

  Site specific water quality targets

- Prior to construction, the project will develop site-specific water quality targets for aquatic ecosystem protection following recognised international methods. This is because there are no Myanmar ambient water quality standards and it is not suitable to apply international default ambient water quality guideline values to river systems that already have contaminant concentrations well in exceedance of those guideline values. The site-specific water quality targets will account for existing water quality (e.g., elevated dissolved metals concentrations) and focus on those contaminants at highest risk of causing harm to aquatic ecosystems should their concentrations be further increased (e.g., dissolved metals including copper, lead and zinc). The reasons for focussing on dissolved metals are:
  a) dissolved metals are known to be elevated in the downstream rivers (Nam Pangyun, Myitnge and Nam La) compared to ANZ ambient water quality criteria, indicating these are providing an existing level of stress to those rivers;
  b) dissolved metals are the most bioavailable form of metals for aquatic biota that could subsequently result in toxic effects; and
  c) evidence from other mining projects, and the legacy of mining and exploration at Bawdwin, indicates that the project can reasonably be expected to contribute additional increases in dissolved metals concentrations in downstream waters.

  Section 6.4.6 provides detail on the approach to developing site-specific water quality targets.

6.4.4 Residual impact assessment

This section assesses the residual significance of impacts identified in Section 6.4.2 after implementation of the management measures outlined in Section 6.4.3. The magnitude of each residual impact is assessed based on the impact's geographic extent, severity and duration, taking into consideration the existing conditions of the features and their importance, vulnerability and resilience. Table 6.51 presents the criteria used to determine the magnitude of each impact.

Table 6.51 Criteria used to determine the magnitude of impacts to surface water

	Very low	Low	Medium	High	Very high
Spatial extent	Impact affects a very small area within the catchment (i.e., less than 5% of a catchment)	Impact affects a localised area within the catchment (i.e., less than 10% of the catchment)	Impact affects a moderate area of the catchment (i.e., 10-20% of the catchment)	Impact affects a widespread area and a large proportion of the catchment (i.e., in the order of 20-60% of the catchment)	Impact affects a large proportion of the catchment (i.e., in the order of >60% of the catchment) and potentially additional catchments
Severity	Impact is entirely within existing disturbance area and/or is a very minor change from background conditions and will probably recover on its own or require minimal rehabilitation effort. The impact will not reduce the capacity to support aquatic ecosystems and/or beneficial uses	Impact is entirely within existing disturbance areas and/or is a minor change from background conditions and can be straightforwardly remedied or rehabilitated using standard management measures. The impact is unlikely to reduce the capacity to support aquatic ecosystems and/or beneficial uses	Impact is partly within existing disturbance areas but also within previously undisturbed (or low-level disturbance) areas of the catchment and/or is a medium change from background conditions and can be partly, remedied or rehabilitated. There is some reduction in capacity to support aquatic ecosystems and/or beneficial uses.	Impact is completely within previously undisturbed (or low-level disturbance) areas of the catchment and/or is a high degree of change from existing conditions and is very difficult to rehabilitate. Most of the surface water's capacity to support aquatic ecosystems and/or beneficial uses is reduced.	Impact is completely within previously undisturbed areas and/or is a very high degree of change from existing conditions and cannot be rehabilitated. Capacity to support aquatic ecosystems and/or beneficial uses is lost
Duration	Impact is very short in duration (i.e., days)	Impact is short term (i.e., months or less)	Impact is medium term (1 to 2 years).	Impact is long term (3 to 15 years).	Impact is greater than 15 years or permanent.

This impact assessment is based on qualitative predictions in the absence of quantitative water quality and hydrological modelling. The impact assessment uses professional judgement informed by experience at similar mine sites in steep, high-rainfall environments. Impact severity is discussed with reference to changes from the existing situation, with the project's objective of making downstream river conditions no worse than pre-project conditions. In the absence of quantitative predictive modelling, there are notable levels of uncertainty associated with the impact assessments and these levels of uncertainty are highlighted throughout the impact assessment. Section 6.4.6 provides additional detail on the uncertainties and proposed further work to reduce the uncertainties.

Physical disturbance

Notwithstanding the existing disturbed aquatic habitat and implementation of management measures outlined in Section 6.4.3, the project will result in increased disturbance to aquatic habitat. Disturbance to aquatic habitat will arise from two pathways: direct removal of instream and riparian habitat to make way for project infrastructure and downstream smothering of streambed, edge and riparian habitat from increased sediment.

Direct Loss

An approximately 3 km section of the Nam Pangyun upper catchment will be converted to an underdrain to allow drainage beneath the TSFs. Also, approximately 750 m of the Nam Pangyun mid catchment will be diverted around mining activity within the open pit footprint and will be converted to a concrete-lined channel with flow directed to the natural Nam Pangyun flow downstream of the pit. In these locations (see Figure 6.16), aquatic habitat such as rocks, pools and remnant vegetation and riparian vegetation will be permanently removed with consequent negative impacts on the populations of aquatic ecosystems residing within them. Artificial habitat in the form of new channels will provide poor habitat for fauna due to the uniformity of the substrate and removal of riffle zones. The impact severity will be higher in the upper catchment where the TSFs will be situated, as the upper catchment currently has higher quality aquatic habitat as it is upstream of most historic mining activity (with the exception of some historic smelting areas). Habitat in the mid and lower catchment is already highly impacted.

Overall, during project construction disturbance of aquatic habitat by direct removal is assessed to be **high significance** in the upper catchment, based on the **high magnitude** of impact and **medium sensitivity** of the feature (Table 6.52) and **low significance** in the mid catchment, based on the **low magnitude** of impact and the **low sensitivity** of the feature (Table 6.53).

Table 6.52 Residual impact significance summary - physical disturbance of habitat due to direct removal of instream and riparian habitat – affecting the upper Nam Pangyun catchment

Value	**Sensitivity of value**			
Ability to support ecosystems and beneficial uses – upper Nam Pangyun catchment	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium In some areas in the upper catchment water supports aquatic ecosystems and has the potential to support a range of beneficial uses	**Medium** Currently exhibits moderate water quality, and is of better quality than the mid and lower catchment. Vulnerable to further deterioration of water quality.	**Medium** Some resilience to change. Some of the associated ecosystem value or use can be regained.	**Medium**
Impact	**Magnitude of impact to value**			
Physical disturbance of habitat due to direct removal of instream and riparian habitat – affecting the upper Nam Pangyun catchment	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	High An approximately 3 km section of the Nam Pangyun upper catchment will be converted to an underdrain to allow drainage beneath the TSFs. This represents an impact to a large proportion (>60%) of the upper catchment.	**High** Impact is partly within existing disturbance areas but also within relatively undisturbed areas of the catchment. Some capacity to support beneficial uses and aquatic ecosystems may be reduced.	**Very high** Instream and riparian habitat will be permanently removed.	**High**
	Residual impact significance			**High**
	Assessment of uncertainty			
	Low Areas of physical disturbance readily predictable based on project footprint			

Table 6.53 Residual impact significance summary - physical disturbance of habitat due to direct removal of instream and riparian habitat – affecting the mid Nam Pangyun catchment

Value	**Sensitivity of value**			
Ability to support ecosystems and beneficial uses – mid Nam Pangyun catchment	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Highly modified and degraded watercourse with poor water quality due to historic mining activities. Water is not used for drinking water. Has limited or no potential to support aquatic ecosystems or be a source of water for beneficial uses	**Low** The watercourse has been impacted by historic mining and ongoing exposure to contaminants, including sewage from Bawdwin villages, there is limited vulnerability to further changes.	**Medium** Some resilience to change. Some of the associated ecosystem value or use can be regained.	**Low**
Impact	**Magnitude of impact to value**			
Physical disturbance of habitat due to direct removal of instream and riparian habitat –affecting the mid Nam Pangyun catchment	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Approximately 750 m of the Nam Pangyun mid catchment will be diverted around mining activity within the open pit footprint and will be converted to a concrete-lined channel with flow directed to the natural Nam Pangyun flow downstream of the pit. This represents an impact to a moderate proportion (10-20%) of the mid catchment.	**Low** Impact is likely to be entirely within existing disturbance area with a highly impacted habitat. The degree of habitat disturbance will be minor in the context of existing poor habitat condition.	**Very high** Instream and riparian habitat will be permanently removed	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Low Areas of physical disturbance readily predictable based on project footprint			

Stream aggradation and sediment effects

As discussed with respect to surface water flow below, there will be times during construction and operations where erosion and surface runoff from project-disturbed areas after rainfall events will result in increased mobilisation and deposition of sediment in downstream waters. Sedimentation and aggradation in the streams may result in loss or degradation of habitat by reducing structural diversity and filling interstitial spaces in stream substrate. There may be a loss of in-stream habitat due to smothering from increased sediment input, reducing the capacity to support ecosystems and the reproductive success of aquatic species, along with loss of edge and riparian vegetation and habitat. Streambed aggradation also has the potential to cause bank overtopping and flood risks in the catchment (see Section 6.4.4 Flood risk subsection).

The bulk of the land disturbance will occur in the Nam Pangyun catchment during construction and, as such, downstream sedimentation will be mostly restricted to the already impacted Nam Pangyun, which (particularly in the mid and lower catchment) has highly modified bed, edge and riparian habitat with extensive aggradation from years of waste rock and slag disposal and erosion.

With upstream sediment control dams in place it is likely that sediment reporting downstream would be primarily finer particles (silts and clays) that do not settle in the sediment dams. Table 6.54 presents the estimated sediment retention efficiency of the waste rock dump sediment dams. This indicates that TSS in discharged water from the waste rock dump sediment dams will comprise primarily clays and very fine, fine and medium silts. Total suspended solids concentrations in the discharge have not been estimated. The other sediment dams downstream of the major project facilities and TSFs (see Figure 4.30 in Chapter 4) will also be designed to retain fine sands and coarser particles up to a 1:100 ARI flow event.

The sediment dam downstream of the open pit will be designed based on a 1 in 2 year 30-minute rainfall duration of 55 mm/h intensity and corresponding retention of 80% of the 62 µm particles (i.e., coarse silts and larger particles). The design will allow retention of greater than 80% for particles coarser than 62 µm (WMM, 2020).

Table 6.54 Estimated sediment retention efficiency of waste rock dump sediment dams

Particle size	ARI (Years)					
	1 in 2	**1 in 5**	**1 in 10**	**1 in 20**	**1 in 50**	**1 in 100**
Very coarse sand	100%	100%	100%	100%	100%	100%
Coarse sand	100%	100%	100%	100%	100%	100%
Medium sand	100%	100%	100%	100%	100%	100%
Fine sand	100%	100%	100%	100%	100%	100%
Very fine sand	100%	100%	100%	100%	99%	99%
Coarse silt	94%	90%	87%	84%	81%	79%
Medium silt	63%	54%	50%	46%	42%	40%
Fine silt	26%	20%	18%	16%	15%	14%
Very fine silt	7%	5%	4%	4%	4%	3%
Clay	**2%**	1%	1%	1%	1%	1%

Source: Knight Piésold, 2020

The sediment dams will attenuate the release of sediment in runoff into the Nam Pangyun. Since the sediment dams are designed to capture mainly the sands and coarse silt portions of the sediment load it is possible that the downstream environment may still experience and overall increase in stream sediment loads and consequent stream sedimentation (comprising mainly the finer material). This is likely to be the case particularly during the construction and early operations phase due to the intensity of upstream land disturbance. As upstream disturbance sites are progressively stabilised and rehabilitated during operations the downstream sedimentation levels will gradually reduce.

While coarser sediments will be captured in the sediment dams, those dams will also regulate peak flows, including those flows that would otherwise disperse the deposited sediment downstream. This effect could result in increased aggradation in the lower catchment until such time that high flow rates return to the catchment (i.e., after closure once the pit lake is full and rapid rainfall runoff commences). Sediment transport and deposition (including scouring) modelling would be required to confirm the extent and thickness of project-caused stream aggradation.

Sedimentation impacts to the upper and mid catchment are relevant to only small sections of the river as large sections of the Nam Pangyun will be converted to concrete-lined drainage structures containing no habitat. There may be a medium-term increase in sediment input into the Myitnge River during construction and operation, and it is expected that this would have a medium severity compared to the sediment generated by existing erosion in the Nam Pangyun catchment and the extensive artisanal mining that takes place in the lower catchment.

To provide context for the assessment of impact severity due to project-caused stream sedimentation and aggradation, Figure 6.17 provides satellite imagery showing existing sedimentation of the lower Nam Pangyun and Myitnge River. The figure shows extensive deposition of sediment at the confluence of the two watercourses, with evidence of material also being deposited downstream in the Myitnge River. However, it is not clear from review of satellite imagery how far downstream the existing sediment impact extends as additional sediment inputs from other rivers are also visible.

Construction of the Namtu – Tiger Camp access road will require earthworks along the length of the Nam Pangyun and will cross a number of small tributary streams. Both permanent and temporary sediment and stormwater management design controls will be adopted to minimise sedimentation to the lower catchment. It is expected that there would be substantial changes to bed sediment deposition and composition in the lower Nam Pangyun and Myitnge River due to project-related sedimentation where side-casting occurs along the access road construction area.

Overall, during project construction and operation, physical disturbance by sediment impacts is assessed to be **low significance** in the upper Nam Pangyun, based on the **low magnitude** of impact and **medium sensitivity** of the feature (Table 6.55).

Figure 6.17 Satellite imagery of existing sedimentation in the lower Nam Pangyun and Myitnge River

Table 6.55 Residual impact significance summary - physical disturbance of habitat due to downstream smothering of streambed, edge and riparian habitat from increased sediment - affecting the upper Nam Pangyun catchment

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Ability to support ecosystems and beneficial uses - Upper Nam Pangyun catchment</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>Medium
Supports some beneficial uses or has medium potential to support aquatic ecosystems</td><td>Medium
Currently stream habitat is in relatively good condition and is better than the mid and lower catchment.
Vulnerable to further deterioration.</td><td>Medium
Some resilience to change. Some of the associated ecosystem value or use can be regained.</td><td>Medium</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact to value</th></tr>
<tr><td rowspan="5">Physical disturbance of habitat due to downstream smothering of streambed, edge and riparian habitat from increased sediment affecting the upper Nam Pangyun catchment</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Low
Impact is expected to affect a small portion of the catchment</td><td>Low
Impact is likely to be entirely within existing disturbance area, and some capacity to support aquatic ecosystems will be reduced</td><td>High
Disturbance will be long term occurring during construction and operations</td><td>Low</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Low</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">High
There is a lack of baseline flow data to characterise flow discharge rates in the catchments. Also, predicted sediment loads in discharge from the sediment dams and spillways have not been quantified, which does not allow for accurate prediction of sediment reporting downstream. Additionally, no sediment transport and deposition modelling has been done to quantify the extent and thickness of accumulated sediments due to the project.</td></tr>
</table>

Overall, during project construction and operation, physical disturbance by sediment impacts is assessed to be **low significance** in the mid Nam Pangyun, based on the **low magnitude** of impact and **low sensitivity** of the feature (Table 6.56).

Table 6.56 Residual impact significance summary - physical disturbance of habitat due to downstream smothering of streambed, edge and riparian habitat from increased sediment - affecting the mid Nam Pangyun catchment

Value	**Sensitivity of value**			
Ability to support ecosystems and beneficial uses - Mid Nam Pangyun catchment	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Has limited or no potential to support aquatic ecosystems or be a source of water for beneficial uses.	**Low** The watercourse has been impacted by historic mining with habitat being highly degraded. There is little vulnerability to further changes.	**Medium** Some resilience to change. Some of the associated ecosystem value or use can be regained.	**Low**
Impact	**Magnitude of impact to value**			
Physical disturbance of habitat due to downstream smothering of streambed, edge and riparian habitat from increased sediment affecting the mid Nam Pangyun catchment	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Impact is expected to affect a small portion of the catchment	**Low** Impact is likely to be entirely within existing disturbance area with a highly impacted habitat and little value. Streambed aggradation is likely to be notable given the sediment dams will attenuate peak flows that may disperse the accumulated sediment. However, the degree of habitat disturbance will be minor in the context of existing poor habitat condition.	**High** Disturbance will be long term occurring during construction and operations	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	High There is a lack of baseline flow data to characterise flow discharge rates in the catchments. Also, predicted sediment loads in discharge from the sediment dams and spillways have not been quantified, which does not allow for accurate prediction of sediment reporting downstream. Additionally, no sediment transport and deposition modelling has been done to quantify the extent and thickness of accumulated sediments due to the project.			

Overall, during project construction and operation, physical disturbance by sediment impacts is assessed to be **low significance** in the lower Nam Pangyun, based on the **medium magnitude** of impact and **low sensitivity** of the feature (Table 6.57).

Table 6.57 Residual impact significance summary - physical disturbance of habitat due to downstream smothering of streambed, edge and riparian habitat from increased sediment - affecting the lower Nam Pangyun catchment

Value	**Sensitivity of value**			
Ability to support ecosystems and beneficial uses - lower Nam Pangyun catchment	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Highly modified and degraded watercourse that has limited or no potential to support aquatic ecosystems or be a source of water for beneficial uses.	**Low** The watercourse has been impacted by historic mining, including the discharge of poor quality water from the Tiger Tunnel, habitat is highly degraded. There is little vulnerability to further changes.	**Medium** Some resilience to change. Some of the associated ecosystem value or use can be regained.	**Low**
Impact	**Magnitude of impact to value**			
Physical disturbance of habitat due to downstream smothering of streambed, edge and riparian habitat from increased sediment affecting the lower Nam Pangyun catchment	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	High Impact is expected to affect most of the catchment	**Low** Impact is likely to be mostly within existing disturbance area with a highly impacted habitat and little value. Increased stream aggradation in this narrow valley could result in sediment accumulation above the existing banks with potential associated risks such as particulate contaminant transport to riparian environments and increased flood risk. However, with much of the lower catchment being already highly impacted, the predicted severity is low.	**High** Disturbance will be long term occurring during construction and operations	**Medium**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	High There is a lack of baseline flow data to characterise flow discharge rates in the catchments. Also, predicted sediment loads in discharge from the sediment dams and spillways have not been quantified, which does not allow for accurate prediction of sediment reporting downstream. Additionally, no sediment transport and deposition modelling has been done to quantify the extent and thickness of accumulated sediments due to the project. The potential for flood risk due to aggradation would also need to be assessed to reduce the uncertainty of this impact assessment.			

During project construction and operation, physical disturbance by sediment impacts is assessed to be of **moderate significance** in the Myitnge River, based on the **low magnitude** of impact and **high sensitivity** of the feature (Table 6.58). This assessment has high uncertainty because the baseline sediment conditions are not well characterised in the Myitnge River and predicted sediment loads, sediment quality and sediment deposition have not been quantified, which does not allow for accurate prediction of sediment reporting downstream in the Myitnge River.

Table 6.58 Residual impact significance summary - physical disturbance of habitat due to downstream smothering of streambed, edge and riparian habitat from increased sediment - affecting the Myitnge River

Value	**Sensitivity of value**			
Ability to support ecosystems and beneficial uses – Myitnge River	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Provides an important source of water for recreation, agriculture/irrigation, industrial use, drinking water and other consumptive uses to communities.	**High** Vulnerable to further changes due to its expected relatively good sediment and water quality compared to the Nam Pangyun	**Medium** May be able to withstand localised and temporary impacts due to its size and flow.	**High**
Impact	**Magnitude of impact to value**			
Physical disturbance of habitat due to downstream smothering of streambed, edge and riparian habitat from increased sediment affecting the Myitnge River	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very low Impact is expected to affect a very small proportion of the river with greatest impact near the confluence with the Nam Pangyun	**Low** Degree of habitat disturbance will be moderate compared to the existing sedimentation and aggradation present near the confluence with the Nam Pangyun	**High** Disturbance will be long term, occurring during construction and operations	**Low**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High There is a lack of baseline flow data to characterise flow discharge rates in the catchments. Also, predicted sediment loads in discharge from the sediment dams and spillways have not been quantified, which does not allow for accurate prediction of sediment reporting downstream. Additionally, no sediment transport and deposition modelling has been done to quantify the extent and thickness of accumulated sediments due to the project.			

During the construction of the Nam La water harvesting facility and earthworks associated with the processing plant construction localised sedimentation of downstream habitat is expected, particularly prior to the embankments and construction site being re-vegetated and stabilised. Construction of the processing plant, accommodation camp and access roads will also contribute a component of runoff to the Nam La catchment where construction activities may span the catchment divide. Although this stream is far less impacted than the Nam Pangyun and has good quality habitat, the impact is expected to be medium-term, temporary and of low magnitude (Table 6.59). It is likely that, after rehabilitation of the Nam La dam embankments and the processing plant construction site and upon commissioning of the dam spillway, sediment inputs would decrease but the regulation of peak flows by the dam would limit flows that would otherwise flush accumulated sediment further downstream. It is therefore likely that the stream habitat will recover over the medium term. The land sloping away from the processing plant site is undulating and standard erosion and sediment management measures are likely to be effective at preventing high sediment runoff into the Nam La catchment. The impact of habitat smothering due to sediment is assessed to be of **moderate significance** for the Nam La, based on the **low magnitude** of impact and the **high sensitivity** of the feature (Table 6.59).

Table 6.59 Residual impact significance summary - physical disturbance of habitat due to downstream smothering of streambed, edge and riparian habitat from increased sediment - affecting the Nam La

Value	**Sensitivity of value**			
Ability to support ecosystems and beneficial uses – Nam La	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Largely undisturbed compared to the Nam Pangyun and is an important source of water for agriculture/irrigation, industrial use, drinking water in nearby communities.	**High** Nam La has relatively good water quality and habitat condition and is vulnerable to degradation particularly during the dry season when flows are limited.	**Medium** Nam La surface water is somewhat resilient to change due to its alkalinity and hardness, which reduce bioavailability and toxicity of some metals.	**High**
Impact	**Magnitude of impact to value**			
Physical disturbance of habitat due to downstream smothering of streambed, edge and riparian habitat from increased sediment affecting the Nam La	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Sedimentation is expected to affect a localised area downstream of construction	**Low** The impact will affect an area of relatively good quality habitat; however, it is likely that surface water feature will readily recover from impact after implementation of standard management measures	**High** Disturbance will be long term (in the order of more than two years) until flows gradually flush the accumulated sediment from the catchment	**Low**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High There is a lack of baseline flow data to characterise flow discharge rates in the catchments. Also, predicted sediment loads in discharge from the sediment dams and spillways have not been quantified, which does not allow for accurate prediction of sediment reporting downstream. Additionally, no sediment transport and deposition modelling has been done to quantify the extent and thickness of accumulated sediments due to the project.			

Changes to surface water flow

Nam Pangyun river diversion

The diversion of the Nam Pangyun through the mine pit during year 8 of the project (operations) will permanently alter surface water flows in the mid catchment. The stream diversion is entirely within the mine pit, so changes to surface water flow will be secondary to the direct loss of stream bed, edge and riparian habitat in that section of the river. As this is within the open pit, there will be no available beneficial uses in this section of the Nam Pangyun. During construction of the river diversion and until the diversion is complete, there may be some reduction in surface flow that reaches downstream. Although, the temporary reduction in downstream flow will be to an extent offset by the disposal of water from pit dewatering, there may be a short-term net reduction in overall flow and a change in hydraulic regime for the downstream watercourse.

Once constructed, the river diversion channel will be concrete lined to prevent excessive erosion of the channel during high flows, and to reduce seepage from the channel to the adjacent pit. As a result, it is expected once constructed, flows to the downstream Nam Pangyun natural watercourse will be mostly retained (with the exception of some loss due to seepage around the pit area where the Nam Pangyun is not within a concrete-lined diversion – see below).

Overall, the impact is assessed to be of **low significance** for the Nam Pangyun (mid and lower catchment) based on the **low magnitude** of impact and **low sensitivity** of these features (Table 6.60).

Table 6.60 Residual impact significance summary - changes to surface water flow due to stream diversion - affecting the mid and lower Nam Pangyun catchment

Value	**Sensitivity of value**			
Ability to support ecosystems and beneficial uses - mid and lower Nam Pangyun catchment	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Has limited or no potential to support aquatic ecosystems or be a source of water for beneficial uses.	**Low** The watercourse has been impacted by historic mining has highly degraded habitat. There is little vulnerability to further changes.	**Medium** Some resilience to change. Some of the associated ecosystem value or use can be regained.	**Low**
Impact	**Magnitude of impact to value**			
Changes to surface water flow due to stream diversion affecting the mid and lower Nam Pangyun catchment	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	High Changes in flow are expected to affect most of the mid catchment as flows will be affected within and downstream of the mine pit.	**Low** Impact is likely to be entirely within existing area of the river that is, and has been, prone to periods of low flow during dry conditions. Any temporarily reduced flows would probably be restricted to the already impacted mid and lower Nam Pangyun catchment during dry periods.	**Low** Impact will be short term as changes to flow are expected to occur during construction of the diversion channel.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	High There is limited quantitative data on existing stream flows. Refinement of the water balance and modelling of flows after predicted project water abstraction/diversions would reduce the uncertainty and allow for quantification of water flow changes			

Water abstraction

The project will extract water from both the Nam La and the Nam Pangyun to provide water supply to the project during project operations. Water from the Nam La will be collected via a water harvesting facility in the headwaters of the catchment. Water from the Nam Pangyun will be collected from a diversion dam just upstream of the TSF. Water extracted from both rivers will be directed to the Nam Pangyun Reservoir where it will be stored for use as project raw water.

The Nam La provides water to some parts of Namtu and water abstraction from this water source has the potential for impact to downstream users and aquatic ecosystems (with these values being of higher sensitivity than the Nam Pangyun). The impact of water abstraction will occur throughout the lifetime of the mine. The spatial extent of the impact is expected to be low since only 55% of the runoff from a 10% portion of the Nam La catchment will be extracted, which is approximately equivalent to 5.5% of the total flow at the confluence of the Nam La and Myitnge River at any given time (Figure 6.18). However, modelling of the required abstraction rates for the project and assessment of the downstream flow reductions under different scenarios (e.g., dry season, wet season, dry year, wet year) has not yet been conducted. As the Nam La is the primary water source for several wards and villages in Namtu, flows to the Nam La will be compensated by WMM when the dam has sufficient excess water, with excess water entering the stream via a spillway or pumped from the storage dam. Water from numerous springs and tributaries downstream in the Nam La catchment and the remaining 45% of runoff from the dam catchment area will also continue to flow downstream.

Due to uncertainty regarding the impact of water abstraction under scenarios that involve dry conditions the severity of the impact is considered to be medium, since under drier conditions there is likely to be insufficient excess water available for release from the water harvesting facility and the downstream flows are likely to be also low under these conditions.

WMM will work with key stakeholders to upgrade the Nam La Flume infrastructure so that water from springs in the Nam La catchment can be diverted to the Nam La Flume to supplement normal supply during periods of drought or low flows that may occur as a result of abstraction for the mine water supply. WMM will also conduct further works to assess the capacity of the springs to provide the required flow the flume.

The impact is assessed to be of **high significance** for the Nam La, based on the **medium magnitude** of impact and **high sensitivity** of the feature (Table 6.61); although until predicted changes to downstream water flows are quantified and the feasibility of providing alternative water supply to downstream communities, this impact is associated with a high degree of uncertainty.

Increased abstraction of water from the upper Nam Pangyun (via diversion dam) during operations will be partially offset by discharge of groundwater from the pit dewatering system which will discharge into the Nam Pangyun. The component of groundwater inflows that will be discharged by pit dewatering system is expected to increase from an average of 142 m^3/d in year 1 to 670 m^3/d in year 13. These rates, particularly during the early years of mining are unlikely to completely offset the rate of abstraction higher in the catchment and reduced flows may persist downstream of the Nam Pangyun Reservoir in the mid and lower catchments. The impact is assessed to be of **low significance** in the Nam Pangyun (mid and lower catchment), based on the **medium magnitude** of impact and the **low sensitivity** of these features (

Table 6.62).

Surface flows in the Nam Pangyun around the open pit area are likely to be reduced due to seepage into underlying rocks. This is due to the hydraulic connection between the Nam Pangyun and underlying groundwater, and the influence of pit dewatering that will further lower the water table in the area. While the rate of loss in the area has not been quantified, it will probably be consistent with the rate of loss that would be currently occurring as the stream passes the existing area of the Bawdwin pit and underground mine through most of the mid-catchment, where extensive dewatering has occurred. Additional drawdown is likely to be minor (see Section 6.3) and have a negligible effect on stream flows during operation, but it is expected that this will be a long-term impact until groundwater levels recover after project closure. Notwithstanding, this impact of reduced surface flow would affect the mid and lower catchments (which would be partially offset by discharge of dewatering water) and is expected to be **low significance**, based on the **medium magnitude** of impact and the **low sensitivity** of these features (Table 6.63).

The preferred mine closure option is to divert the Nam Pangyun into the open pit to accelerate filling of the pit and minimise water quality impacts. This closure scenario also relies on the Tiger Tunnel being plugged so that pit water does not escape through the underground workings. Geohydrological modelling indicates that diversion of flow from the Nam Pangyun to the pit would be required for a period of five years at closure to achieve filling, at which point downstream flow would recommence via an engineered spillway. The mid and lower catchments would be impacted by reduced flows. The impact is expected to be of **moderate significance** for the mid and lower Nam Pangyun catchment, based on the **high magnitude** of impact and **low sensitivity** of these features (Table 6.64).

Table 6.61 Residual impact significance summary - changes to surface water flow due to water abstraction from the Nam La during operations

Value	**Sensitivity of value**			
Ability to support ecosystems and beneficial uses - Nam La	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Largely undisturbed compared to the Nam Pangyun and is an important source of water for agriculture/irrigation, industrial use, drinking water in nearby communities.	**High** Nam La is vulnerable to changes in flow particularly during the dry season when flows are already limited.	**Medium** Nam La surface water is somewhat resilient to change due to numerous other tributaries contributing to flow in the catchment	**High**
Impact	**Magnitude of impact to value**			
Changes to surface water flow due to water abstraction from the Nam La during operations	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Reduced surface flow is likely to be localised to the upper catchment (less than 10 %).	**Medium** Reduced flow rates are unlikely to persist downstream as numerous other small tributaries join the main river and provide inflows. The project may need to provide compensation flows to downstream water users, releasing excess water from the raw water dam to maintain supply. However, during dry conditions there may not be excess water available for release from the Nam La water harvesting facility.	**Medium** Impacts are expected to occur in the peak dry season (for a period of months) and may occur annually throughout operations.	**Medium**
	Residual impact significance			**High**
	Assessment of uncertainty			

	High There is limited quantitative data on existing stream flows. Refinement of the water balance and modelling of flows after predicted project water abstraction/diversions would reduce the uncertainty and allow for quantification of water flow changes. The feasibility of providing alternative water supply to downstream conditions, particularly in dry periods, needs to be confirmed.

Table 6.62 Residual impact significance summary - changes to surface water flow due to water abstraction from the Nam Pangyun during operations - affecting the mid and lower Nam Pangyun

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Ability to support ecosystems and beneficial uses - mid and lower Nam Pangyun</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>Low
Has limited or no potential to support aquatic ecosystems or be a source of water for beneficial uses.</td><td>Low
The watercourse has been impacted by historic mining and habitat is highly degraded. There is little vulnerability to further changes.</td><td>Medium
Some resilience during the wet season during high flow periods.</td><td>Low</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact to value</th></tr>
<tr><td rowspan="6">Changes to surface water flow due to water abstraction from the Nam Pangyun during operations affecting the mid and lower Nam Pangyun</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>High
Reduced flows may persist downstream of the Nam Pangyun Reservoir in the mid and lower catchment. Impact affects a large proportion of the catchment</td><td>Low
Impact is pervasive through a highly disturbed area and is unlikely to reduce the capacity to support aquatic ecosystems and/or beneficial uses.
Abstraction of water from the Nam Pangyun during operations will be offset to an extent by discharge of groundwater from the pit dewatering system which will discharge into the Nam Pangyun</td><td>High
Impact will be long term, occurring throughout operations.</td><td>Medium</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Low</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">High
There is limited quantitative data on existing stream flows. Refinement of the water balance and modelling of flows after predicted project water abstraction/diversions would reduce the uncertainty and allow for quantification of water flow changes</td></tr>
</table>

Table 6.63 Residual impact significance summary - reduced surface flows due to seepage into underlying rocks - affecting the mid and lower Nam Pangyun

Value	**Sensitivity of value**			
Ability to support ecosystems and beneficial uses - mid and lower Nam Pangyun	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Has limited or no potential to support aquatic ecosystems or be a source of water for beneficial uses.	**Low** The watercourse has been impacted by historic mining and habitat is highly degraded. There is little vulnerability to further changes.	**Medium** Some resilience during the wet season during high flow periods	**Low**
Impact	**Magnitude of impact to value**			
Reduced surface flows in the mid and lower Nam Pangyun due to seepage into underlying rocks	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	High Reduced flows are expected to affect a large proportion of the mid and lower catchments (which would be partially offset by discharge of dewatering water)	**Very Low** Impact is expected to have a negligible effect on stream flows during operations. The impact would represent a very minor change from existing conditions (i.e., minor additional drawdown in addition to existing drawdown in the pit area).	**High** Impact will be long-term until groundwater levels recover after project closure	**Medium**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Medium Numerical predictions of reduced surface flows due to seepage into underlying rocks has not been completed.			

Table 6.64 Residual impact significance summary - reduced surface flows to the mid and lower Nam Pangyun for 5 years after mine closure

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Ability to support ecosystems and beneficial uses - mid and lower Nam Pangyun</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>Low
Has limited or no potential to support aquatic ecosystems or be a source of water for beneficial uses</td><td>Low
The watercourse has been impacted by historic mining and habitat is highly degraded. There is little vulnerability to further changes.</td><td>Medium
Some resilience during the wet season during high flow periods</td><td>Low</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact to value</th></tr>
<tr><td rowspan="6">Reduced surface flows to the mid and lower Nam Pangyun for 5 years after mine closure</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>High
Reduced flows are expected to affect a large proportion of the mid and lower catchments (which would be partially offset by discharge of dewatering water)</td><td>Medium
Flows may cease completely, however due to the poor existing condition of the stream there is little ecological value or beneficial uses
Some reduction in capacity of stream to support aquatic ecosystems and beneficial uses may occur</td><td>High
Impact will be long term, as diversion of flow from the Nam Pangyun to the pit would be required for a period of five years to achieve filling.</td><td>High</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Moderate</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">High
The effects of diverting the Nam Pangyun to the open pit to accelerate filling and downstream hydrological effects has not been quantified.</td></tr>
</table>

Landform and drainage changes

The TSF, Wallah waste rock dump and the open pit are all permanent landform features that will change site drainage in terms of the nature of the runoff (i.e., flow rate after rainfall) as well as the location of the drainage. The Wallah waste rock dump will contribute drainage to the Wallah valley via a spillway and three-stage sediment dam. It is expected that the drainage will then follow the existing tributary down to the Nam Pangyun. The open pit, after closure, will have the Nam Pangyun flowing into it and will develop a permanent pit lake. This will permanently and significantly change the surface flow regime within the catchment. For example, the rapid rainfall runoff response that is currently experienced in the Nam Pangyun would be highly attenuated by the lake and the lower reaches of the Nam Pangyun would see less rapid fluctuations in flow (and contaminant dispersal) with rainfall. This may also change the sediment transport capacity of the watercourse and therefore the volume and nature of material being deposited downstream, with potentially lower flow rates resulting in increased settlement of coarser particles closer to the source as well as increased settlement of finer particles. This may increase stream aggradation further upstream in the catchment, resulting in smothering of habitat and increased risk of bank overtopping (see Flood risk subsection). The post-closure flow regime and flood risk to downstream communities and activities (e.g., artisanal miners) has not been assessed and quantitative modelling to address this has been proposed in Section 6.4.6.

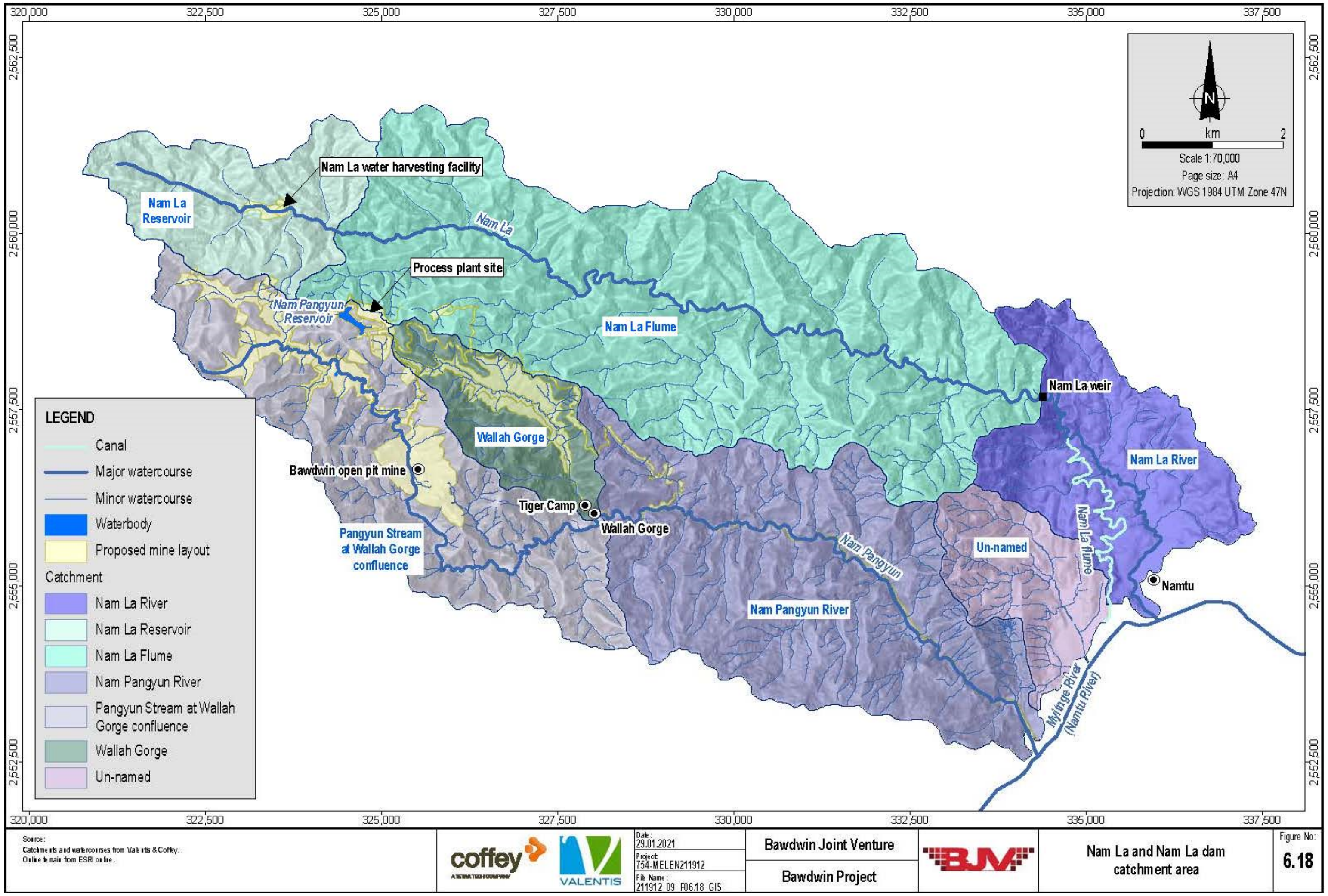


Figure 6.18 Nam La and Nam La dam catchment area

The TSF C embankment will reduce the upstream Nam Pangyun catchment area by about 70% when compared to pre-development. While this will significantly reduce the rainfall runoff through the catchment, this change is partially offset by the ongoing release of ponded water in the TSF during high rainfall periods and from inputs from groundwater baseflows. Also, as sections of the catchment (TSF underdrain and in pit diversion) will be concrete lined, some areas that currently lose water to seepage will be reversed and that water will be able to flow downstream. TSFs A and B will also store water from the Nam Pangyun upper catchment. At the end of year 9 of operations, to maintain the integrity of TSFs A and B, excess supernatant water will be released via the TSF A spillway into the Nam La catchment during average rainfall conditions. The release will occur at a rate ranging from approximately 2,000 m^3/month to 382,000 m^3/month. At the end of Year 12, approximately 5,000 m^3/month to 417,000 m^3/month of offsite release into the Nam Pangyun will occur from the TSF C spillway under average conditions. At closure and prior to covering of the TSFs, all TSFs will be partially drained to reduce the amount of water (and pressure) overlying the tailings. The water will be released via the spillways into the Nam Pangyun and Nam La catchments. After closure, water will continue to drain from the TSF store-and-release covers into the Nam Pangyun and Nam La catchments.

Overall, it is expected that with appropriate project design and management measures in place the overall drainage changes in the Nam Pangyun catchment will be substantial; however, downstream flows are expected to be maintained, although with altered and more regulated flow regimes. Spillways will be in place to allow for discharge from the TSFs after project closure. However, there is high uncertainty with the prediction of residual impact significance in the absence of a project water balance describing the water abstraction volumes and proportion of flows to be abstracted during different scenarios. The impact is assessed to be of **low** (mid and lower Nam Pangyun) **to moderate** (upper Nam Pangyun) **significance**, based on the **medium magnitude** of impact and **low** (mid and lower catchment) **to medium** (upper catchment) **sensitivity** of these features (Table 6.65)

Table 6.65 Residual impact significance summary - altered flow regime in the Nam Pangyun due to landform and drainage changes

Value	**Sensitivity of value**			
Ability to support ecosystems and beneficial uses - Nam Pangyun (upper, mid and lower catchment)	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low (mid and lower catchment) to medium (upper catchment) The upper catchment is relatively undisturbed compared to the mid and lower catchment, and has beneficial uses, including drinking water. The mid and lower catchment is highly modified and degraded watercourse that is not used for drinking water.	**Low (mid and lower catchment)** The watercourse has been impacted by historic mining and habitats are highly degraded. There is little vulnerability to further changes. **Medium (upper catchment)** Currently stream habitat is in relatively good condition and is better than the mid and lower catchment. Vulnerable to further deterioration.	**Medium** Some resilience during the wet season during high flow periods	**Low (mid and lower catchment) to medium (upper catchment)**
Impact	**Magnitude of impact to value**			
Altered flow regime due to landform and drainage changes affecting the Nam Pangyun	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	High A large portion of the Nam Pangyun catchment will be affected as landform and drainage changes occur in several locations.	**Medium** Impact is partially within an existing disturbance area (mid and lower catchment) and an area of low-level disturbance (upper catchment). The change to flows will be notable during the five-year period of filling the pit with Nam Pangyun flow. Despite substantial drainage changes, the severity (i.e., degree of change to downstream ecosystems and potential for beneficial uses) will be low if downstream flows are adequately maintained).	**Very high** Changes to landform and drainage and subsequent changes to flow regime are expected to be permanent	**Medium**
	Residual impact significance			**Low (mid and lower catchment) to moderate (upper catchment)**
	Assessment of uncertainty			
	High There is uncertainty with this rating in the absence of a project water balance describing the water abstraction volumes and proportion of flows to be abstracted during different scenarios. This means the impact significance could be lower (if modelling were to show a low proportion of Nam Pangyun flows will be affected) or higher (if modelling were to show a high proportion of Nam Pangyun flows will be affected) than assessed herein. Also, the changes to the flow regime in the Nam Pangyun due to flooding the open pit will be complex and would need to be assessed by hydrological modelling.			

Flood risk

Flood risk assessment has not yet been completed to characterise the existing flood conditions or to determine what effect the altered catchment landform, infrastructure placement and changes to sediment load may have on flood levels and flow velocities during construction, operation or closure. Assessment of flood risk is also required to inform the safe placement and design of mine infrastructure to ensure that they are adequately constructed to withstand flood conditions.

Flood risk assessment for both the Nam Pangyun and Nam La catchments will be undertaken by WMM prior to construction. The flood risk assessment will incorporate relevant climate change scenarios which are likely to result in more frequent and severe flood events in high rainfall areas. It will also consider the combined effects of increased sediment load from disturbed project areas and a reduced capacity for sediment transport (as a result of reduced stream flow velocities during periods of water abstraction and as a result of engineered water dams. These changes may result in streambed aggradation, and in turn an increased flood risk.

The following discussion is based on a qualitative assessment of flood risk and will be verified by more detailed assessment and flood modelling as required during detailed design and prior to construction.

Flood levels in areas downstream of the TSFs and waste rock dump are likely to be lower when compared to the existing conditions where flood levels and flow velocities are reported to respond rapidly to runoff from storm events. TSFs will be designed and constructed with embankments and spillway levels that will retain rainfall falling within the TSF footprint under normal operation and rainfall conditions. Collected rainfall will be returned to the process water circuit during operation. Retained water in the TSFs will result in a reduced flow contribution to the downstream Nam Pangyun catchment and lower flood levels. However, these reduced flow rates downstream of TSFs may lead to streambed aggradation contributing to an increased flood risk over time.

Flood risk will be higher downstream of the TSF engineered spillways. The TSF's engineered spillways have been designed based on an estimated probable maximum precipitation (PMP) event of 284 mm over 24 hours. Large storm events that exceed the TSF's design capacity during operation will result in concentrated discharge of surface water flow that is expected to result in locally increased flood flow velocities in the area immediately downstream of the engineered spillways. Spillways will be appropriately designed to dissipate increased flow velocities, however detailed assessment is required to fully characterise downstream flood risks during a large storm event that exceeds the PMP.

TSF engineering design for closure incorporates an engineered spillway that will discharge some runoff from the Nam Pangyun catchment (from TSF-A and TSF-B) into the Nam La catchment. This change to the water balance at closure will increase the volume of runoff to the Nam La catchment during high rainfall events, and is expected to increase the downstream flood risks in the Nam La catchment. A flood risk assessment is required to quantify the risk posed to downstream receptors, such as the Nam La weir and flume infrastructure, roads, river crossings and nearby communities.

The waste rock dump and a series of three downstream sediment retention ponds will occupy all of the Wallah Valley. Under existing conditions, a high proportion of rainfall is expected to report to Wallah Valley stream as runoff. Construction of the waste rock dump in Wallah Valley is expected to result in lower rainfall runoff than under pre-mining condition due to an increased proportion of rainfall infiltrating the higher permeability waste rock and the subdued topography that will result from filling a portion of the valley. While a portion of rainfall will continue to enter surface water drains as runoff, a component of rainfall that would normally contribute to runoff and flood events in Wallah Valley and the downstream Nam Pangyun catchment is expected to infiltrate through the waste rock and either be collected at the base of the waste rock dump by the under-drainage system or contribute to groundwater mounding. All runoff and captured seepage will report to three sediment dams beyond the toe of the waste rock dump embankment where it will be retained and diverted through an initial 12 m high dam, followed by two supplementary 8 m high dams further downstream. The net effect of the altered landform in Wallah Valley and construction of sediment dams is expected to create a time lag between rainfall and water reporting to the downstream catchment, that will attenuate the downstream flood peak levels and flow velocities.

Largely, it is assumed that the engineering design will work towards flattening flood peaks, as mine contact water and water falling on TSFs and the waste rock dump will be retained for settling of solids before release. These controls will probably reduce downstream flood risks but may result in localised areas of increased flood risks around mine infrastructure where they represent barriers to flow. These will need to be appropriately addressed by the engineering design and mine planning.

Overall, it is expected that with appropriate project design flood risk around the project infrastructure and other community assets in the lower Nam Pangyun catchment can be managed. The impact is assessed to be of **low** (mid and lower Nam Pangyun) **to moderate** (upper Nam Pangyun) **significance**, based on the **medium magnitude** of impact and **low** (mid and lower catchment) **to medium** (upper catchment) **sensitivity** of these features (Table 6.66). The residual impact assessment has a high degree of uncertainty, since the magnitude of flood events has not been quantified due to the limited data on baseline stream flows and detailed flood risk assessment/modelling for a range of scenarios has not been undertaken.

Table 6.66 Residual impact significance summary - altered flood risk in the Nam Pangyun from project infrastructure

Value	**Sensitivity of value**			
Ability to support ecosystems and beneficial uses - Nam Pangyun (upper, mid and lower catchment)	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low (upper catchment) to medium (mid and lower catchment) The upper catchment is relatively undisturbed compared to the mid and lower catchment, and has beneficial uses. The mid and lower catchment is highly modified and degraded watercourse.	**Low (mid and lower catchment) to medium (upper catchment)** While the overall vulnerability of the Nam Pangyun is low to medium, the vulnerability to flood risk is considered high. The Nam Pangyun catchment is characterised by rapid flood response to high rainfall events. The catchment contains drainage with highly aggraded channels and banks as well as narrow valleys. The catchment contains villages, road and rail infrastructure in close proximity to the watercourse and is considered to be highly vulnerable to altered flood conditions.	**Medium** Some resilience during the wet season during high flow periods	**Low (mid and lower catchment) to medium (upper catchment)**
Impact	**Magnitude of impact to value**			
Altered flood risk in the Nam Pangyun from project infrastructure	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Areas of increased flood risk are expected to be localised	**Low** Impact is within partially within an existing disturbance area (mid catchment) and an area of low-level disturbance (upper catchment). Changes to drainage unlikely to reduce the capacity to support aquatic ecosystems and/or beneficial uses. Minimal impact or possibly improved (i.e. reduced) flood conditions may be achieved in the lower catchment if infrastructure design and placement takes into account localised increased flood risk around the mine area.	**Very high** Impact is expected to be permanent as project infrastructure will be permanent	**Low**
	Residual impact significance			**Low (mid and lower catchment) to moderate (upper catchment)**
	Assessment of uncertainty			
	High The magnitude of flood events has not been quantified due to the limited data on baseline stream flows. Detailed flood risk assessment would reduce uncertainty by predicting the spatial extents and severity of flood risks under a range of scenarios and allow better understanding of risks to downstream communities.			

While flood modelling has not been completed for the Nam La catchment, some preliminary assumptions can be made based on the engineering design for the TSFs and anecdotal evidence of existing conditions in the catchment. It is understood that flash flooding is common in the Nam La catchment and requires that the existing Nam La weir (at the offtake point for the Nam La flume) to be manned by an operator who can respond quickly to the rising flood levels and avoid damage to the flume infrastructure. As mining progresses, and TSFs A and B reach capacity, runoff from the TSFs will be diverted via spillways to the head of the Nam La. This will ultimately increase the catchment area and volume of water in the Nam La catchment during a flood event and may pose an increased flood risk to downstream infrastructure and the Namtu township. Flood risk assessment is required to quantify the increased flood risk to the Nam La catchment so that appropriate mitigations can be developed.

Increased flow contribution from TSF spillways to the Nam La catchment after mine closure could have a **high significance** to downstream receptors, based on the **medium magnitude** of impact and **high sensitivity** of the features. Flood risk assessment is required to quantify the flood risk so that appropriate mitigation measures that can be implemented to reduce the impact significance to an acceptable level (Table 6.67).

Table 6.67 Residual impact significance summary - altered flood risk in the Nam La from project infrastructure

Value	**Sensitivity of value**			
Ability to support ecosystems and beneficial uses - Nam La	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Largely undisturbed compared to the Nam Pangyun and is an important source of water for agriculture/irrigation, industrial use, drinking water in nearby communities. The watercourse passes through Namtu and hosts the Nam La weir and Nam La flume, which supply potable water to parts of Namtu.	**High** Existing conditions in the Nam La are characterised by rapid response to storm events and flash flooding. The catchment is likely to be vulnerable to increased flows, particularly when they coincide with high rainfall events.	**Medium** Nam La surface water is somewhat resilient to change due to limited development of the catchment. The Nam La weir is manually controlled so that flood flows can pass without damaging the structure. Infrastructure may already be at limit of flood levels and damage has been experienced under existing conditions. The capacity to manage increased flood levels and flow velocities and flood levels are unknown, but probably will be limited.	**High**
Impact	**Magnitude of impact to value**			
Altered flood risk in the Nam La from project infrastructure	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Areas of increased flood risk are expected to extend through the catchment.	**Medium** Changes to flood levels and velocities are unknown and may impact the capacity to support aquatic ecosystems and/or beneficial uses. Moderate potential for increased flood risk impacting potable water supply infrastructure, and other community infrastructure.	**Low** While infrastructure will be in place for a long term period, it is expected that flood events would be short term and infrequent..	**Medium**
	Residual impact significance			**High**
	Assessment of uncertainty			
	High The magnitude of flood events has not been quantified due to the limited data on baseline stream flows. Currently limited understanding of flood risk as a result of TSF spillway diversion. Detailed flood risk assessment would reduce uncertainty by predicting the spatial extents and severity of flood risks to the Nam La at closure and allow better understanding of risks to downstream communities.			

Reduced water quality

Context and water quality criteria

The project water management strategy involves diverting rainfall runoff and stream flow from undisturbed areas around areas of project disturbance and into downstream watercourses where practicable. This approach will minimise the volume of water coming into contact with disturbed mine areas and minimise the potential for contamination. The strategy to manage water quality impacts associated with drainage from disturbed areas is to direct the drainage into sediment dams, where the suspended sediments in the water (likely to contain high metals concentrations) will settle out and water quality can be monitored prior to controlled release into the environment with the aim of meeting the mining effluent guideline values in the Myanmar draft national environmental quality emission guidelines (Myanmar effluent guidelines). The sediment dams (see Figure 4.30) will capture and settle much of the high TSS loads (coarser fractions; i.e., sands and coarse silts) in the ‘initial flush’ of runoff from disturbed sites and reduce the sediment loads, and potentially particulate metal loads into downstream surface waters.

Notwithstanding, it is expected that even with these measures in place, the project will result in reduced downstream water quality, particularly in relation to dissolved metals and finer suspended sediments, which are more difficult to control in surface runoff. The project will treat process plant water, waste rock dump seepage water and TSF supernatant water to meet Myanmar draft national environmental quality emission guidelines (where practicable) prior to discharge to the environment. Fine particles, residual reagents and both dissolved and particulate metals are likely to be present in this water at concentrations that may pose a risk to beneficial uses of surface water if discharge is untreated. Process water, seepage and excess supernatant water will be collected and treated via a process water treatment plant which incorporates a lamella clarifier and microfiltration system. The backwashed residual sludge will be periodically sent to the tailings tank for discharge into the TSF.

The project will monitor runoff, leachate and effluent discharge sources to check contaminant concentrations against the Myanmar draft national environmental quality emission guidelines. An effluent discharge is a controlled release of wastewater from the project. Table 6.68 presents the Myanmar draft national environmental quality emission guidelines for mining effluent levels, which apply to effluent prior to be disposed into the environment. The standards are based on IFC mining effluent guidelines, which are applicable to total contaminant concentrations.

Impacts in this section are assessed assuming the design and management controls outlined in Section 6.4.3 are implemented. However, where impacts are still likely to occur, these are described in this section with supporting commentary. In addition, the impacts to water quality are assessed in the context of the already heavily impacted existing surface water features and the lack of current and beneficial uses associated with surface waters, in particular the Nam Pangyun, which has a low sensitivity. The impacts to water quality are assessed below.

In the absence of water quality standards for aquatic ecosystem protection in Myanmar, parameters in surface water have been assessed with reference to the Australia and New Zealand water quality guidelines. These outline default guideline values (DGVs) for ecological protection. As discussed in Section 5.3, the existing mid and lower Nam Pangyun sections are currently highly impacted with poor water quality, characterised by total and dissolved metal concentrations (such as lead, cadmium and zinc) significantly elevated above the DGVs. The upper catchment of the Nam Pangyun currently has relatively good water quality (being upstream of the existing major mining and waste disposal activities), although at some baseline monitoring sites numerous metals concentrations were above Australian and New Zealand ambient water quality guidelines. It is the upper catchment that is therefore more vulnerable to water quality impacts.

Table 6.68 Mining effluent standards in the Myanmar draft national environmental quality (emission) guidelines (MOECAF, 2014)

Parameter	Unit	Maximum concentration/Effluent limit value
Arsenic	mg/L	0.1
Cadmium	mg/L	0.05
Chemical oxygen demand	mg/L	150
Chromium (hexavalent)	mg/L	0.1
Copper	mg/L	0.3
Cyanide	mg/L	1
Cyanide (free)	mg/L	0.1
Cyanide (weak acid dissociable)	mg/L	0.5
Iron (total)	mg/L	2
Lead	mg/L	0.2
Mercury	mg/L	0.002
Nickel	mg/L	0.5
pH	Standard unit	6-9
Temperature	°C	< 3 differential
Total suspended solids (TSS)	mg/L	50
Zinc	mg/L	0.5

Sources of reduced water quality

This section provides detail of the project sources that may contribute to reduced water quality. For context, a summary of characteristics of the key project mine wastes, tailings and waste rock, is given (further detail is provided in Chapter 4 Project Description); and then the project sources of runoff, leachate and discharge and subsequent contamination of each of the surface water features are described.

Mine waste

Testwork by Knight Piésold (2020) showed that leachate from most of the 90 waste rock samples analysed contains metals/metalloids, sulfate and total dissolved solids (TDS) at concentrations well in exceedance of Myanmar National Environmental Quality (Emission) Guidelines. Aluminium, arsenic, cadmium, cobalt, copper, nickel, lead, zinc, sulfate and TDS all exceeded the guidelines (see Table 4.17 in Chapter 4 Project Description). Only 1% of the waste rock is potentially acid forming (PAF) and selective management of the PAF waste rock will be required to limit acid forming conditions and to reduce leaching of metals and metalloids from the waste rock.

Supernatant water from two tailings samples was tested to provide a preliminary indication of the water quality which may be encountered in the TSFs during operations (Knight Piésold, 2020). The composited samples analysed represented early (‘Stage 1/2’) and late (‘Stage 4’) stage tailings. Testing of the supernatant water showed the water to be of a very poor quality with TDS, cadmium, cobalt, lead, nickel, sulfate and zinc exceeding the Myanmar National Environmental Quality (Emission) Guidelines for both samples. Additional exceedances were recorded for arsenic in the early (Stage 1/2) sample and free cyanide in the late (Stage 4) sample. Testing indicated that the tailings will not generate excess acidity.

The implications of the testing results for potential contamination of water in the Nam Pangyun and other catchments are discussed in the following text.

Project sources of potential water contaminants

Project sources of runoff, leachate and discharge that have potential for subsequent contamination of surface waters are as follows:

- Nam Pangyun upper catchment – high metals and sulfate concentrations and potentially residual cyanide in TSF leachate and discharge of excess TSF decant water; and high TSS concentrations in surface runoff from construction areas. Discharge from the TSFs into the Nam Pangyun will occur via controlled discharge via the water treatment plant, via the spillway in the event of extreme circumstances and via uncaptured seepage through the base of the TSF, which may eventually report to surface waters. The high TSS concentrations in runoff will be greatest downstream of major earthworks such as at the TSF embankment constructions, power station site, processing plant site, haul roads, and mining services area.
- Nam Pangyun mid catchment – sediment and contaminants in runoff from contaminated areas around the mine (including stockpile areas, soils with high legacy contamination and areas where contaminated water is used for dust suppression), and overflow of pit water after closure. At closure, there will be two pits – main pit and small pit – that will eventually form pit lakes. The overflow of pit water after closure will not be treated and will probably contain high total and dissolved metals concentrations. Tables 6.20 and 6.21 present the results of mass balance modelling (CSA, 2020) of predicted water quality in the final pit lakes of the main and small pits (in terms of total metals) and the elevated totals metals concentrations are discussed earlier in this section. There is uncertainty in the assessment of acid formation in the pit at closure as outlined in Section 6.4.6. The residual impact assessment has made assumptions that the proposed closure strategy will involve rapid filling of the pit lake, which will limit formation of acid. The impact assessment has not specifically assessed the impact of acid formation.
- Nam Pangyun mid catchment – pit dewatering will have variable water quality that is expected to contain higher concentrations of total and dissolved metals over time as the pit depth increases. Water produced by dewatering will include some or all of the existing discharge of contaminated water from Tiger Tunnel in later years, ultimately releasing to the mid-catchment rather than the existing point at the top of the lower catchment.
- Nam Pangyun lower catchment – leachate from the Wallah waste rock dump which may contain metals; excess water runoff from the same dump, continued discharge of highly turbid and metal-rich dewatering water from the Tiger Tunnel, and the contamination sources listed above for the upper and mid catchment. Construction of the access road is also expected result in local sediment runoff into the Nam Pangyun lower catchment.
- Myitnge River downstream of the confluence with the Nam Pangyun – potential for increased sedimentation, TSS and dissolved and total metals from the Nam Pangyun contribution of contaminants as described above.
- Nam La – short-term increase in TSS and turbidity during construction of the process plant, power accommodation facility, raw water storage dam in the stream’s headwaters and from the earthworks at the processing plant site. Potential long-term, periodic increase in TSS, turbidity and heavy metals (total and/or dissolved) associated with spillway releases from the capped TSF-A.

While the project will treat discharges to meet the Myanmar mining effluent standards (i.e., for treated TSF seepage and runoff and wastewater discharges from camps) during construction and operations, there may still be water quality impacts downstream of project activities even if the effluent standards are met. This is due to the following reasons:

- Dilution in a mixing zone will be required before some parameters reduce to concentrations below ANZ guidelines or below or within measured background ranges in the receiving waters.
- The effluent standards are based on ‘total’ (i.e., unfiltered) contaminant concentrations which include both the dissolved and particulate forms of the contaminant. Treating discharge, leachate and runoff to meet the total concentrations does not necessarily mean that downstream increases in dissolved concentrations above ambient ANZ water quality guidelines, and impacts to environmental values and beneficial uses, will not occur.

- There are some parameters (e.g., antimony, manganese and sulfate) that can cause ecotoxicity in waters but there are no effluent standards for them.

This impact assessment has assumed treatment, as outlined in Section 6.4.3 Water seepage, collection and management, will enable the Myanmar mining effluent criteria to be met. Although, as outlined above this does not necessarily mean impacts to values associated with water quality will not occur. .

Post closure water quality (runoff and leachate from the pit, TSF and Wallah waste rock dump) has not been quantitatively modelled and it is currently not confirmed how post-closure water quality will be managed. Section 6.4.6 further discusses the uncertainty and further work required on this issue.

Assessment of water quality impacts

In this assessment of water quality impacts the existing background water quality, downstream beneficial uses and relevant effluent and ambient water quality guidelines are considered.

In the Nam Pangyun upper catchment, the existing water quality is relatively good, and the existing concentrations of numerous water quality parameters are below the limits outlined in the effluent standards. Discharges to the upper catchment that contain contaminants but are under the limits outlined in the effluent standards will result in the receiving environment having increased contaminant levels compared to the existing background ranges – until the dilution of effluent in the stream reduces the concentrations to within background ranges.

At the three surface water monitoring sites in the upper catchment (SWSP04, SWNP01 and SWNP02; see Section 5.3), the maximum measured total concentrations of arsenic (maximum concentration of 0.05 mg/L), cadmium (0.0035 mg/L), mercury (0.00028 mg/L) and nickel (0.049 mg/L) are below the respective effluent standards of 0.1 mg/L, 0.05 mg/L, 0.002 and 0.5 mg/L for these metals. Therefore, effluents treated to the Myanmar effluent standards would require approximately 2, 14, 7 and 10 dilutions for arsenic, cadmium, mercury and nickel respectively to be within the measured background ranges. These estimates assume natural flow in the Nam Pangyun; however, significant portions of the upper catchment will be affected by either tailings disposal or mining activities and dilution will probably only occur in a substantial way during passage of water through the lower catchment.

In the Nam Pangyun mid catchment, the maximum recorded value of several total metal concentrations measured during the monitoring period exceed the limits for effluent discharge, with only cadmium, mercury and nickel below it. In the mid catchment, the maximum measured total metal concentrations of cadmium (0.0224 mg/L), mercury (0.00121 mg/L) and nickel (0.101 mg/L) are below their respective effluent criteria of 0.05 mg/L, 0.002 mg/L and 0.5 mg/L. Discharges treated to the effluent standards would require approximately two, two and five dilutions for cadmium, mercury, and nickel respectively to be within background ranges.

Based on the baseline data collected, any discharge into the lower catchment which meets effluent criteria will be within existing background ranges, with the exception of mercury, which would require five dilutions to reduce from the effluent criterion of 0.002 mg/L to within the maximum recorded baseline value of 0.00036 mg/L.

There has been no quantitative modelling of predicted downstream water quality changes due to the project, including no modelling to predict concentration increases above existing levels and points in the receiving stream where contaminant concentrations will reduce to within background ranges and/or meet Australian and New Zealand ambient water quality guidelines for aquatic ecosystem protection (adopted in the absence of Myanmar ambient water quality standards). Similarly, there has been no modelling of water quality changes due to leaching and runoff from the open pit, TSFs and Wallah waste rock dump after closure. The assessment of changes to water quality is therefore approached qualitatively in this section, with reference to existing water quality conditions and Australian and New Zealand ambient water quality guidelines. It is not possible to assess how treating discharge, leachate and runoff to the Myanmar effluent standards may result in downstream water quality meeting (or exceeding) Australian and New Zealand ambient water quality guidelines for aquatic ecosystem protection. This is because, as mentioned above, the Myanmar effluent standards are based on total (i.e., unfiltered) metals concentrations whereas the Australian and New Zealand ambient water quality guidelines for aquatic ecosystem protection are relevant to dissolved (i.e., bioavailable) metals concentrations.

As locals source drinking water from springs and do not drink from the Nam Pangyun within the Bawdwin concession area, impacts to drinking water sources are addressed in Section 6.4. Water quality impacts in this section are assessed solely in terms of the Nam Pangyun's ability to support aquatic ecosystems.

It is likely that during construction of the TSFs and other project facilities in the upper catchment, there will be times where surface runoff from disturbed areas will result in TSS concentrations above the effluent standard of 50 mg/L, as runoff can become very turbid in heavy rainfall. Turbidity and TSS increases will be most intense during construction when large areas of disturbed earth are exposed to erosion. As outlined in Section 6.2.4, measures will be implemented to manage surface drainage around construction sites and limit erosion. However, prior to revegetation of surfaces, disturbed earth such as the TSF embankments will pose a source of sediment-laden runoff during rainfall events. It has been assumed that all runoff from disturbed areas will be collected and diverted to sediment dams. The use of sediment dams will allow much of the sands and coarse silts fractions of suspended sediments (see Stream aggradation and sediment effect subsection) to settle out during the initial 'first flush' after heavy rainfall when TSS (and turbidity) is typically at its highest.

It is likely that the upper catchment will have some increases in contaminants (e.g., dissolved and total metals, sulfate and residue reagents as a result of seepage, runoff and discharge from the TSFs during project operations. This will further reduce the water quality in the upper Nam Pangyun and reduce its ability to support aquatic ecosystems. It is expected that the impact of reduced water quality will be secondary to the direct removal of in-stream and riparian habitat in that section of the river due to it being converted to an underdrain beneath the TSF. Similarly, in the mid catchment within the open pit, that section of the Nam Pangyun will be diverted within the pit in the form of a concrete-lined channel, and all riparian and edge vegetation, if present, will be removed. Again, reduced water quality in the mid Nam Pangyun will be secondary to the direct loss of potential habitat and the potential for beneficial uses (due to the river section being within the open pit). Direct loss of habitat is assessed in Section 6.8.

In the mid and lower Nam Pangyun catchment, existing water quality is very poor as described in Section 5.3. It is expected that, the treatment of leachate, runoff and discharge sources during project operations to the Myanmar mining effluent standards, combined with the continuation of current discharge of poor quality groundwater via the Tiger Tunnel, will result in impacts to water quality that are comparable to the current situation. In the context of existing high TSS concentrations (maximum ranges being between 100 mg/L to 1,000 mg/L TSS) and numerous dissolved metals concentrations being orders of magnitude above ANZ ambient guidelines for aquatic ecosystem protection, it is likely that contamination sources from the project will be of low severity given the already highly impacted river system. Water quality modelling is required to quantify increases in specific contaminant concentrations with respect to background ranges. It is possible that existing concentrations of coarser fractions of suspended sediments and associated particulate metals observed in site runoff could be reduced as a result of coordinating all runoff and diverting it through sediment dams, prior to discharge into the Nam Pangyun. The concentrations of dissolved metals may however increase.

Although the TSFs and waste rock dump will be capped upon project closure, ongoing leaching will occur after closure and release dissolved metals into the surrounding environment (Knight Piésold, 2020). Also, after closure, the open pit will eventually fill with groundwater and rainwater and will overflow, releasing waters that contain high concentrations (i.e., above international ambient water quality guidelines for aquatic ecosystem protection) of metals into the surrounding environment. The predicted downstream water quality changes due to these sources have not been modelled and so cannot be accurately quantified. However, it is considered that these contamination sources will continue to result in poor water quality in the Nam Pangyun (and to a lesser extent the Myitnge River) after project closure, although modelling of post-closure water quality is needed to be able to describe the water quality changes and timeframes over which those changes will occur. After closure, based on mass balance estimations, it is predicted that the pit lake in the main pit will have concentrations of total arsenic, cadmium, copper, lead, nickel and zinc that are within the Myanmar mining effluent standards due to dilution by the Nam Pangyun inflows. These estimated pit lake concentrations are shown in Table 6.69 (main pit) and Table 6.70 (small pit). The small pit is predicted to form a pit lake 14 years after closure. The pit water is predicted to have arsenic, cadmium, copper and nickel concentrations that are within the Myanmar mining effluent standards and lead and zinc in exceedance of the standards (Table 6.70).

Table 6.69 Estimated metal concentrations in final pit lake (main pit)

Parameter	Unit	Mining emission guideline (MOECAF, 2014)	Estimated concentration in final pit lake
Arsenic	mg/L	0.1	0.0016
Cadmium	mg/L	0.05	0.0016
Copper	mg/L	0.3	0.1003
Lead	mg/L	0.2	0.1184
Nickel	mg/L	0.5	0.0334
Zinc	mg/L	0.5	0.2919

Source: CSA (2020)

Table 6.70 Estimated metal concentrations in final pit lake (small pit)

Parameter	Unit	Mining emission guideline (MOECAF, 2014)	Estimated concentration in final pit lake
Arsenic	mg/L	0.1	0.0008
Cadmium	mg/L	0.05	0.0072
Copper	mg/L	0.3	0.0682
Lead	mg/L	0.2	0.5019
Nickel	mg/L	0.5	0.0179
Zinc	mg/L	0.5	0.8753

Source: CSA (2020)

Overall, the impact of reduced water quality is expected to be largely contained to within the Nam Pangyun catchment, which will be the primary recipient of surface water contamination due to the project. –However, modelling of impact to downstream water quality is still required to confirm this. The upper catchment is likely to receive the most severe change in water quality from existing conditions, due to seepage, discharge and runoff from the TSFs and considering it currently has relatively good water quality. During construction and operations, water quality in the mid- and lower- Nam Pangyun is expected to continue to be impacted at a severity similar to the existing situation, largely due to the discharge of dewatering water, which is expected to be very high in metals and TSS (as per the current Tiger Tunnel discharge). With the collection and diversion of all site drainage (i.e., from disturbed areas) to sediment dams, it is possible that coarse and silt fractions of the suspended sediment loads and associated particulate metals inputs into the Nam Pangyun catchment could be reduced from the current situation at Bawdwin where sediment runoff into the Nam Pangyun is not controlled. The attenuation of TSS and particulate metals into drainage in the dams would lessen the initial intensity of increased suspended sediments in runoff, but it is likely that high TSS and turbidity will still report to downstream waters once the levels of sediment reach the design capacity in the dams, and particularly due to finer sediments which may not be able to be settled in the dams. Pangyun catchment, which will be the primary recipient of surface water contamination due to the project.

Given the current and ongoing sources of impact (e.g., Tiger Tunnel discharge, erosion of historic slag and waste rock deposits, sediment accumulation and mobilisation of sediments from artisanal mining) to the mid and lower Nam Pangyun, and with sediment management and water treatment in place, it is not expected that the project will materially increase the existing severity of impacts in the Myitnge River downstream of the Nam Pangyun confluence during construction and operations. However, there is high uncertainty with this prediction as there is limited water quality data for the Myitnge River downstream of the confluence with the Nam Pangyun, and modelling of downstream water quality is required to reduce the uncertainty. The uncertainty is largely driven by lack of data on existing flow discharge rates and the severity and extent of existing water quality, sediment quality and habitat impacts.

During and after closure, however, leachate and runoff from the TSF, open pits and Wallah waste rock dump may provide an ongoing source of metals into the Nam Pangyun, and in the case of the open pits, increased metals and potentially increased acidity . The closure strategy which involves removing the TSF surface water management channels, Nam Pangyun drainage channels, and surface water management channels will allow runoff from the upper catchment to fill the open pit within five years of closure (CSA, 2020). Mass-balance water balance modelling of this closure scenario by CSA (2020) determined inflows of water from the Nam Pangyun would sufficiently dilute metals in the pit lake such that water released from the lake will meet effluent discharge standards.

It should be noted that the mass balance modelling undertaken by CSA does not take account of untreated TSF seepage which is likely to report to the open pit lake post-closure. This seepage is likely to contain elevated concentrations of total and dissolved metals and TSS. Additionally, potential dissolved metal concentrations and the pH of the pit lake after closure are also unknown. The potential for acidic and metalliferous conditions to form in the post-closure period will be assessed and quantified to better understand the predicted changes in water quality. In the absence of water quality modelling, for the purposes of this impact assessment the post-closure impacts to the catchment water quality due to ongoing contamination from the TSF, open pit and Wallah waste rock dump are expected to be long term.

Impacts to the Upper Nam Pangyun due to reduced water quality are as follows. There will probably be a measurable reduction in water quality due to increased total and dissolved metals, sulfate, TSS and potentially cyanide from the TSFs. In the context of the stream being changed to a drainage channel beneath the TSF, water quality impacts are considered secondary to direct loss of the habitat and the loss of available beneficial uses in that area. The impact to the Upper Nam Pangyun is assessed as being of high significance, based on the high magnitude of impact and medium sensitivity of the feature (Table 6.71). There is also likely to be a measurable reduction in water quality in the Upper Nam Pangyun due to increased metals, sulfate and potentially cyanide from the TSFs due to the ongoing and long-term leachate/seepage from the TSFs after closure. Due to the extended duration of impact the significance is assessed as being of high significance, based on the high magnitude of impact and medium sensitivity of the feature (Table 6.72).

Table 6.71 Residual impact significance summary - reduced water quality due to contamination from project sources around the mine and runoff from the TSFs - affecting the upper Nam Pangyun

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Ability to support ecosystems and beneficial uses - upper Nam Pangyun</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>Medium
In some areas in the upper catchment water supports aquatic ecosystems and has the potential to support a range of beneficial uses</td><td>Medium
Currently exhibits moderate water quality, and, is of better quality than the mid and lower catchment.
Vulnerable to further deterioration of water quality.</td><td>Medium
Some resilience to change. Some of the associated ecosystem value or use can be regained.</td><td>Medium</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact to value</th></tr>
<tr><td rowspan="6">Reduced water quality due contamination from project sources around the mine and runoff from the TSFs affecting the upper Nam Pangyun.</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>High
Impacts will affect most of the upper catchment, downstream of contaminant sources</td><td>Medium
Water quality impacts are considered secondary to direct loss of the habitat and the loss of available beneficial uses in that area. However, even with management measures in place and treatment of effluent with the aim of meeting Myanmar standards, the reduction in water quality in this section of river is expected to have medium severity, with some capacity to support aquatic ecosystems reduced</td><td>High
Impact will be long term, occurring throughout construction and operations.</td><td>High</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>High</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">High
There is limited baseline stream flow data and lack of quantitative predictions of downstream water quality chemistry. To reduce uncertainty and allow for understanding of changes to water quality in relation to existing concentrations in ambient waters and international water quality guidelines, geochemical modelling of runoff contaminant concentrations (correlated with a range of flow conditions) and predicted changes to water quality will be necessary. Concentrations of cyanide in receiving waters (under a range of flow conditions) should be predicted from the modelling as this contaminant will be of concern to stakeholders.</td></tr>
</table>

Table 6.72 Residual impact significance summary - reduced water quality due contamination from project sources around the mine and runoff from the TSFs after closure - affecting the upper Nam Pangyun

Value	**Sensitivity of value**			
Ability to support ecosystems and beneficial uses - upper Nam Pangyun	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium Supports some beneficial uses or has medium potential to support aquatic ecosystems	**Medium** Currently stream habitat is in relatively good condition and is better than the mid and lower catchment. Vulnerable to further water quality deterioration.	**Medium** Some resilience to change. Some of the associated ecosystem value or use can be regained.	**Medium**
Impact	**Magnitude of impact to value**			
Reduced water quality due contamination from project sources around the mine and runoff from the TSFs after closure affecting the upper Nam Pangyun.	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	High Impacts will affect most of the catchment, downstream of contaminant sources	**Medium** Water quality impacts are considered secondary to direct loss of the habitat and the loss of available beneficial uses in that area. However, the reduction in water quality in this section of river is expected to have medium severity, with some capacity to support aquatic ecosystems reduced	**High** Impact is expected to be long term, however the extended duration of impact does not increase the significance as this section of the river will be underneath a TSF	**High**
	Residual impact significance			**High**
	Assessment of uncertainty			
	High There is limited baseline stream flow data and lack of quantitative predictions of downstream water quality chemistry. To reduce uncertainty and allow for understanding of changes to water quality in relation to existing concentrations in ambient waters and international water quality guidelines, geochemical modelling of leachate/seepage contaminant concentrations and predicted changes to water quality will be necessary. Concentrations of cyanide in receiving waters (under a range of flow conditions) should be predicted from the modelling as this contaminant will be of concern to stakeholders.			

Impacts to the mid Nam Pangyun due to reduced water quality are as follows. There will be continued contribution to poor water quality (high total and dissolved metals, sulfate and high TSS) from runoff from contaminated areas around the mine (including stockpile areas, soils with high legacy contamination and areas where contaminated water is used for dust suppression), from the TSFs as mentioned above, and from pit dewatering during construction and operations. Impacts to water quality are expected to be of low severity given the impact is entirely within the existing disturbance area and will be minor in context of existing poor water quality. It is expected that the water quality changes would result in minor reduction in capacity of this section of river to support aquatic ecosystems. The impact is assessed as being of **low significance** during construction and operations, based on the **medium magnitude** of impact and **low sensitivity** of the feature (Table 6.73). After closure, release of water from the pit may increase metals concentrations in the mid catchment. This impact is assessed as being of **moderate significance**, based on the **high magnitude** of impact and **low sensitivity** of the feature, although with a high level of uncertainty until geochemical predictive water quality modelling is done (Table 6.74).

Table 6.73 Residual impact significance summary - reduced water quality due to contamination from project sources around the mine and runoff from the TSFs - affecting the mid Nam Pangyun

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Ability to support ecosystems and beneficial uses - mid Nam Pangyun</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>Low
Highly modified and degraded watercourse with poor water quality.</td><td>Low
The watercourse has been impacted by historic mining and ongoing exposure to contaminants, and there is little vulnerability to loss of value due to further water quality changes.</td><td>Medium
Some resilience to change. Some of the associated ecosystem value or use can be regained.</td><td>Low</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact to value</th></tr>
<tr><td rowspan="5">Reduced water quality due to increased total and dissolved metals, sulfate, TSS and cyanide from contaminated areas around the mine and runoff from the TSFs affecting the mid Nam Pangyun</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>High
Impacts will affect most of the catchment, downstream of contaminant sources</td><td>Low
Impact is entirely within existing disturbance area and will be minor in context of existing poor water quality. Minor reduction in capacity to support aquatic ecosystems.</td><td>High
Impact will be long term, occurring throughout construction and operations.</td><td>Medium</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Low</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">High
There is limited baseline stream flow data and lack of quantitative predictions of downstream water quality chemistry. To reduce uncertainty and allow for understanding of changes to water quality in relation to existing concentrations in ambient waters and international water quality guidelines, geochemical modelling of runoff contaminant concentrations and predicted changes to water quality will be necessary. If cyanide was predicted to exceed ambient water quality standards and drinking water standards this would increase the impact magnitude and significance.</td></tr>
</table>

Table 6.74 Residual impact significance summary - reduced water quality due to release of water from the pit after closure - affecting the mid Nam Pangyun

Value	**Sensitivity of value**			
Ability to support ecosystems and beneficial uses - mid Nam Pangyun	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Highly modified and degraded watercourse with poor water quality.	**Low** The watercourse has been impacted by historic mining and ongoing exposure to contaminants, and there is little vulnerability to loss of value due to further water quality changes.	**Medium** Some resilience to change. Some of the associated ecosystem value or use can be regained.	**Low**
Impact	**Magnitude of impact to value**			
Reduced water quality due to release of water from the pit after closure affecting the mid Nam Pangyun	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very high Impacts will probably affect the entire mid catchment downstream of contaminant sources	**High** Impact is entirely within existing disturbance area, however, will be very difficult to rehabilitate and some capacity to support aquatic ecosystems and beneficial uses may be lost from increases in dissolved metal concentrations.	**High** Reduced water quality is expected to persist for a long-term period	**High**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High There is limited baseline stream flow data and lack of quantitative predictions of downstream water quality chemistry. To reduce uncertainty and allow for understanding of changes to water quality in relation to existing concentrations in ambient waters and international water quality guidelines, geochemical modelling of pit water concentrations and predicted changes to water quality will be necessary.			

Impacts to the lower Nam Pangyun due to reduced water quality are as follows. There will be continued contribution to poor water quality from the sources described above with the addition of metal-rich leachate and excess water runoff from the Wallah waste rock dump, and discharge of highly turbid and metal-rich dewatering water from the Tiger Tunnel (or from pumped dewatering directly from the pit sump, depending on the dewatering option selected). Again, in the context of existing poor water quality, degraded habitat, and limited value of this section of the river, impacts to water quality are considered to be similar to the existing level of impact. This impact is assessed as being of **low significance** during construction and operations, based on the **medium magnitude** of impact and **low sensitivity** of the feature (Table 6.75).

Table 6.75 Residual impact significance summary – reduced water quality due to contamination from project sources around the mine and the TSF, metal-rich leachate from the Wallah WRD, and turbid and metal-rich discharge from Tiger Tunnel - affecting the lower Nam Pangyun

Value	**Sensitivity of value**			
	Importance	***Vulnerability***	***Resilience***	***Sensitivity***

Ability to support ecosystems and beneficial uses – lower Nam Pangyun	**Low** Highly modified and degraded watercourse with poor water quality.	**Low** The watercourse has been impacted by historic mining and ongoing exposure to contaminants, including discharge from Tiger Tunnel. There is little vulnerability to further loss of value due to water quality changes.	**Medium** Some resilience to change. Some of the associated ecosystem value or use can be regained.	**Low**
Impact	**Magnitude of impact to value**			
Reduced water quality due to contamination from high total and dissolved metals, cyanide and high TSS from project sources, runoff from contaminated areas around the mine and the TSF, acidic and metal-rich leachate from the Wallah WRD, and turbid and metal-rich discharge from Tiger Tunnel affecting the lower Nam Pangyun	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	High Impacts will affect most of the catchment, downstream of contaminant sources	**Low** Impacts to water quality are considered to be consistent with the existing level of impact, with existing poor water quality, degraded habitat, and limited value of this section of the river	**High** Impact will be long term (i.e., in the order of 15 years), occurring throughout construction and operations.	**Medium**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	High There is limited baseline stream flow data and lack of quantitative predictions of downstream water quality chemistry. To reduce uncertainty and allow for understanding of changes to water quality in relation to existing concentrations in ambient waters and international water quality guidelines, geochemical modelling of pit water concentrations and predicted changes to water quality will be necessary.			

In the context of the already heavily-impacted lower catchment of the Nam Pangyun system, the impact severity post closure is considered to be low; however given the expected long term duration and high spatial extent of this impact, it is predicted to be of **moderate significance,** based on the **high magnitude** of impact and **low sensitivity** of the feature (Table 6.76). Although, in the absence of operational or post-closure water quality modelling, these impact ratings are accompanied with a high degree of uncertainty.

Table 6.76 Residual impact significance summary – reduced water quality due to release of water from the pit after closure increasing dissolved metals concentrations - affecting the lower Nam Pangyun

Value	**Sensitivity of value**			
Ability to support ecosystems and beneficial uses – lower Nam Pangyun	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Highly modified and degraded watercourse with poor water quality.	**Low** The watercourse has been impacted by historic mining and ongoing exposure to contaminants, including discharge from Tiger Tunnel. There is little vulnerability to further loss of value due to water quality changes.	**Medium** Some resilience to change. Some of the associated ecosystem value or use can be regained.	**Low**
Impact	**Magnitude of impact to value**			
Reduced water quality due to release of water from the pit after closure increasing dissolved metals concentrations affecting the lower Nam Pangyun	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	High Impacts will affect most of the catchment, downstream of contaminant sources	**Low** Impacts are expected to be minor in the context of the heavily impacted Nam Pangyun system and low value of this section of river	**High** Reduced water quality is expected to persist for a long-term period	**High**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High There is limited baseline stream flow data and lack of quantitative predictions of downstream water quality chemistry (including metals and pH) after closure. To reduce uncertainty and allow for understanding of changes to water quality in relation to existing concentrations in ambient waters and international water quality guidelines, geochemical modelling of pit water concentrations and predicted changes to water quality will be necessary.			

Impacts to the Myitnge River due to reduced water quality are as follows. There will be continued reduction in water quality (due to increased TSS and dissolved and total metals concentrations) downstream of the Nam Pangyun confluence during construction and operations. Impacts to water quality are expected to be within the existing level of impact (i.e., existing high TSS and metals concentrations recorded in the Myitnge River downstream of the Nam Pangyun). However, modelling is required to confirm this.

The extent of current impact in the Myitnge River is currently not known (i.e., how far downstream existing reduced water quality extends); however, it is expected that continued contributions of contaminated water from the Nam Pangyun during construction and operations will not increase the physical extent of the Myitnge River that is impacted. As discussed in this section, the use of sediment dams may reduce the levels of TSS and particulate metals downstream during initial rainfall response. Also, flows in the Nam Pangyun may be reduced during mining (due to seepage/dewatering) and river diversion, potentially resulting in periods where the Nam Pangyun contaminant load contribution into the Myitnge River is reduced. During construction and operations, as per the reasons outlined above, the impact is considered to be of **moderate significance,** based on the **low magnitude** of impact and the **high sensitivity** of the feature (Table 6.77).

Table 6.77 Residual impact significance summary – reduced water quality due to increased total and dissolved metals and TSS - affecting the Myitnge River

Value	Sensitivity of value			
Ability to support ecosystems and beneficial uses – Myitnge River	*Importance*	*Vulnerability*	*Resilience*	*Sensitivity*
	High The Myitnge River important source of water for recreation, agriculture/irrigation, industrial use, drinking water and other consumptive uses to communities	**High** Vulnerable to further changes due to its relatively good water quality compared to the Nam Pangyun	**Medium** May be able to withstand localised and temporary impacts due to its size and flow.	**High**
Impact	**Magnitude of impact to value**			
Reduced water quality due to increased total and dissolved metals and TSS affecting the Myitnge River	*Spatial extent*	*Severity*	*Duration*	*Magnitude*
	Low Impact will probably affect a small proportion of the river, although the extent will need to be confirmed by water quality modelling	**Low** Impacts to water quality are unlikely to reduce the capacity to support aquatic ecosystems and/or beneficial uses. It is expected that continued contributions of contaminated water from the Nam Pangyun during construction and operations will not increase the extent of Myitnge River impacted	**High** Impact will be long term, occurring throughout construction and operations	**Low**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High There is limited baseline stream flow data and lack of quantitative predictions of downstream water quality chemistry. To reduce uncertainty and allow for understanding of changes to water quality in relation to existing concentrations in ambient waters and international water quality guidelines, geochemical modelling of pit water concentrations and predicted changes to water quality will be necessary			

Impacts to the Nam La due to reduced water quality are as follows. There may be a minor and short-term increase in TSS/turbidity during construction of the raw water dam and the process plant site preparation. Impact would be restricted to the headwaters as the river is fed by numerous tributaries downstream prior to where it reaches the Namtu area and this would dilute and disperse TSS and turbidity. Also, runoff from the area is less likely to be contaminated than the Nam Pangyun catchment given it is upstream of previous mining activity where mine waste has accumulated in the catchment over many years.

During operation of TSF-A and TSF-B, excess supernatant water may be released via a spillway (via TSFA) to the Nam La during high rainfall periods. The water may include elevated total and dissolved metals, sulfate and potentially residual cyanide. Once the tailings beaches on TSFs A and B are rehabilitated in end of Year 9, approximately 2,000 m^3/month to 382,000 m^3/month of spillway release into the Nam La will occur from the TSF A spillway under average conditions.

During operation of the TSF, there is the potential that contaminated seepage migrates to the Nam La catchment aquifers and subsequent groundwater discharge into the stream affects water quality. However, in the absence of groundwater contaminant modelling, there is high uncertainty in this impact pathway and contaminant concentrations that may reach the Nam La (if at all). Impacts to the Nam La catchment via contaminated groundwater seepage are addressed in Section 6.2.

At closure of the TSF-A and TSF-B, some of the water will be drained from the facilities prior to capping of the facilities. This water will be released into the Nam La and may be elevated in total and dissolved metals, sulfate and residual cyanide.

After closure of TSF-A and TSF-B, runoff from the capped TSF-A (also receiving TSF-B runoff) will be released to the Nam La via a spillway. This represents a permanent change to the water balance and establishes a potential pathway for mine contact water to enter this unimpacted catchment. Geochemical modelling has not been completed and the quality of water released via the spillway during operations and after closure has not been predicted, but may include concentrations of TSS and total and dissolved metals, sulfate and potentially cyanide above background conditions in the Nam La. Release from the spillway will only occur during high rainfall periods and at closure when some of the water overlying the tailings is released prior to capping. Geochemical modelling is required as part of the mine closure plan to confirm the impact significance. The residual impact is assessed to be of **high to major significance**, based on the **medium to high magnitude** of impact and the **high sensitivity** of the feature (Table 6.78).

Table 6.78 Residual impact significance summary – reduced water quality due to increased TSS, turbidity and possibly metals concentrations - affecting the Nam La

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Ability to support ecosystems and beneficial uses – Nam La</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>High
Largely undisturbed compared to the Nam Pangyun and is an important source of water for agriculture/irrigation, industrial use, drinking water in nearby communities.</td><td>High
Nam La has relatively good water quality and is vulnerable to degradation particularly during the dry season when flows are limited.</td><td>Medium
Nam La surface water is somewhat resilient to change due to its alkalinity and hardness, which reduce bioavailability and toxicity of some metals. Numerous other tributaries downstream contributing to flow in the catchment, which can disperse and dilute contaminants.</td><td>High</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact to value</th></tr>
<tr><td rowspan="6">Reduced water quality due to increased TSS, turbidity and possible metals concentrations in capped TSF surface runoff and increased metals, sulfate and potentially cyanide in TSF overflow affecting the Nam La</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Low
Impact would be restricted to a localised area in the headwaters as the river is fed by numerous tributaries downstream prior to where it reaches the Namtu area and this would dilute and disperse turbidity, TSS and metal contaminants</td><td>Low to moderate
Degree of change due to surface runoff is likely to be minor as runoff from the area is less likely to be contaminated being upstream of previous mining activity. The project will use non-contaminated materials for capping. Impact from surface runoff is unlikely to reduce the capacity to support aquatic ecosystems and/or beneficial uses resulting in low severity impact.</td><td>High
Impact will be short term during construction of the raw water dam and the process plant site preparation, however runoff from the capped TSF-A will be released to the Nam La via a spillway post-closure.
This represents a permanent change to the water balance and establishes a potential pathway for mine contact water to enter this unimpacted catchment.</td><td>Medium to high</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>High to major</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">High
There is limited baseline stream flow data and a lack of quantitative predictions of downstream water quality with the project. Geochemical modelling of contaminant concentrations and predicted changes to water quality would reduce uncertainty and allow for understanding of changes to water quality in relation to existing concentrations in ambient waters and international water quality guidelines. Further uncertainty exists due to a lack of groundwater modelling and the potential for contaminated seepage to enter the Nam La aquifers and subsequently be discharged to the Nam La stream.</td></tr>
</table>

Reduced streambed sediment quality

Erosion of stockpiles/spoil and of material from the mine disturbance area will introduce particulates into the Nam Pangyun during project construction, operations and closure. The primary impacts to streambed biota will be from direct smothering (see Section 6.4.2). However, adjacent to these smothering zones, the primary impact pathway to aquatic biota may be in the form of exposure to increased metals in the bed sediment and associated increased ecotoxicity. With the use of sediment dams downstream of all surface runoff points, it is considered that the finer sediment particles such as sands and coarse silts (which typically contain higher metals concentrations per unit mass) would migrate and deposit downstream, with coarser material such as gravels and sands being retained in the dams.

Due to the existing poor condition of the Nam Pangyun, and the elevated metals concentrations in the bed sediment above ANZ sediment quality guidelines, any streambed biota present are likely to be resilient to exposure to sediments with elevated metals concentrations. The existing habitat for instream biota is also very poor due to the highly modified stream substrate containing random assortments of cobbles, pebbles, gravels and sands interspersed with silts due to long-running historic upstream mining disturbance, waste rock disposal and erosion.

The stream has existing poor aquatic habitat, lack of aquatic ecosystems and lack of beneficial uses; and soil and waste rock spoil material that might report to the Nam Pangyun would probably contain elevated particulate metals concentrations that would deposit in the already impacted Nam Pangyun. Sediments with elevated metals concentrations will deposit and accumulate in the Nam Pangyun throughout construction and operation of the mine. It is expected that with rehabilitation and revegetation of disturbed land, contaminated soil and sediment runoff would be reduced after project closure and the quality of bed sediment would eventually improve as upstream erosion is reduced – however, this would probably occur over a long-term period (potentially decades). The overall impact of reduced sediment quality in the Nam Pangyun and the Myitnge downstream of the Nam Pangyun is likely to be a low increase to the existing situation of poor sediment quality and instream habitat condition due to years of slag and waste rock disposal. Overall, the residual impact is assessed to be of **low significance** for the upper, mid and lower Nam Pangyun catchment, based on the **medium magnitude** of impact and the **low sensitivity** of the feature (Table 6.79). The impact is assessed to be of **moderate significance** for the Myitnge River, based on the **low magnitude** of impact and **high sensitivity** of the feature (Table 6.80).

Table 6.79 Residual impact significance summary – reduced streambed sediment quality due to deposition of material eroded from upstream stockpiles/spoil and contaminated soils - affecting the mid and lower Nam Pangyun

Value	**Sensitivity of value**			
Ability to support ecosystems and beneficial uses – mid and lower Nam Pangyun	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Highly modified and degraded watercourse with little instream habitat value.	**Low** The watercourse has been impacted by historic mining and ongoing exposure to contaminants and sediment deposition. There is little vulnerability to further changes.	**Medium** Some resilience to change. Some of the associated ecosystem value or use can be regained.	**Low**
Impact	**Magnitude of impact to value**			
Reduced streambed sediment quality due to deposition of material eroded from upstream stockpiles/spoil and contaminated soils affecting the mid and lower Nam Pangyun	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Impacts will affect a moderate portion of the catchment	**Low** Impact is entirely within existing disturbance area, with poor quality existing aquatic habitat, lack of aquatic ecosystems and lack of beneficial uses of the stream. Numerous metals in stream sediments currently exceed international guidelines for sediment quality currently. Soil and waste rock spoil material that might report to the Nam Pangyun would probably contain elevated metals concentrations, although, further sediment assessment would be required to quantify changes in contaminant concentrations in accumulated sediments	**High** The impact will be long term as sediments with elevated metals concentrations will deposit and accumulate in the Nam Pangyun throughout construction and operation of the mine. It is expected that with rehabilitation and revegetation of disturbed land, contaminated soil and sediment runoff would be reduced after project closure and the quality of bed sediment would eventually improve as upstream erosion is reduced – however, the recovery may take in the order of ten or more years.	**Medium**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	High Further characterisation of existing sediment quality and mass balance modelling would reduce uncertainty and allow for quantification of changes to downstream sediment quality (i.e., predict changes to particle sizes and contaminant loads)			

Table 6.80 Residual impact significance summary – reduced streambed sediment quality due to deposition of material eroded from upstream stockpiles/spoil and contaminated soils - affecting the Myitnge River

Value	**Sensitivity of value**			
	Importance	***Vulnerability***	***Resilience***	***Sensitivity***

Ability to support ecosystems and beneficial uses – Myitnge River	**High** The Myitnge River important source of water for recreation, agriculture/irrigation, industrial use, drinking water and other consumptive uses to communities.	**High** Vulnerable to further changes due to its relatively good water quality compared to the Nam Pangyun	**Medium** May be able to withstand localised and temporary impacts due to its size and flow.	**High**
Impact	**Magnitude of impact to value**			
Reduced streambed sediment quality due to deposition of material eroded from upstream stockpiles/spoil and contaminated soils affecting the Myitnge River	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Impact is likely to affect a small proportion of the river, although the extent will need to be confirmed by sediment transport modelling.	**Low** Impact is likely to be minor in the context of existing poor sediment quality and extensive aggradation near the confluence with the Nam Pangyun	**Medium to high** Impact will be medium to long term	**Low**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High Further characterisation of existing sediment quality and mass balance modelling would reduce uncertainty and allow for quantification of changes to downstream sediment quality (i.e., predict changes to particle sizes and contaminant loads). Sediment transport modelling is required to understand the spatial extent of sediment quality impacts in the Myitnge River.			

Summary of residual impact assessment

Table 6.81 provides a summary of residual impacts to surface water and their significance.

Table 6.81 Summary of residual impacts to surface water and their significance

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Physical disturbance of habitat due to direct removal of instream and riparian habitat	Ability to support ecosystems and beneficial uses – upper Nam Pangyun catchment • Medium sensitivity	Operations	High magnitude • High spatial extent • High severity • Very high duration	• Erosion and sediment control measures	High	An approximately 3 km relatively clean section of the Nam Pangyun will be converted to an underdrain beneath the TSFs. This section is partially in relatively undisturbed area and will result in permanent loss of instream and riparian habitat.	Low • Areas of physical disturbance readily predictable based on project footprint
	Ability to support ecosystems and beneficial uses – mid Nam Pangyun catchment • Low sensitivity	Operations	Low magnitude • Medium spatial extent • Low severity • Very high duration	• Erosion and sediment control measures	Low	An approximately 750 m of a highly disturbed section of the Nam Pangyun will be diverted, resulting in permanent loss of habitat currently in poor condition.	Low • Areas of physical disturbance readily predictable based on project footprint
Physical disturbance of habitat due to downstream smothering of streambed, edge and riparian habitat from increased sediment	Ability to support ecosystems and beneficial uses - Upper Nam Pangyun catchment • Medium sensitivity	Construction	Low magnitude • Low spatial extent • Low severity • High duration	• Erosion and sediment control measures	Low	A small portion of the catchment in an existing disturbance area will be impacted, causing long term effects to the capacity to support aquatic ecosystems	High • Lack of baseline flow data • Sediment loads in discharge have not been quantified • Absence of sediment transport and deposition modelling

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
	Ability to support ecosystems and beneficial uses – mid Nam Pangyun catchment • Low sensitivity	Construction	Low magnitude • Low spatial extent • Low severity • High duration	• Erosion and sediment control measures	Low	Through construction and operations, a small portion of the catchment in a low value existing disturbance area will be impacted to a minor degree considering the existing condition.	High • Lack of baseline flow data • Sediment loads in discharge have not been quantified • Absence of sediment transport and deposition modelling
	Ability to support ecosystems and beneficial uses – lower Nam Pangyun catchment • Low sensitivity	Construction	Medium magnitude • High spatial extent • Low severity • High duration	• Erosion and sediment control measures	Low	Impact is likely to be mostly within existing disturbance area with a highly impacted habitat and little value. Increased stream aggradation in this narrow valley could result in sediment accumulation above the existing banks with potential associated risks such as particulate contaminant transport to riparian environments and increased flood risk. However, with much of the lower catchment being already highly impacted, the predicted severity is low.	High • Lack of baseline flow data • Sediment loads in discharge have not been quantified • Absence of sediment transport and deposition modelling • Absence of flood risk modelling

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
	Ability to support ecosystems and beneficial uses – Myitnge River • High sensitivity	Construction	Low magnitude • Very low spatial extent • Low severity • High duration	• Erosion and sediment control measures	Moderate	A small proportion of the river near the confluence with the Nam Pangyun is expected to be impacted through construction and operations. The degree of disturbance will be minor considering existing sedimentation and aggradation and considering the potential of the river to be able to withstand localised impacts.	High • Lack of baseline flow data • Sediment loads in discharge have not been quantified • Absence of sediment transport and deposition modelling
	Ability to support ecosystems and beneficial uses – Nam La • High sensitivity	Construction	Low magnitude • Low spatial extent • Low severity • High duration	• Erosion and sediment control measures	Moderate	A localised area of relatively god quality habitat will be impacted during construction, however, will readily recover with the implementation of standard management measures	High • Lack of baseline flow data • Sediment loads in discharge have not been quantified • Absence of sediment transport and deposition modelling
Changes to surface water flow due to stream diversion	Ability to support ecosystems and beneficial uses – mid and lower Nam Pangyun catchment • Low sensitivity	Operations	Low magnitude • High spatial extent • Low severity • Low duration	• Hydrology and water supply measures	Low	Flows downstream of the pit in an existing area of river which has been prone to periods of low flows during dry conditions will be temporarily impacted as the diversion channel is constructed	High • Limited quantitative stream flow data

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Changes to surface water flow due to water abstraction during operations	Ability to support ecosystems and beneficial uses – Nam La • High sensitivity	Operations	Medium magnitude • Low spatial extent • Medium severity • Medium duration	• Hydrology and water supply measures	High	The impact will be localised to the upper section of the catchment during dry periods throughout operations. The Nam La is somewhat resilient due to downstream tributaries providing inflows. However, it has high importance as a public water source and is vulnerable during the dry season.	High • Limited quantitative stream flow data
	Ability to support ecosystems and beneficial uses – mid and lower Nam Pangyun catchment • Low sensitivity	Operations	Medium magnitude • High spatial extent • Low severity • High duration	• Hydrology and water supply measures	Low	A large proportion of the highly disturbed catchment will be impacted. However this is unlikely to reduce the capacity to support aquatic ecosystems and/or beneficial uses, and abstraction will be offset to an extent by discharge of groundwater from pit dewatering.	High • Limited quantitative stream flow data

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Reduced surface flows in the mid and lower Nam Pangyun due to seepage into underlying rocks	Ability to support ecosystems and beneficial uses – mid and lower Nam Pangyun catchment • Low sensitivity	Operations	Medium magnitude • High spatial extent • Very low severity • High duration	• Hydrology and water supply measures	Low	The impact will affect a large portion of the mid and lower catchment, however, is expected to have a negligible effect and a minor change from existing conditions until groundwater levels recover	Medium • Absence of numerical predictions of reduced surface flows due to seepage into underlying rocks
Reduced surface flows to the mid and lower Nam Pangyun for 5 years after mine closure	Ability to support ecosystems and beneficial uses – mid and lower Nam Pangyun catchment • Low sensitivity	Closure	High magnitude • High spatial extent • Medium severity • High duration	• Develop and implement mine closure plan • Hydrology measures	Moderate	A large proportion of the mid and lower catchment will be impacted for five years, with flows potentially ceasing. Due to the poor exiting condition there is little value and only some reduction in capacity to support aquatic ecosystems and beneficial uses may occur.	High • Effects of diverting the Nam Pangyun have not been quantified
Altered flow regime due to landform and drainage changes	Ability to support ecosystems and beneficial uses - Nam Pangyun (upper, mid and lower catchment) • Low sensitivity (mid and lower catchment) • Medium sensitivity (upper catchment)	Construction, operations and closure	Medium magnitude • High spatial extent • Medium severity • Very high duration	• Hydrology management measures • Erosion and sediment control measures • Drainage and water discharge measures	Low (mid and lower catchment) to moderate (upper catchment)	Permanent changes to landform and drainage and subsequent changes to flow regime will occur in a large portion of the catchment, however the severity of this impact is limited by the existing level of disturbance and measures to adequately maintain downstream flow	High • Absence of a project water balance describing water abstraction volumes and proportions

Impact	**Value and sensitivity**	**Impact phase**	**Impact magnitude**	**Key management measure(s)**	**Impact significance**	**Justification for impact significance**	**Uncertainty**
Altered flood risk from project infrastructure	Ability to support ecosystems and beneficial uses - Nam Pangyun (upper, mid and lower catchment) • Low sensitivity (mid and lower catchment) • Medium sensitivity (upper catchment	Construction, operations and closure	Low magnitude • Low spatial extent • Low severity • Very high duration	• Considering floods during design	Low (mid and lower catchment) to moderate (upper catchment)	Localised areas of permanent, increased flood risk may occur. Due to the existing level of disturbance, changes to drainage are expected to be minimal. Impact may be minimised or flood risk reduced if localised flood risk is considered in infrastructure design and placement.	High • Limited baseline stream flow data • Absence of detailed flood risk assessment
	Ability to support ecosystems and beneficial uses - Nam La • High sensitivity	Closure	Medium magnitude • Medium spatial extent • Medium severity • Very high duration	• Considering floods during design	High	Permanent changes to flood risk may occur through the catchment, and may reduce the capacity to support aquatic ecosystems and/or beneficial uses, including impacts to potable water supply infrastructure	High • Limited baseline stream flow data • Absence of detailed flood risk assessment
Reduced water quality due to contamination from project sources around the mine and runoff from the TSFs	Ability to support ecosystems and beneficial uses - upper Nam Pangyun • Medium sensitivity	Construction and operations	High magnitude • High spatial extent • Medium severity • High duration	• Erosion and sediment control measures • Water seepage, collection and management measures	High	Most of the catchment downstream of contaminants will be impacted through construction and operations, with some capacity to support aquatic ecosystems reduced	High • Limited baseline stream flow data • Lack of quantitative predictions of downstream water quality chemistry, including cyanide concentrations • Geochemical modelling required

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Reduced water quality due to contamination from project sources around the mine and runoff from the TSFs	Ability to support ecosystems and beneficial uses - upper Nam Pangyun • Medium sensitivity	Closure	High magnitude • High spatial extent • Medium severity • High duration	• Erosion and sediment control measures • Water seepage, collection and management measures	High	Most of the catchment downstream of contaminants will be impacted after closure, with some capacity to support aquatic ecosystems reduced. The impact is secondary to habitat loss, as part of this river will be beneath a TSF.	High • Limited baseline stream flow data • Lack of quantitative predictions of downstream water quality chemistry, including cyanide concentrations • Geochemical modelling required
Reduced water quality due to contamination from project sources around the mine and runoff from the TSFs	Ability to support ecosystems and beneficial uses - mid Nam Pangyun • Low sensitivity	Construction and operations	Medium magnitude • High spatial extent • Low severity • High duration	• Erosion and sediment control measures • Water seepage, collection and management measures	Low	Most of the catchment downstream of contaminants will be impacted through construction and operations. Considering the existing poor water quality, only a minor reduction in the capacity to support aquatic ecosystems is expected	High • Limited baseline stream flow data • Lack of quantitative predictions of downstream water quality chemistry, including cyanide concentrations • Geochemical modelling required
Reduced water quality due to release of water from the pit after closure increasing dissolved metals concentrations	Ability to support ecosystems and beneficial uses - mid Nam Pangyun • Low sensitivity	Closure	High magnitude • Very high spatial extent • High severity • High duration	• Develop and implement mine closure plan	Moderate	The entire mid catchment is likely to be impacted long-term, with some loss of capacity to support aquatic ecosystems and beneficial uses due to increases in dissolved metal concentrations and difficulty rehabilitating the impact	High • Limited baseline stream flow data • Lack of quantitative predictions of downstream water quality chemistry • Geochemical modelling required

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Reduced water quality due to contamination from project sources around the mine and the TSF, metal-rich leachate from the Wallah WRD, and turbid and metal-rich discharge from Tiger Tunnel	Ability to support ecosystems and beneficial uses - lower Nam Pangyun • Low sensitivity	Construction and operations	Medium magnitude • High spatial extent • Low severity • High duration	• Erosion and sediment control measures • Water seepage, collection and management measures	Low	Most of the catchment downstream of contaminants will be impacted through construction and operations. Considering the existing poor water quality and low value, the impact will be low severity	High • Limited baseline stream flow data • Lack of quantitative predictions of downstream water quality chemistry • Geochemical modelling required
Reduced water quality due to release of water from the pit after closure increasing dissolved metals concentrations	Ability to support ecosystems and beneficial uses - lower Nam Pangyun • Low sensitivity	Closure	High magnitude • High spatial extent • Low severity • High duration	• Develop and implement mine closure plan	Moderate	Most of the catchment downstream of contaminants will be impacted long term, however, are expected to be minor considering the current condition and low value of this section of the Nam Pangyun	High • Limited baseline stream flow data • Lack of quantitative predictions of downstream water quality chemistry • Geochemical modelling required
Reduced water quality due to increased total and dissolved metals and TSS	Ability to support ecosystems and beneficial uses – Myitnge River • High sensitivity	Construction and operations	Low magnitude • Low spatial extent • Low severity • High duration	• Erosion and sediment control measures	Moderate	A small proportion of the river is expected to be affected through construction and operations, however the impact is unlikely to reduce the capacity to support aquatic ecosystems and/or beneficial uses.	High • Limited baseline stream flow data • Lack of quantitative predictions of downstream water quality • Geochemical modelling required

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Reduced water quality due to increased TSS, turbidity and possibly metals concentrations	Ability to support ecosystems and beneficial uses – Nam La • High sensitivity	Construction, operations and closure	Medium to high magnitude • Low spatial extent • Low to moderate severity • High duration	• Erosion and sediment control measures	High to major	A localised area in the headwaters is expected to be impacted during construction of the raw water dam and process plant site preparation, as well as after closure due to TSF-A runoff entering the Nam La. The TSF-A spillway runoff is likely to be poor quality compared to the existing condition of the Nam La	High • Limited baseline stream flow data • Lack of quantitative predictions of TSF-A spillway discharge water quality and downstream water quality • Lack of groundwater modelling
Reduced streambed sediment quality due to deposition of material eroded from upstream stockpiles/spoil and contaminated soils	Ability to support ecosystems and beneficial uses – mid and lower Nam Pangyun • Low sensitivity	Construction, operations and closure	Medium magnitude • Medium spatial extent • Low severity • High duration	• Erosion and sediment control measures	Low	A moderate portion of the catchment will be impacted throughout construction and operations, eventually improving after closure. The severity is expected to be minimal in the context of the current poor condition of the existing aquatic habitat and low value of this section of the Nam Pangyun.	High • Further characterisation of existing sediment quality and mass balance modelling required • No quantification of changes to downstream sediment quality

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
	Ability to support ecosystems and beneficial uses – Myitnge River • High sensitivity	Construction, operations and closure	Low magnitude • Low spatial extent • Low severity • Medium to high duration	• Erosion and sediment control measures	Moderate	A small proportion of the river will be impacted medium to long term. The severity is minimal in the context of existing poor sediment quality and aggradation, and the potential to withstand localised changes.	High • Further characterisation of existing sediment quality and mass balance modelling required • No quantification of changes to downstream sediment quality

6.4.5 Monitoring

Discharges from project infrastructure and areas will be monitored to check compliance with Myanmar mining effluent discharge criteria. This will involve monitoring discharge from the process plant, TSFs and waste rock dump spillways and seepage, and discharge points of all sediment dams.

A water quality monitoring program to assess water quality downstream of the project area will be developed and implemented by WMM to ensure compliance with the Environmental Compliance certificate (ECC)and internal water quality targets and identify changes or trends in water quality that need intervention (DFS Ch18). A downstream compliance point is proposed near the rail spiral bridge slightly downstream of Tiger Camp and the existing railyard, at the location of an existing flow monitoring station. At this location a site-specific water quality target will be established that takes into account the existing background water quality and contaminant flux (i.e. the net annual discharge of a contaminant) and the project's water quality objective of making downstream riverine impacts no worse than pre-project conditions. Water quality monitoring points will also be established in the Myitnge River, upstream and downstream of the confluence with the Nam Pangyun. Again, monitoring of this river will be conducted to check for changes in water quality compared to background conditions and, once they are developed, to site-specific water quality targets. Water quality monitoring points will also be established in the Nam La, with site-specific water quality targets developed as part of the ECC.

Prior to construction, water quality monitoring will be conducted across a range of flow discharge rates to expand the baseline dataset, parameters will include major ions, turbidity, pH, TSS, cyanide, metals and nutrients. Control sites in the upper Nam Pangyun, Nam La and Myitnge rivers will be included to allow an upstream/downstream comparison of water quality to aid in identifying water quality impacts. Water quality monitoring will continue through operations and in the closure and post-closure phases; the specification of monitoring parameters will be identified following review of the extended baseline data set, during the construction phase.

Following the installation of automatic level loggers in the Nam Pangyun and Nam La catchments, surface flows will be gauged to collect velocity estimates across a range of water levels. These will be used in conjunction with calibration tables to convert water velocity and depth to flow rate for a given cross-section at the time of sampling. Water levels will be recorded when taking water quality samples, so water level can be correlated with contaminant concentrations. This will allow establishment of a relationship between contaminant concentration and flow rate in the form of a ratings curve. The ratings curve can then be used to make predictions of contaminant concentrations at various flow rates and can also inform the derivation of site-specific water quality targets.

Bed sediment quality monitoring will be conducted in the mid and lower Nam Pangyun and the Myitnge River, where practicable, downstream of the confluence. Parameters monitored will include particle size distribution, metals and organic carbon content. This monitoring will be conducted quarterly during construction and annually during operations. The objective will be to determine the changes to bed sediment physical characteristics and contaminant loads due to project-caused sedimentation.

Monitoring of bed aggradation will be conducted in the mid and lower Nam Pangyun and the Myitnge River, where practicable, downstream of the confluence. Such monitoring will occur at suitable river cross-sections to determine early indication of potentially problematic aggradation that may cause increased flood risk to communities. The results of the monitoring would be used in flood risk modelling (see Section 6.4.6).

6.4.6 Uncertainties and further work

This section outlines the key uncertainties associated with the impact assessment and outlines recommended further work to address uncertainties.

The key uncertainties and further work required to address these uncertainties are outlined in Table 6.82.

Table 6.82 Uncertainties and further work in respect of surface water impacts

Uncertainty	Further work	Purpose	Assumptions
There has been limited baseline water quality monitoring over a range of flow rates. There is uncertainty regarding background fluctuations of contaminant concentrations in surface waters.	Conduct ongoing baseline water quality monitoring, targeting a range of flow conditions. Monitor flow discharge along with the water quality parameters so flow can be correlated with contaminant concentrations. This should commence as soon as possible.	To better understand the range of contaminant concentrations under a range of flow conditions. Established rainfall and flow ratings curve relationships (i.e., stream flow discharge with relation to depth) with associated contaminant loads will inform downstream water quality modelling and potential establishment of a project-specific water quality compliance target.	Background water quality data used in the assessment has been based on monitoring conducted to date (less than ten monitoring events over 12 months at all sites) and it has been assumed that the ranges are generally representative of baseline conditions; although, some high-flow spikes in contaminants may not have been covered by the monitoring.
There has been limited baseline water and sediment quality data, habitat assessment and information on beneficial uses in the receiving Myitnge River.	Conduct additional baseline water and sediment quality monitoring and aquatic habitat assessment in the Myitnge River downstream of the Nam Pangyun confluence. Conduct flow discharge monitoring (over a range of low, medium and high flow conditions) at the same time as water quality monitoring. These tasks should commence as soon as possible so long-term seasonality can be addressed.	Better understand the extent and severity of existing impact in the Myitnge River and community beneficial uses that may be impacted. Establish a contaminant load to flow relationship for input into contaminant modelling.	The existing level of impact was interpreted from limited sampling data near the confluence with Nam Pangyun, review of aerial imagery and assumptions based on known upstream pollution sources.

Uncertainty	Further work	Purpose	Assumptions
There is a lack of predictive data on cyanide concentrations in seepage and spillway discharge from the TSFs and subsequent predicted concentrations in the Nam Pangyun and Nam La rivers.	Conduct an assessment of cyanide concentrations leaching from the TSFs and reporting to watercourses. The first step will be to confirm the representativeness of the tailing sample(s) (and corresponding analytical results) to be used in the assessment, with appropriate conservatism. The assessment will calculate the level of dilution of cyanide-rich tailings and estimate concentrations in TSF discharges under a range of scenarios (i.e., seepage, piped and treated discharge, and spillway discharge). To do this, the schedule of cyanide-rich tailings storage volumes in the TSF, along with all TSF water volumes for each operational year will be developed. The estimated concentrations will represent an initial screening of maximum theoretical total cyanide concentrations in the TSFs at each operational year. The cyanide concentrations will be compared to Myanmar effluent standards, Myanmar drinking water guidelines, and ANZ water quality guidelines for aquatic ecosystem protection. If the estimated concentrations indicate that the standards and guidelines are likely to be exceeded, conduct further work to assess the speciation of cyanide in the discharge (e.g., concentrations of free, weak-acid dissociable and total cyanide). The findings of the work will be used to determine the level of required treatment or destruction of cyanide in tailings discharge. As part of the water quality modelling above, predict the cyanide concentrations in the Nam Pangyun and Nam La (under a range of flow conditions) as a result of seepage and overflow from the TSF. These tasks should commence as soon as possible.	As cyanide is a toxic chemical to the environment and to people, it will be critical to demonstrate to stakeholders the predicted concentrations of cyanide in receiving waters due to seepage from the TSFs. To allow understanding of level of cyanide treatment/destruction required in tailings discharge.	It has been assumed that residual cyanide may be present in TSF discharges although concentrations are unknown.

Uncertainty	Further work	Purpose	Assumptions
There is a lack of quantitative predictions of downstream water quality changes during construction, operations and post-closure. There is limited understanding of predicted concentrations of contaminants in waters over different flow discharge rates and how these compare to ambient water quality criteria for aquatic ecosystem protection (or background concentrations). This does not allow for accurate quantification of water quality related impacts.	Conduct downstream water quality modelling for the Nam Pangyun, Nam La and Myitnge River of both total and dissolved metals contaminants, sulfate, cyanide and TSS. Model construction, operations and post-closure water quality discharges and resulting concentrations in receiving waters from the open pit, TSFs and waste rock dump, including dissolved metals and potential for acid formation. Engage a suitably qualified hydrogeochemical specialist to outline the post-closure modelling assessment approach. The quality of water produced from dewatering the open pit requires further assessment. Quality is expected to worsen over time as the pit becomes deeper and water from the underground mine workings (including Tiger Tunnel) are progressively encountered and drained to the pit. Prepare estimates of contaminants and TSS in project discharges. Confirm how post closure water quality (runoff and leachate from the pit, TSF and Wallah waste rock dump), will be managed after closure. These tasks should commence as soon as possible.	To allow for accurate predictions of the severity and extent of water quality impacts. To allow for development of project-specific compliance criteria based on methods outlined in international water quality guidelines. To predict the water quality in seepage, leachate and runoff from major project sites during construction, operations and after closure, including the severity and duration of changes to water quality, so that any additional management measures can be considered.	Quantitative predictions of changes to water quality parameters are not included in the assessment, although commentary is given on the expected spatial extent, severity and duration of impact.

Uncertainty	Further work	Purpose	Assumptions
Several options for water management during construction operation of the project, and after project closure have been discussed in the Bawdwin Project Mine Water Management Feasibility Report (CSA, 2020) and DFS (WMM,2020); however, the proposed closure strategy has not been confirmed. It is unknown whether acid and metalliferous drainage will be an issue in the mine pit, to what extent it might be an issue and whether it can be successfully managed. Modelling of water quality after pit closure by CSA (2020) does not take into account untreated seepage from the TSFs which may migrate to the mine pit. Modelling of the final pit lake water quality also does not address dissolved metal concentrations, which are considered to be the more bioavailable forms of metals.	Confirm the approach to water management after project closure. Conduct modelling of water quality, including dissolved metals and potential for acid formation, from overflow and seepage from the pit after closure. These tasks should commence as soon as possible after completion of the detailed project design.	Ascertain whether acid and metalliferous drainage will be an issue in the mine pit, to what extent it might be an issue and whether it can be successfully managed. Confirm the closure water management approach.	The residual impact assessment has made assumptions that the proposed closure strategy will involve rapid filling of the pit lake, which will limit formation of acid. The impact assessment has not specifically assessed the impact of acid formation.
The impact assessment assumes that at closure the pit will be rapidly filled with water to establish a pit lake within five years and oxidation of potentially acid generating material will be minimised. The feasibility of this approach has yet to be demonstrated with extensive historical underground mine workings present that will be intersected by the mine pit and may provide multiple drainage points through the walls and base of the pit.	Confirm the feasibility of the pit lake closure option and assess the potential for acid and metalliferous drainage from the pit. Develop an adaptive plan for progressively plugging adits, shafts and tunnels. These tasks should commence as soon as possible after completion of the detailed project design.	To confirm the post closure impacts to surface waters from pit drainage and to develop appropriate management measures.	The impact assessment has assumed that acid generation will be minimal after rapid flooding of the pit. Quantitative predictions of changes to water quality parameters are not included in the assessment, although commentary is given on the expected spatial extent, severity and duration of impact.

Uncertainty	Further work	Purpose	Assumptions
The potential for additional demand on Nam La as a water source if Bawdwin residents are resettled in Namtu has not been considered in the project water balance modelling and management strategy.	Modelling and quantification of all Nam Pangyun and Nam La water volume use and assessment of the availability of the balance for downstream water users, particularly at Namtu. Identify and assess the suitability of additional water supply to users of the Nam La, including upgrading the Nam La flume and directing spring flow to the flume. This task should commence as soon as possible.	To determine changes in downstream flow due to project water use and how much flow will remain available (under a range of seasonal conditions) for downstream users	Impact assessment assumes that some water will be able to be released from the Nam La water harvesting facility during wet season; however, water will not be available for release in the dry season, resulting in a greater severity impact during that time.
It is currently not confirmed whether all project discharges will comply with the Myanmar mining effluent standards and what limitations if any the proposed water treatment designs have in terms of operating rates/capacity.	Conduct assessments of predicted water quality parameter concentrations (i.e., water quality modelling) for all project discharges. This should commence as soon as possible.	To provide reduce uncertainty around the ability of the project to comply with the standards, and the nature of any non-compliances. To determine the level of treatment of effluent required.	Quantitative predictions of changes to water quality parameters are not included in the assessment, although commentary is given on the expected spatial extent, severity and duration of impact. Information on expected elevated contaminants was derived from DFS assessment of tailings and waste rock characteristics. It is assumed that the samples analysed in the DFS are representative of the material that will be stored in the TSFs and waste rock dump. Discharges are assumed to meet Myanmar mining effluent standards under all circumstances.

Uncertainty	Further work	Purpose	Assumptions
Flood risk has not been modelled for the Nam Pangyun or Nam La catchments. Significant changes to the upstream Nam Pangyun and Nam La catchments and the large-scale storages of mine waste and water will alter the flood risks around the mine infrastructure and potentially to downstream communities (e.g., Lopah village, artisanal miners). The influence of the mine infrastructure and planned water management activities on flood risk is likely to change over the life of the mine. The effect of project activities may include both increased flood risk around mine infrastructure and potentially reduced flood risk in the lower catchment where flood peaks are attenuated. An assessment of impacts associated with climate change has not been included due to the lack of baseline stream flow data and detailed flood risk assessment.	Conduct detailed flood risk assessment for the project and account for effects of climate change of the timescale of project impacts. This should commence during project detailed design.	To determine risk of flooding to downstream communities and buildings caused by project changes to hydrology and landform in the Nam Pangyun catchment. To quantify the increased flood risk to the Nam La catchment that may result from the from added flow contributed from the TSF spillways during large rainfall events. To inform what appropriate mitigations can be developed.	Flood risk has not been fully assessed. Flood impacts have been assessed qualitatively and do not consider climate change.

Uncertainty	Further work	Purpose	Assumptions
Lack of understanding of changes to the Nam Pangyun sediment transport and deposition regime due to project related sediment. Sediment transport and deposition modelling has not been conducted.	Conduct downstream sediment deposition modelling for the Nam Pangyun, Nam La and Myitnge rivers. This task should commence as part of project detailed design. This would involve collecting information on the catchment topography (LiDAR), existing flow discharge conditions, and existing sediment characteristics (including existing TSS concentrations, particle size distribution and total sediment loads). Hydraulic modelling would be conducted for wet and dry season conditions and focus on event-based scenarios (e.g., a selection of representative time points where key changes to downstream flow and sedimentation are expected due to project activities). The modelling would address existing flow and sediment transport regime and future scenarios due to project-related changes and factoring in climate change effects where relevant. As such, the scope will require review of the locations and extents of project infrastructure and activities that will influence downstream runoff. The modelling would describe the changes to downstream river profile, accounting for scour, avulsion and sedimentation and predict TSS concentrations and extent (and locations) of aggradation. The results would inform the flood risk assessment and development of water quality criteria for TSS (under separate scopes).	To determine the extent and thickness of sediment deposition from project sources compared to baseline levels, including assessment of particulate contaminant concentrations in accumulated material. Inform the assessment of changes to bank overtopping/flood risk potential.	Quantitative predictions of changes to sediment transport and deposition are not included in the assessment, although commentary is given on the expected spatial extent, severity and duration of impact. Information on particle size retention criteria from sediment dam design (from the DFS) has been used in the assessment to inform characteristics of sediment being transported and deposited downstream.
Effects of project changes to hydrology and waste discharge causing scour of rivers	Conduct scour modelling as part of the sediment transport and deposition modelling. This task should commence as part of project detailed design.	Inform engineering design of river crossing and infrastructure. Confirm the extent of scour and inform assessment of project-caused stream aggradation.	Qualitative predictions have been made for stream bed aggradation and changes to surface flows.
Lack of predictions of quality of sediments that may be deposited during flood events.	Using the sediment transport and deposition and flood risk modelling, assess predicted metals concentrations in the deposited material and compare to sediment quality guidelines and soil ecological investigation levels (EILs). This task should commence as part of project detailed design.	To predict the quality of sediments deposited in downstream waters and on people’s gardens and agricultural land if such areas are predicted to be inundated.	High level assumptions on stream bed sediment quality changes have been made. No prediction of deposited sediments on land have been made.

Uncertainty	Further work	Purpose	Assumptions
Lack of quantitative predictions of the reduction in flow volumes in the Nam La and Nam Pangyun and the balance available for downstream use and environmental flows.	Conduct stream flow monitoring of the Nam La and Nam Pangyun. Conduct quantitative modelling of changes to downstream flows. These tasks should commence as soon as possible.	Confirm that sufficient water will be available for downstream beneficial uses and environmental flows to support ecosystems.	Qualitative assumptions have been made about the degree of flow reduction expected due to project activities.
Beneficial uses of waters in the lower Nam Pangyun. Engagement with communities in the lower Nam Pangyun has not occurred to date due to security concerns.	Engage communities in the lower Nam Pangyun catchment. This should commence as soon as possible.	To better understand use of water from the Nam Pangyun. There are known farming practices in the lower catchment; however, understanding their use of the river (if at all) will better inform the prediction of impacts and required mitigation and management measures.	Beneficial uses of this receptor were not specifically addressed, but high-level commentary on effects to potential beneficial uses is provided.
The potential for TSF seepage entering the Nam La aquifers and subsequent contaminated groundwater discharge to the Nam La stream is not well understood.	Groundwater modelling as outlined in Section 6.3.6. This should be conducted as soon as possible.	To assess and seepage transport around the TSFs, predict groundwater mounding and changes in flow, and identify likely contaminant transport pathways at TSFs. This should include the potential for contaminated groundwater discharge to watercourses.	Assumed in the groundwater impact assessment (Section 6.2) that there is a high likelihood of seepage (containing elevated dissolved metals and potentially sulfate) dispersing to the Nam La catchment.
The project is committing to design, construct, operate and close the TSF in line with the Global Industry Standard on Tailings Management. However, the DFS design was not aligned with the Global Industry Standard on Tailings Management and it is currently not certain how the project will meet the requirements of the standard.	As part of detailed design work, the existing outline design and other information relevant to TSF construction, operation and closure will be updated to address compliance with the Global Industry Standard on Tailings Management.	To confirm how the project will comply with the Global Industry Standard on Tailings Management and demonstrate the feasibility of implementing the measures.	The impact assessment assumes that the TSF will be designed, constructed, operated and closed in accordance with the Global Industry Standard on Tailings Management.

Developing site-specific water quality targets

This section provides an overview of further works to develop site-specific water quality targets for the Project. Development of the targets should be conducted by a water quality specialist.

The approach to deriving the site-specific targets will follow international good practice guidelines such as the approaches outlined in ANZG (2018). The ANZG guidelines outline an approach whereby reference data (i.e., baseline data recommended to be collected over a period of at least two years) is collected and using this data, appropriate percentiles are adopted as the target for each contaminant of concern. It is therefore important that additional baseline water quality data is collected, targeting various flow discharge rates of the Nam Pangyun, Nam La and Myitnge so that the current flux of dissolved metals is accurately understood.

Under the ANZG approach, to measure performance against the targets, the measured median concentrations of contaminants are compared to the targets.

Typically, for slightly-to-moderately disturbed aquatic ecosystems, the approach is to use an 80th percentile value of a given water quality parameter (e.g., metal concentration) derived from measurements taken in a reference stream (i.e., one that has not been impacted previously) and adopt this value as the site-specific water quality target. This approach is unlikely to be useful for the Nam Pangyun given that the concentrations of some metals are very high and would rarely (if at all) be below the 80th percentile of concentrations in any reference streams in the region.

A more suitable approach for the Nam Pangyun that the project will consider is adopting a suitable percentile from baseline data collected in the lower catchment (prior to the confluence with Myitnge River) for each dissolved metal and use this to derive the site-specific water quality targets for each dissolved metal. Adopting a 50th percentile of measured water quality parameters would essentially reflect an approach to ‘no change’ in water quality from current conditions. However, there will be times where water quality will be reduced due to the project and the application of 50th percentile site-specific targets would be not possible to achieve. A percentile between the 50th and 80th could be suitable for dissolved metals in the lower Nam Pangyun. The Myitnge River also has existing reduced water quality, although additional baseline monitoring is required downstream of the Nam Pangyun confluence (see Section 6.4.5 and 6.4.6) to better understand how far downstream dissolved metals are elevated above ANZ guidelines for ecosystem protection. A similar approach as proposed for the Nam Pangyun could be adopted to derive site-specific water quality targets for the Myitnge River. Using the Myitnge River water quality upstream of the confluence would not provide suitable reference data as it is known the water quality currently reduces significantly after mixing with the Nam Pangyun (see Section 5.3). As the Nam La could be considered a ‘slightly to moderately disturbed’ watercourse as outlined in the ANZG guidelines, site-specific-water quality targets could be derived by using the 80th percentile concentrations from baseline sampling in nearby reference locations or in the stream itself prior to disturbance.

6.5 Air quality impact assessment

6.5.1 Approach to impact assessment

This section assesses the project impacts to the air quality values identified in Section 5.5. Section 5.5 described the levels of importance, vulnerability and resilience associated with each of the air quality values (i.e., airsheds) in the study area. Subsequent air quality impacts to flora and fauna and human health are assessed further in Section 6.8 and Section 6.11.

The impact assessment approach adopted in this section is a 'significance assessment' (for further detail see Section 6.1). A significance assessment of air quality impacts involves:

- Identifying the nature of the impact to an air quality value (i.e., airshed and its associated value to receptors). An 'airshed' in this context is an air mass within a defined geographic area that behaves consistently with respect to the dispersion of emissions.
- Determining the magnitude of the impact through an assessment of the spatial extent, severity and duration of the impact.
- Assessing the significance of the residual impact (i.e., with assumed successful implementation of avoidance and management measures). The significance (very low, low, moderate, high or major) of the impact to an air quality value is determined by considering the importance, vulnerability and resilience of the air quality value (as assessed in Section 5.5.6) and the predicted magnitude of the impact to the value. Impact magnitude (very low, low, medium, high or very high) is determined based on the spatial extent, severity and duration of the impact.

Impacts to air quality values are assessed qualitatively, i.e., no numerical modelling of project air emissions has been conducted. The adopted method identifies and assesses the likely changes to air quality due to project activities within each airshed and qualitatively describes predicted changes in dust deposition at receptors (e.g., villages). The method makes reference to recommended separation distances between sensitive receptors and air emissions sources as published in the Australian Capital Territory (ACT) Government Separation Distance Guidelines for Air Emissions (ACT Government 2018). These guidelines aim to protect the amenity of sensitive receptors by providing a recommended distance between a source of reduced air quality and a receptor. The applied separation distances in the guidelines assume that 'best available technology economically achievable' will be applied to the relevant industry sectors to reduce the severity of emissions at source. The following specific aspects of separation distances between sources and receptors have been taken into account in this assessment:

- A general recommended separation distance of 500 m has been adopted for the process plant and ROM pad, waste rock dump, mine pit and tailing storage facilities, based on the prescribed separation distance in the ACT guidelines for materials handling including the 'crushing, grinding or milling of rocks, ores or minerals' and also the guidance for 'extractive industries' involving blasting.
- Additional sources of air emissions during operations discussed in Section 6.5.2 do not have recommended separation distances outlined in the guidelines. However, a 500 m distance has been adopted in this impact assessment for the power station based on the guidance for chemical and petroleum in the guidelines.
- Air emissions from construction sites are not addressed in the guidelines. However, where the extent of earth moving/clearing is significant they are likely to have a similar impact profile to the material handling guidelines.

The ACT guidelines allow the recommended separation distance (500 m) to be adjusted if there are clear factors that would influence the dispersion of air emissions. These may include:

- Topographic factors, e.g., hills separating the source of emissions and sensitive receptors, whether source/receptor is upslope or downslope (receptors upslope of an emission source are likely to be less impacted than those downslope). Hilly terrain attenuates the air flow to an extent and therefore a shorter separation distance can be applied. Receptors separated from the source by hilly terrain are expected to be less impacted than receptors the same distance from the source but separated by flat terrain.
- Surface roughness factors, e.g., presence of dense vegetation which may inhibit air movement. In the presence of such features a shorter separation distance could be applied.
- Other factors such as modelling, site specific meteorological conditions (including wind direction and speed). Where the prevailing wind blows in the same direction as a receptor from a source, a longer separation distance may be applied, as emissions may be able to travel further than in other directions.

- Application of best available rather than best available and economically achievable technology, etc. Best available is typically, of a higher standard than the technology that is deemed best available and economically achievable.

Figure 6.19 shows a 500 m buffer around sources of air emissions, providing an indication of receptors that are within the recommended separation distance and may be more significantly impacted by emissions.

It is recommended that air quality modelling based on detailed designs is conducted during the detailed design phase of the project, to confirm this assessment of predicted impacts and to inform the development of a detailed monitoring and management plan (see Section 6.5.6). Such work may also provide defensible information that allows the separation distances to be adjusted, if justified.

Impact severity is assessed within the context of relevant air quality criteria, noting that in some cases air quality criteria are already exceeded in the project area. Section 5.5.3 provides detail on the adopted ambient air quality criteria. Locations in the Bawdwin concession area, the Nam Pangyun valley and at Namtu (see Figure 6.20) are already affected by degraded air quality from high levels of particulate matter and dust deposition from historic and some current mining and processing sources, industrial and traffic sources, as well as ongoing wind erosion of the landscape.

Myanmar's Environmental Impact Assessment Guidelines (Myanmar Mining EIA Guidelines Working Group, 2018) for the Mining Sector stipulate ambient air quality standards for nitrogen dioxide (NO_2), sulphur dioxide (SO_2), particulate matter and ozone. These standards represent upper limits in receiving ambient air which should not be exceeded. The Myanmar National Environmental Quality (Emission) Guidelines (MOECAF, 2014) provide criteria for nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and particulate matter at the point of discharge from the power station. The emission guidelines are applicable to non-degraded airsheds, however have been implemented here as the airshed is not considered degraded with respect to gaseous pollutants (see Section 5.5.4).

The guidelines are relevant to gaseous pollutants, NO_2 and SO_2, and particulate matter, which are predicted to be the key emissions to air during the project.

The air quality impact assessment also refers to international guidelines (health screening criteria) for dust deposition rates (NSW EPA, 2017), and for particulate lead deposition rates (WHO, 2000) to provide context of existing conditions and inform assessment of impact severity. Health screening criteria for airborne particulates and airborne particulate metals have also been adopted from a range of sources as described in Section 5.5.

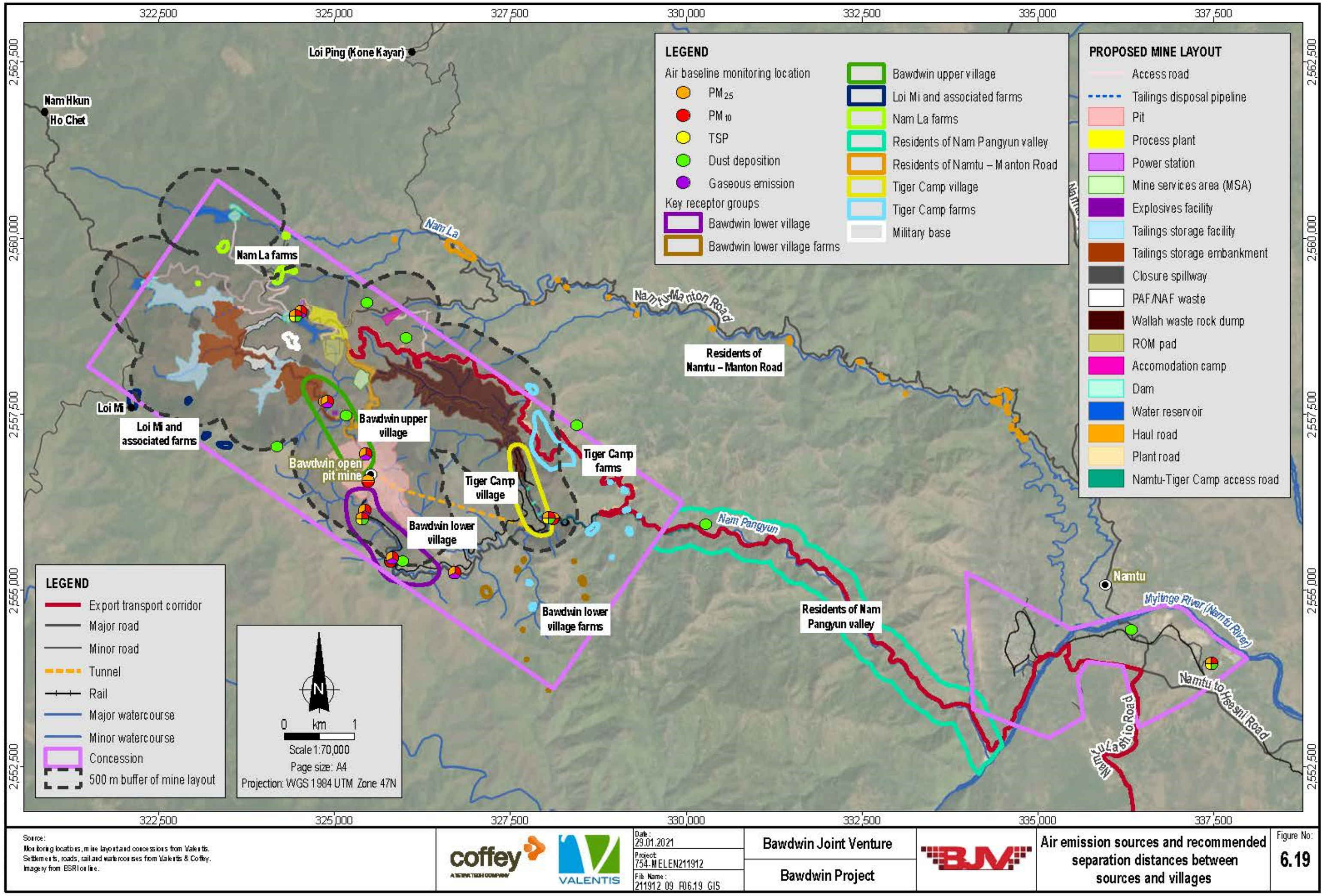


Figure 6.19 Air emission sources and recommended separation distances between sources and village

6.5.2 Potential air quality impacts

The project has the potential to reduce ambient air quality, which may adversely affect airsheds at receptor locations in the vicinity of the project area. Reduced air quality may affect associated values such as good quality and good visibility air that supports human health, wellbeing and amenity.

Potential sources of reduced air quality include:

- Increased airborne particulate matter (and in some cases associated airborne particulate toxicants) due to:
  - Ground disturbance during earthworks (construction, operations and closure).
  - Mining excavation and blasting (operations).
  - Handling, transport and disposal of soils, ore and waste rock material (construction, operations and closure).
  - Wind erosion of disturbed areas, stockpiles and dumps (construction, operations and closure).
  - Raised dust from vehicle movements on unsealed roads (construction, operations and closure).
  - Combustion emissions from the power plant (during operations), and diesel generations, project vehicles and machinery (during construction and operations).
- Increased dust deposition due to particulate emissions settling out of the air column. Increased dust deposition in areas within and surrounding the project can lead to health effects (for example if dust is ingested after depositing on food sources or being inhaled after resuspension), reduce amenity, and affect plant growth.
- Increased airborne gaseous pollutants due to:
  - Emissions from diesel generators during construction and from the power plant during operations.
  - Emissions from project vehicles and machinery (construction, operations and closure).
  - Blasting fumes.

These potential impacts are described further below.

Increased airborne particulate matter

The project may increase the amount of airborne particulate matter (dust) resulting in reduced visibility and amenity and also inhalation and ingestion by people.

Particulate matter includes:

- Total suspended particles (TSP), which comprises dust particles with a diameter of less than 50 µm. Particles of this size can remain suspended in air under prevailing meteorological conditions where they can be transported out of the project area.
- Particles of diameter less than 10 µm (PM_{10}), which are associated with health impacts including heart and respiratory diseases when inhaled.
- Particles of diameter less than 2.5 µm ($PM_{2.5}$), which are very fine particles that typically originate from combustion sources, such as vehicles and generators, and can readily enter the lungs and bloodstream when inhaled. Short term exposure to $PM_{2.5}$ can cause acute and chronic health problems.

The key potential sources of increased airborne particulate matter are outlined below.

The discussion of potential impacts associated with increased airborne particulate matter is discussed according to the project phase in which they occur i.e. construction, operations or closure. The assessment accounts for the combined effects on air quality from multiple simultaneous sources of airborne particulates rather than assessing each impact source in isolation.

Construction Phase

During construction, airborne particulate emissions will primarily occur during vegetation stripping and site earthworks during dry conditions. The main sources of these particulate emissions will be the larger construction sites, including the process plant, power station, ROM pad, mine services area, TSF embankments, explosives facility, accommodation camp, waste rock dump, haul roads and access roads.

Construction of the power station (0.3 ha), process plant (10.3 ha), ROM pad (9.2 ha), accommodation village and access road (6.8 ha), mine services area (4.4 ha), haul roads (14.8 ha) and access roads (44.4 ha) will result in a total of 90.2 ha of land disturbance and potential for dust generation. Additionally, construction of the initial TSF embankments, WRD and sediment control dams and pre-stripping of the mine pit (stage 1a) will expose another 99.5 ha of land.

Areas of exposed earth (i.e., sites cleared of vegetation or other cover, including construction sites, unsealed roads and soil stockpiles) will be susceptible to wind erosion, which could mobilise dust and emissions of particulates to air. Dust emissions will be most prevalent during dry (typically most common during November to April) and windy conditions, particularly in exposed elevated areas prone to higher wind speeds.

The Namtu to Tiger Camp access road and plant access road will be sealed. Roads within the mining operation (i.e., pit ramp and haul road) will be unsealed. The public Namtu-Manton Road between Namtu and the project is sealed. Heavy vehicles and machinery moving along these roads during dry conditions will generate dust. Dust will also be generated during the earthworks and transportation of soils, rock and fill.

Particulates emitted to air from these sources are likely to have elevated concentrations of heavy metals such as lead, due to existing contamination of soils throughout the project area from historic mining and mine waste disposal (see Section 6.2).

Small amounts of particulate material (likely to be mostly $PM_{2.5}$), will be emitted from vehicle exhaust and temporary power sources (i.e., diesel generators) during construction; however, they are expected to be minor sources of airborne particulate emissions over the two-year construction period and are not discussed further.

Operations Phase

Sources of particulate emissions to air during operations will be mining, mine waste management and ore handling. Mining will be performed by conventional open pit drill and blast methods and use of shovels and haul trucks. These activities will result in direct emissions of particulates to air throughout project operations, with these emissions being greatest during dry and windy conditions.

Dust will also be generated at TSF sites and during handling and stockpiling of ore and waste rock throughout operations. Wind erosion of disturbed earth around the pit, TSF embankments, dry portions of the TSF surface and Wallah waste rock dump, and at the soil, ore and waste rock stockpiles will contribute to the ongoing dust emissions prior to rehabilitation of these areas.

Heavy vehicle movements will continue throughout operations as waste rock is hauled to the Wallah waste rock dump and ore is hauled to the ROM pad. These activities will suspend dust along the haul roads.

Regular vehicle movements on public roads will also occur during the export of concentrate and supply of materials to the project (e.g., diesel for the power station). As these roads will be all sealed, dust impacts are not predicted and are not discussed further for public roads during project operation.

The project footprint is substantially larger than the existing footprint of the current open pit and associated infrastructure. The area that will be exposed to potential erosion and dust generation will vary throughout the operations as the footprint expands and as progressive rehabilitation occurs. Up to approximately 422.8 ha area will be exposed to potential erosion and dust generation during the course of operations, including the open pit (98.2 ha), ROM pad (9.2 ha), TSFs (149.0 ha), Wallah waste rock dump (107.2 ha), haul roads (14.8 ha) and access roads (44.4 ha).

Some particulates emitted to air during operations are expected to contain elevated concentrations of heavy metals such as lead, given the existing levels of land contamination throughout the project area and also the levels of metals present in the ore, waste rock and tailing.

The largest source of particulates in combustion emissions will be the power station and, to a lesser extent, exhaust emissions from vehicles and machinery. Combustion typically results in the emission of very fine particles, so it is expected that combustion emissions will include a greater proportion of $PM_{2.5}$. The power station is predicted to emit exhaust gases containing up to 47 $\mu g/m^3$ of particulate matter during operations. Rates of particulate emissions from vehicle and machinery combustion sources are expected to be minor sources of airborne particulate emissions during operations and are not discussed further.

Closure Phase

Airborne particulate emissions during closure are expected to be similar to construction for a short period during decommissioning works, mainly from ground disturbance as infrastructure is removed and final landforms are created. Dust will also be generated as soil and subsoil material is handled and transported, and during wind erosion of disturbed areas and stockpiles. Once decommissioning is complete, airborne particulate emissions are predicted to progressively decline as dust generating activities cease and exposed areas are revegetated or otherwise rehabilitated.

Increased dust deposition

As outlined above, the project will result in the emission of airborne dust particles. These particles have the potential to settle and form layers of dust on the ground, vegetation and buildings, depending on the prevailing weather conditions. Most dust deposition will occur in proximity to the active areas of the mine (i.e., the mine, waste rock dump, ROM pad and TSF areas), major construction areas, and around haul roads. Dust deposition will occur throughout the project and will be most prevalent during dry and windy conditions.

Dust deposition can cause adverse impacts due to physical smothering or covering of vegetation, fauna, water and garden resources and populated areas. The deposited particles can directly affect physiological processes of organisms (e.g., photosynthesis of plants) and processes such as temperature regulation and breathing by animals. Impacts of dust deposition on specific biological values are discussed further in Section 6.8. Physical deposition effects can also cause a nuisance to community receptors, reducing amenity and/or causing health effects when the dust attaches to skin or is resuspended and breathed in. Deposited dust that contains metal species can also have toxic effects on flora and fauna as well as humans. Section 6.11 identified that concentrations of lead in deposited dust at Bawdwin are anticipated to be of potential health risk (as is currently the case from baseline monitoring of deposited dust in the region). Therefore, this section considers the lead in deposited dust as well as the physical effect of smothering or covering the environment and community receptors.

Increased gaseous pollutants

The project will emit gaseous pollutants that can adversely impact air quality, including sulphur dioxide (SO_2) and nitrogen dioxide (NO_2). These gases are commonly generated by combustion emissions from power generation and from vehicles. Human exposure to these gases can lead to impacts on human health, including respiratory problems. Due to their odour, emissions of these gases can also reduce amenity.

The power station is predicted to emit exhaust gases containing up to 420 $\mu g/m^3$ of SO_2 and 2,469 $\mu g/m^3$ of NO_2 during operations. Rates of SO_2 and NO_2 emission from vehicle and machinery combustion sources are considered minor in the context of the power plant operations emissions and are not discussed further. The only exception is the ongoing movement of traffic along the concentrate export corridor during operations. High volumes of traffic are expected to produce noticeable exhaust emissions throughout the 13-years of operations. Other gaseous pollutants that will be emitted by the power station include carbon monoxide (CO) (up to 106 $\mu g/m^3$) and volatile hydrocarbons (up to 124 $\mu g/m^3$).

Blasting may generate fumes containing carbon monoxide (CO) and several oxides of nitrogen (NO_x). These gases can potentially pose a health risk to workers and the community. Prior to blasting, a nominal radius of 500 metres from the blast will used to determine a blast exclusion zone. The operational blast radius will be monitored and adapted as blasting practices, procedures, and monitoring are optimised. With this exclusion zone in place, along with the implementation of a Blasting Management Plan and Community Health, Safety and Security Plan, no impacts to receptors due to blast fumes are predicted and it is not considered further in this assessment. Management of blast fumes with respect to occupational health and safety will be addressed in the OSH Plan.

Summary of sources of potential impact

Table 6.83 summarises sources of potential impacts to air quality in each of the three project phases.

Table 6.83 Summary of sources of potential impact

Potential impacts	Construction	Operation	Closure
Increased airborne particulate matter, dust deposition and potential for airborne particulate toxicants, due to mobilisation of dust from areas exposed by ground disturbance, earthworks and vegetation clearance.	X	X	X
Increased airborne particulate matter, dust deposition and potential for airborne particulate toxicants due to direct emission of particles from mining excavation and blasting.		X	
Increased airborne particulate matter, dust deposition and potential for airborne particulate toxicants due to dust generated by handling, transport and disposal of soils, ore and waste rock material.	X	X	X
Increased airborne particulate matter, dust deposition and potential for airborne particulate toxicants due to wind erosion of disturbed areas, stockpiles, TSF surfaces and dumps.	X	X	X
Increased airborne particulate matter, dust deposition and potential for airborne particulate toxicants due to raised dust from vehicle movements on unsealed roads.	X	X	X
Increased airborne particulate matter, dust deposition and potential for airborne particulate toxicants due to combustion emissions from the power plant.		X	
Increased airborne particulate matter, dust deposition and potential for airborne particulate toxicants due to combustion emissions from project vehicles and machinery.	X	X	
Increased airborne gaseous pollutants due to emissions from power plant.		X	

X = occurring in this phase

6.5.3 Proposed mitigation and management measures

Potential air quality and dust deposition impacts will be avoided through project design and administrative controls or minimised through developing and implementing an air quality management plan. Proposed avoidance and management measures are outlined below.

Avoidance measures

A measure to avoid air quality impacts to human receptors will be the resettlement of communities that are located in proximity to the project area where the greatest potential impacts to air quality will occur. The various receptors will be resettled at different times depending on their location with respect to project activities.

Resettlement locations have not been confirmed and further engagement with resettled communities, planning and approvals are required, but the resettlement location(s) will almost certainly lie outside the zone of influence of air quality impacts that arise from the Bawdwin concession area itself.

Figure 6.20, 6.21, and 6.22 show the locations of all potential air quality and dust deposition receptor groups and Section 6.5.4 provides a description of these receptors, including the timing of resettlement (if applicable) in relation to project works.

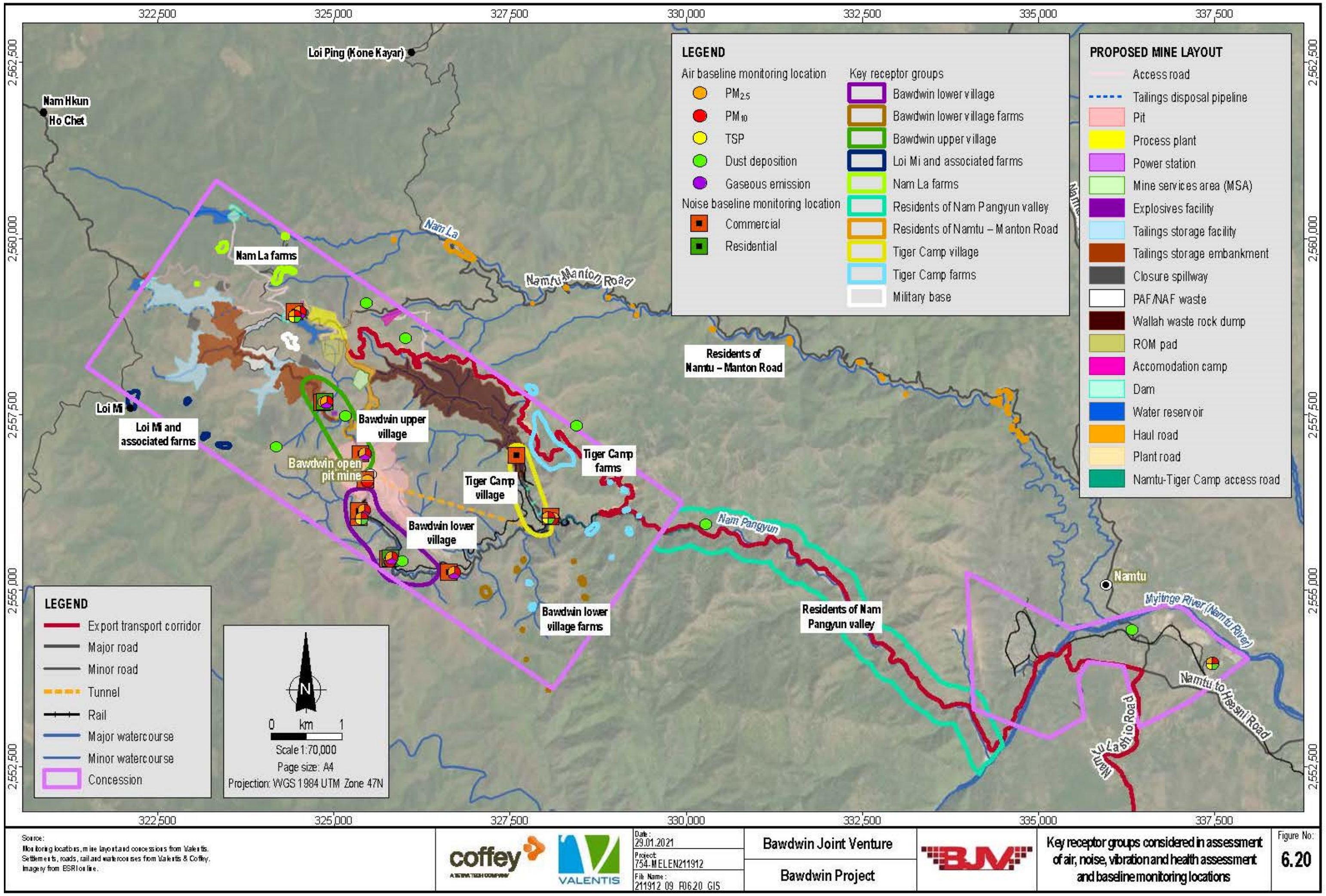


Figure 6.20 Key receptor groups considered in assessment of air, noise, vibration and health assessment and baseline monitoring locations

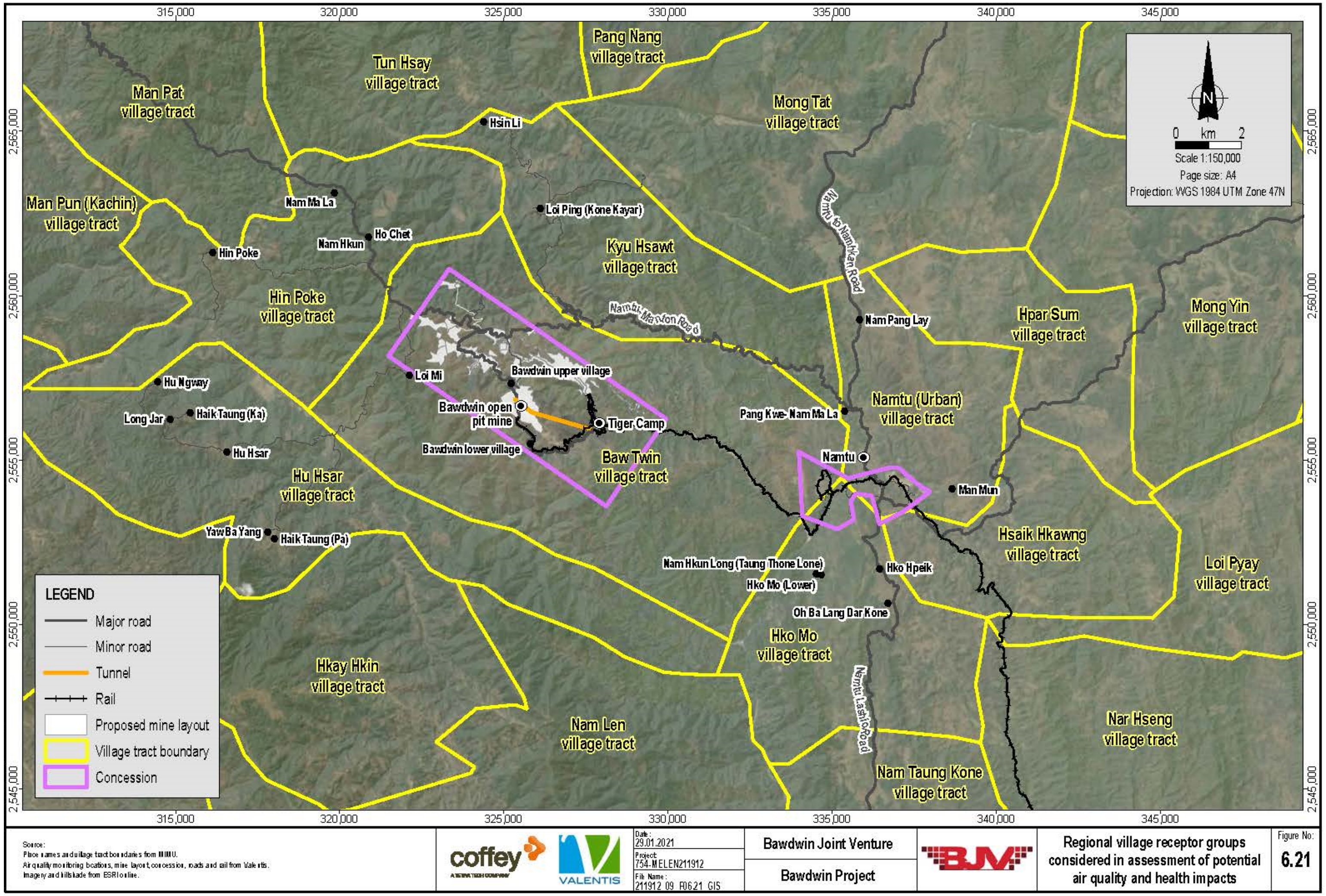


Figure 6.21 Regional village receptor groups considered in assessment of potential air quality and health impacts

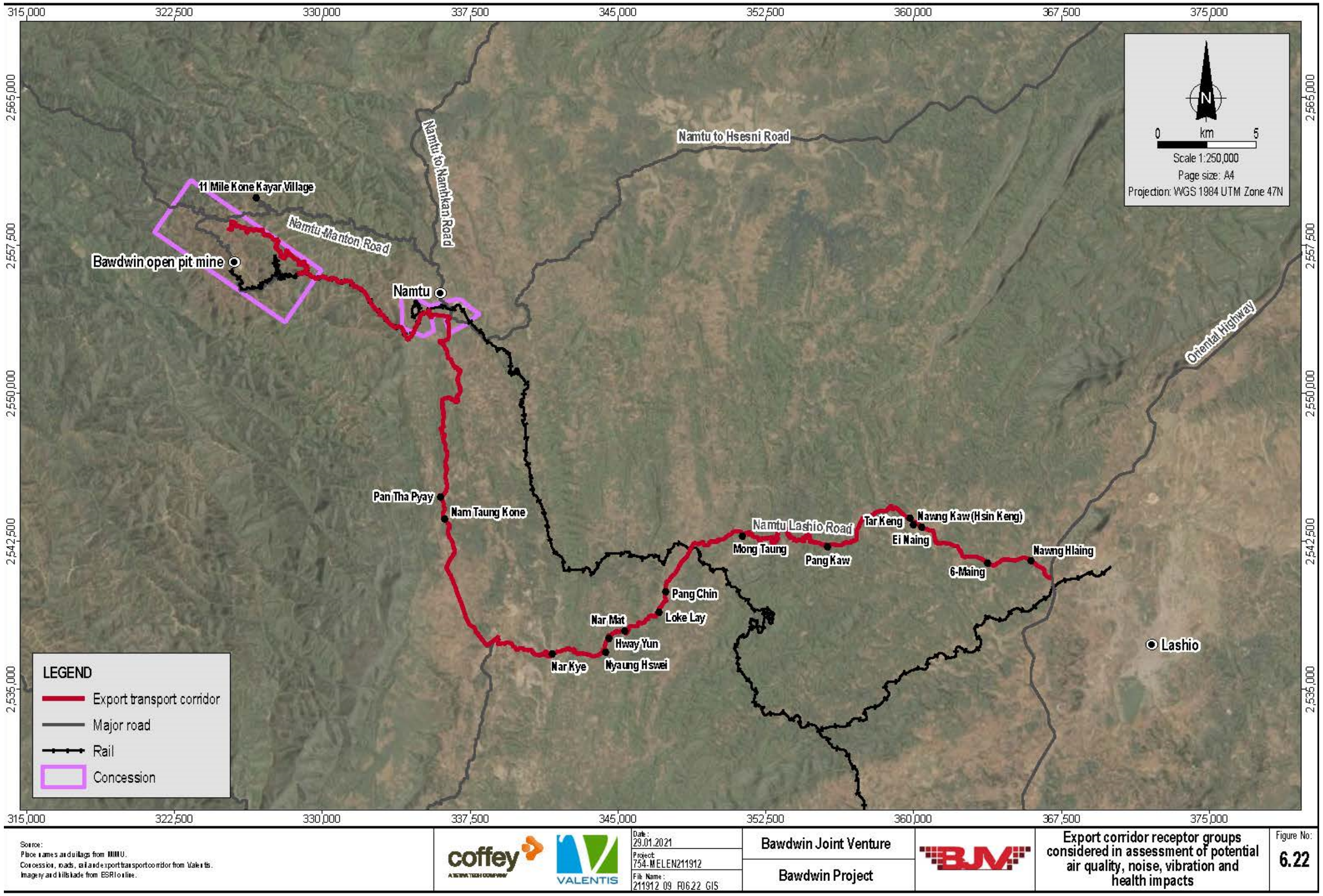


Figure 6.22 Export corridor receptor groups considered in assessment of potential air quality, noise, vibration and health impacts

Mitigation and management measures

Mitigation and management measures to minimise air emission and dust deposition impacts will include the following:

- Conduct real-time monitoring of dust emissions and weather conditions (wind speed and direction) and:
  - Avoid work near villages and settlements and increase dust suppression activities during high-risk periods.
  - Avoid blasting when wind speed and direction will blow blast gases over villages or settlements.
- Use of water to suppress dust in areas that have high potential for dust generation including construction sites, the open pit, ore stockpiles, waste rock dumping zones and haul roads.
- Use surface binding agents for constructed unsealed roads to minimise potential for dust generation.
- Minimise the extent, and time, that ground surfaces and stockpiles are exposed through staged works wherever possible.
- Cover exposed earth and stockpiles either temporarily with suitable material and/or revegetate to minimise the potential for wind erosion.
- Minimise the handling of soils, ore and waste rock material where practicable.
- Operate the power station in accordance with equipment operating specifications and regularly monitor exhaust emissions to ensure they meet Myanmar air emission criteria.
- Use vehicles, plant and equipment that is well maintained and minimises emissions to air.
- Establish and enforce speed limits on roads carrying project vehicles to minimise dust and noise generation.
- Adopt a tailings deposition strategy to minimise potential for dust generation, within the constraints imposed by the overall tailings design and management strategy (Knight Piésold, 2020).
- Undertake progressive rehabilitation and revegetation of disturbed areas (including the TSFs and waste rock dump) to minimise the length of time that disturbed areas are exposed to wind and erosion.

6.5.4 Residual impact assessment

This section presents the assessment of potential residual impacts identified in Section 6.5.2 after implementation of the management measures outlined in Section 6.5.3.

The magnitude of each residual impact is assessed based on the impact's geographic extent, severity and duration, taking into consideration the existing air quality and dust deposition conditions and the sensitivity of air quality values to receptors. Table 6.84 presents the criteria used to determine the magnitude of each impact.

Table 6.84 Criteria used to determine the magnitude of impacts to air quality

Criteria	Very low	Low	Medium	High	Very high
Spatial extent	Impact affects a very small proportion of the receptor (i.e., less than 5% of individual residences in the receptor group)	Impact affects a small proportion of the overall receptor (i.e., in the order of 5-25% of individual residences in the receptor group)	Impact affects a moderate proportion of the overall receptor (i.e., in the order of 25-50% of individual residences in the receptor group)	Impact affects most of the receptor group (i.e., in the order of 50-75% of individual residences in the receptor group)	Impact affects the entire receptor group (i.e., all individual residences in the receptor group)
Severity	Impact has a very low severity and is	Impact has a low severity and is	Impact is detectable against	Impact is readily detectable against	Impact results in a very large change

Criteria	Very low	Low	Medium	High	Very high
	not detectable against baseline. Changes to air quality are well below ambient air quality criteria at receptors.	barely detectable with against baseline. Impact is not likely to contribute noticeably to ambient air quality criteria at receptors.	baseline. Impact does not contribute more than 25% to the ambient air quality criteria at receptors.	baseline. Air quality criteria are exceeded at receptors, contribution is more than 25% of the ambient air quality criteria at receptors.	against baseline. Air quality criteria are exceeded at receptors, contribution is more than 50% of the ambient air quality criteria at receptors.
Duration	Impact is very short in duration (i.e., days)	Impact is short term (i.e., months or less)	Impact is medium term (1 to 2 years).	Impact is long term (3 to 15 years).	Impact is greater than 15 years or permanent.

Receptor groups

For the purposes of this impact assessment, the social receptors to air quality and dust deposition impacts are defined in Table 6.85. Figures 6.20, 6.21 and 6.22 shows the locations of these receptors and the location of baseline monitoring sites. The proximity of the receptors to the baseline monitoring sites is considered when assessing the uncertainty of the impact assessment, as more assumptions are made regarding existing air quality at sites further from monitoring locations.

Table 6.85 Receptor groups

Receptor Name	Description	Sources of potential impacts	Resettlement timing
Military base	Located less than 500 m south of the process plant and power station and less than 500 m from the TSF B and C embankments, and 1 km from the haul road.	Construction and operation of the process plant and power station Construction of the TSF B and C embankments Construction and use of the haul road	None proposed as this stage. Will be decided in consultation with the army.
Bawdwin upper village	Located immediately north of the open pit.	Construction activities associated with access and haul road construction and construction of accommodation, mine services area, process plant and power station.	Approximately 7 to 9 months after commencement of the project Prior to commencement of mining operations in month 10
Bawdwin lower village	Located immediately to the south of the open pit and 1.5 km south of the haul road.	Construction activities associated with Bawdwin South to Tiger Camp Road upgrades, haul road construction and pre-stripping. Operations including blasting, mining, haulage.	Approximately 40 to 42 months after commencement of the project (30 to 32 months after commencement of mining operations).
Bawdwin lower village farms	Scattered farms and associated houses located more than 1.5 km southeast of the open pit. This receptor is not anticipated to be impacted by noise due to its distance from project activities and is not assessed in this chapter.	Construction activities associated with Bawdwin South to Tiger Camp road upgrades, haul road, plant road and pre-stripping. Operations including blasting, mining and haulage.	Approximately 40 to 42 months after commencement of the project (30 to 32 months after commencement of mining operations).

Receptor Name	Description	Sources of potential impacts	Resettlement timing
Tiger Camp village (including Wallah Gorge)	Located immediately south of the proposed waste rock dump, approx. 1 km to the plant road and adjacent to the Namtu-Tiger Camp access road.	Construction activities associated with plant access road and Namtu-Tiger Camp access road, approximately 800 m away. Operations activities associated with haulage.	Approximately 29 to 30 months after commencement of the project (19 to 20 months after commencement of mining operations, 1 to 2 months before waste rock dump sediment dam construction and 8 to 9 months before waste rock dump construction) (and 9 to 10 months before deposition to the waste rock dump begins).
Tiger Camp farms – north and northeast of Tiger Camp	Scattered farms and associated houses to the east and northeast of Tiger Camp. Several of these farms and houses are within 500 m of the plant road and Namtu-Tiger Camp access road.	Construction activities associated with plant road, Namtu-Tiger Camp access road and waste rock dump and sediment dam early works. Operations including waste rock dump development and operation of plant road and Namtu-Tiger Camp access road.	Farms on the plant access road will be resettled prior to road construction 5 to 6 months after commencement of the project. Remaining farms above Tiger Camp resettled 40 to 42 months after commencement of the project (30 to 32 months after the commencement of operations).
Tiger Camp farms – Chin Hill farms	Scattered farms about 1 km to the south of Tiger Camp village.	Construction activities associated with Namtu-Tiger Camp access road and Bawdwin South to Tiger Camp road upgrades	Chin Hill farms will be resettled with Tiger Camp village 29 to 30 months after commencement of the project (19 to 20 months after the commencement of mining).
Loi Mi village and associated farms	Loi Mi village and associated farms located less than 500 m south of TSF-B and approx. 1.8 km from the pit.	Construction and operation of TSFs. Operations including blasting, mining and haulage.	To be determined, based on engagement and further investigation of impacts.
Nam La farms	Scattered farms and associated houses located between the Nam La water harvesting facility, the process plant and TSF-A	Construction of Nam La water harvesting facility and process plant access roads. Operation of process plant and power station, and haulage.	Approximately 7 to 9 months after commencement of the project when construction of the process plant, power plant etc occurs, prior to commencement of mining operations in month 10
Residents of Nam Pangyun valley downstream of Tiger Camp	Includes artisanal miners and permanent and seasonal residences associated with agricultural plots along the lower Pangyun valley downstream of the Bawdwin concession area alongside the Namtu-Tiger Camp access road.	Construction and operations noise from vehicles along the Namtu-Tiger Camp access road. Wheel generated dust and gaseous emissions from vehicles along the Namtu-Tiger Camp access road. General amenity impacts from construction and operations Closure-related vehicles	None
Villages in tracts adjoining the Bawdwin concession area	Includes twelve villages within an 8 km radius of the Bawdwin concession area: Ho Hoke, Ho Pat, Haik Taung (Pa), Hu Hsar, Haik Taung (Kai), Long Jar, Hu Ngway, Hin Poke, Ho Chet, Nam Hkun, Hsin Li, Loi Ping (Kone Kayar)	General amenity impacts from cumulative dust emissions from construction and operations.	None

Receptor Name	Description	Sources of potential impacts	Resettlement timing
Namtu	Namtu town	Noise from vehicles along the export corridor, which will pass through the southern part of Namtu town and alongside the northern bank of the Myitnge River Wheel generated dust and gaseous emissions from vehicles along the export corridor Closure related vehicles	None
Residents along the export route.	Residents (including standalone houses, settlements, villages and towns) along the export route from the processing plant to the National Highway 3, which is located approximately 70 km by road to the east of the concession.	Noise from vehicles along the export corridor. Gaseous emissions from vehicles along the export route.	None
Residents along the Namtu-Manton Road	Residents (including standalone houses and settlements) along the Namtu-Manton Road northeast of the Bawdwin concession area between Namtu and the accommodation camp.	Noise from vehicles along the Namtu-Manton Road during the early part of construction, before the Namtu-Tiger Camp-plant access roads are constructed. Gaseous emissions from vehicles along the export route.	None
Project workforce	Project personnel working on construction and operations.	Inhalation of dust including particles containing elevated lead and other heavy metals.	N/A

The locations described in Table 6.85 within the Bawdwin concession area, the Nam Pangyun valley and at Namtu (see Figure 6.20) are already affected by degraded air quality from high levels of particulate matter and dust deposition from historic mining, industrial and traffic sources, as well as ongoing wind erosion of the landscape. The villages outside the Bawdwin concession area are currently exposed to lower background levels of dust. Air quality and dust deposition impacts are assessed within this context, as described in Section 5.5.

This chapter does not assess impacts to project personnel working in the project area (project workforce receptor) which may be impacted by changes in air quality during the project. Occupational health and safety risks to project workforce are addressed in Section 6.11.

The environmental receptor referred to in this assessment is the general ecosystem functions in the region (i.e., from Bawdwin to Namtu). Impacts to environmental receptors are assessed in terms of the effect on the ecosystem generally. Section 6.8 provides further assessment of dust impacts to particular flora and fauna. The credible impacts to ecosystems will be via dust deposition, so only this pathway is assessed. Impacts due to air quality and dust effects are assessed in more detail in Section 6.8.

Climatic influences

Air quality and dust impacts are influenced by the weather conditions, particularly rainfall and wind. During high rainfall periods, dust emissions and deposition will be lower than during dry conditions. Sporadic heavy rainfall occurs in the wet season typically between May and October, with August being the wettest month, receiving almost 300 mm on average. Therefore, particulate air emissions are expected to be generally lower between May and October and higher between November and April. This relationship has been demonstrated during baseline monitoring, which showed lower levels of particulates in air during the wet season (see Section 5.5). While dry conditions may occur within the wet season and wet conditions may occur within the dry season, for the purposes of this impact assessment is assumed that suspension of dust is less during the wet season (May to October).

Wind data collected between January and May 2020 at the Bawdwin weather station located near the Nam Pangyun Reservoir, showed prevailing regional winds to be south-southwesterly. The highest wind speeds were recorded in January, reaching over 2.4 m/s in the south-southwesterly direction. In April and May, wind speeds in the south-southwesterly direction were still the most prevalent but wind speeds decreased. This pattern indicates that for at least some of the year, the predominant winds will tend to transport airborne particulates and dust towards the mountainous terrain areas north of the Bawdwin concession area. Further monitoring is needed to develop an understanding of the wind trends throughout the year. Wind speed and direction in Bawdwin are discussed further in Section 5.4.4.

Based on climate models prepared by Meteoblue (Meteoblue, 2020), the annual prevailing wind at Namtu is in a southerly direction. Here the monsoon creates steady strong winds from December to April, and calm winds from June to September. During 2019, modelled wind speeds were strongest between February and May when northwesterly winds dominated. Prevailing winds then ease and shift to a southwesterly between June through early September before tending south-southeasterly between late September through to January. This modelling indicates that during the strongest winds air emissions will be directed to the southeast, but for most of the time the dominant winds in the region (i.e., the south- southwesterlies, and southeasterlies) will direct air emissions in a northly direction. The May to October period coincides with the wetter months and the amounts of dust transported are predicted to be relatively low during this period; however, increased rainfall is assumed to not decrease the gaseous pollutants transported by air during this period. From October to May, prevailing wind directions vary, and it is expected that gaseous air emissions from the Bawdwin area would also vary in their direction.

This climate information has been used to inform the likely durations of air quality and dust deposition impacts experienced at receptor locations around the project area. Though, additional meteorological monitoring may change some of the assumptions around rainfall and wind direction influences.

Increased airborne particulate matter and dust deposition

Construction Phase

During construction, the project will result in increased airborne particulate matter due mainly to dust generated from site earthworks and vehicle movement on project access and haul roads. Ongoing wind erosion of disturbed earth and soil stockpiles will contribute to levels of airborne particulate matter until the sites are covered, either with temporary cover or vegetation. Notwithstanding the implementation of dust suppression and minimisation management measures, the project will result in suspension and subsequent deposition of some dust in the surrounding environment.

Due to the scale of disturbance during the construction period, increased levels of airborne particulate matter over and above the existing conditions are expected. Most of the dust will come from site earthworks in the central Bawdwin concession area where the large construction areas (mine services area, process plant, ROM pad, power station, TSFs and waste rock dump) are located. To a lesser extent, road construction will contribute to the dust emissions in a transient manner, as the road disturbance progresses linearly. Dust emissions from vehicle movements are expected to be relatively localised.

Most of the dust deposition is expected to occur around the major construction sites in the central project area. At times finer particles (probably PM_{10} and smaller) will probably be transported greater distances before being deposited. Dust deposition will be sporadic depending on the timing and location of source(s) of raised dust and the prevailing weather conditions at the time. For example, under drier, windier conditions, more dust will be generated and transported further distances.

During construction, the emission of dust will be attenuated by ongoing active dust suppression across the site. This will be achieved by spraying water onto the key sources of dust during dry conditions. During the wet season (i.e., May to October), less active dust suppression is expected to be necessary to mitigate dust generation due to rainfall and wet conditions. The effect of wind erosion and suspension of dust will reduce as disturbed areas are progressively stabilised and rehabilitated.

As much of the landscape in the Nam Pangyun catchment is cleared of vegetation, highly eroded and contaminated with heavy metals, the area is of low ecosystem value and has minimal associated land and water resource beneficial values. Section 6.8 discusses habitat loss and degradation in more detail; however, with dust suppression measures in place increased dust deposition is not expected to be a significant cause or contributor to the loss or reduced functioning of ecosystems.

During the construction period it is unlikely that extensive dust deposition will occur outside of the Bawdwin concession area due to the separation distance between the concession boundary and the majority of the dust sources. The highest levels of dust deposition will occur closer to project activities/sources.

Baseline air monitoring has shown that the Bawdwin and Namtu region currently experiences elevated levels of particulate concentrations in air. Background ranges exceed the adopted ambient air quality screening criteria for total suspended particulates (150 ug/m^3) and PM_{10} (50 ug/m^3) at all sites across the Bawdwin, Tiger Camp and Namtu monitoring areas (see Figure 6.20 for monitoring locations and Section 5.5 for more detail on the baseline data).

The baseline monitoring also showed that current lead concentrations in the particulates exceed the health screening criterion (0.5 ug/m^3) across all monitoring sites in Bawdwin, Tiger Camp and Namtu. Within the Bawdwin concession area, this is probably due to dust containing elevated lead levels from wind erosion of the Bawdwin mine and waste rock disposal areas and cleared hillsides. Within Namtu, historic pollution and the remining of tailings (that is being undertaken by a third party) is likely to contribute to dust levels.

Across the Bawdwin to Namtu region the measured baseline dust deposition rates exceed the adopted screening criterion of 4 g/m^2/month (with the exception of one of the twelve monitoring sites near Bawdwin village at 13 Mile; see Figure 6.20). Baseline dust deposition rates were highest at Namtu (average of 1,000 mg/m^2/day), which is possibly the result of reprocessing/mining of historic tailings deposits. Baseline dust deposition sampling also found lead concentrations in deposited dust to be above the WHO (2000) health screening criterion of 0.25 mg/m^2/day at all 12 monitoring sites, with a maximum recorded concentration of about 3 mg/m^2/day just north of Bawdwin Village (see Figure 6.20).

The receptors likely to receive the highest levels of dust during the construction period will be the Bawdwin upper village (albeit for a short period), Bawdwin lower village and the Bawdwin military base. Bawdwin upper village will be resettled approximately 7 to 9 months after commencement of construction and will be exposed to dust from construction of the process plant, power station and haul road. If it remains in its current location, the military base will also be exposed to dust from these sources throughout the construction period. Bawdwin lower village will be resettled 30 to 32 months after the commencement of mining operations (month 10) and will be exposed to particulate matter from construction of the haul road and development throughout the construction period. Tiger Camp village will be resettled 19 to 20 months after the commencement of mining operations and is expected to experience elevated level dust as the Namtu-Tiger Camp access road construction passes adjacent to the village (see Figure 6.19).

Tiger Camp farms are also likely to experience high levels of particulate matter from construction of the Namtu-Tiger Camp access road and plant road and possibly from construction of the Wallah waste rock dump sediment dams. While farms immediately along the plant access road will be resettled prior to road construction, the remaining farms will be resettled during the operations phase (29 to 32 months after operations commence). Residents of the Nam Pangyun valley will experience dust emissions during the construction of the Namtu-Tiger Camp access road along the rail corridor. These receptors will not be resettled. Nam La farms will be exposed to particulate matter during construction of the access road to the Nam Law water harvesting facility, from site earthworks at the process plant and power station. This receptor will be resettled 7 to 9 months after commencement of construction.

Bawdwin lower village, Tiger Camp village, Tiger Camp farms, residents of the Nam Pangyun valley and Nam La farms will be most prone to dust deposition impacts due to their proximity to project activities. The extent of dust deposition (i.e., predicted thickness and locations of deposition) at each of these receptors needs to be confirmed by predictive dust deposition modelling. Airsheds further away from the Bawdwin concession area will be less affected by increased airborne particulate matter. This includes Loi Mi village and associated farms, Namtu and the twelve villages in tracts adjoining the Bawdwin concession area and Namtu. These receptors would be more likely to experience occasional dust deposition comprising finer particles transported by prevailing winds, given these receptors are located further away from construction ground disturbance sources of dust.

Despite implementation of dust suppression measures Bawdwin upper village will experience dust from construction of the process plant, power station, mine services area and haul road. The significance of increased dust to Bawdwin upper village during the construction phase is considered to be of **high significance**, based on the **medium magnitude** of impact and the **high sensitivity** of the value (Table 6.86).

Table 6.86 Residual impact significance summary – construction phase – reduced air quality due to increased airborne particulate matter and increased dust deposition – affecting Bawdwin upper village

Value	**Sensitivity of value**			
Bawdwin upper village airshed – cleanliness of air and visual amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The airshed is of high importance due to it supporting amenity, human health and ecosystems.	**High** The airshed has high levels of existing particulate matter and rates of dust deposition, so has high vulnerability to amenity, health and wellbeing effects from additional air emissions	**Low** The airshed is not resilient to further increases in air emissions due to high levels of existing emissions.	**High**
Impact	**Magnitude of impact**			
Reduced air quality due to increased airborne particulate matter and increased dust deposition during construction	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very high Impact is expected to affect the entire receptor given the proximity to the dust generating activities	**Medium** There is predicted to be a notable increase in dust (despite intensive dust suppression) given the receptor's proximity to a range of construction activities (within 500 m of the haul road and mine services area), which are likely to result in a cumulative contribution of dust. The dust may contain elevated heavy metals such as lead.	**Low** Impact is short term over 7 to 9 months of construction activities prior to resettlement of the receptor. While the impact will vary depending on the exact location of construction, and to an extent the prevailing wind and rain conditions, the increases in dust levels will be most pronounced in the dry season.	**Medium**
	Residual impact significance			**High**
	Assessment of uncertainty			
	High There is an absence of air quality modelling and limited meteorological baseline. The use of general recommended separation distances has been adopted for guidance.			

If it remains in its current location, the existing Bawdwin military base will experience dust emissions from construction of the process plant, power station, haul road and TSF embankments. The significance of increased dust to the military base during the construction phase is considered to be of **major significance**, based on the **high magnitude** of impact and the **high sensitivity** of the value (Table 6.87).

Table 6.87 Residual impact significance summary – construction phase – reduced air quality due to increased airborne particulate matter and increased dust deposition – affecting the Bawdwin military base

Value	**Sensitivity of value**			
Military base airshed- – cleanliness of air and visual amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The airshed is of high importance due to it supporting amenity and human health.	**High** The airshed has moderate to high levels of existing particulate matter and rates of dust deposition. It has moderate degree of attenuation by surrounding topography. The airshed is highly vulnerable to changes in air quality due to its close proximity to the project.	**Low** The existing airshed experiences moderate to high concentrations of dust and pollutants. Considering the current quality of the airshed in terms of its physical and chemical properties (i.e., poor quality), there is a little capacity to withstand further adverse air quality changes.	**High**
Impact	**Magnitude of impact**			
Reduced air quality due to increased airborne particulate matter and increased dust deposition during construction	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very high Impact is expected to affect the entire receptor given the proximity to the dust generating activities	**High** There is predicted to be a notable increase in dust given the receptor's proximity to a range of construction activities (approximately 400 m of the power station and process plant sites and TSF-C embankment), which are likely to result in a cumulative contribution of dust. The impact will be readily detectable with respect to existing variability and dust may contain elevated heavy metals such as lead.	**Medium** Impact is medium term throughout the construction period. While the impact will vary depending on the exact location of construction, and to an extent the prevailing wind and rain conditions, the increases in dust levels will be most pronounced in the dry season.	**High**
	Residual impact significance			**Major**
	Assessment of uncertainty			
	High There is an absence of air quality modelling and limited meteorological baseline. The use of general recommended separation distances has been adopted for guidance.			

The residual impact significance of reduced air quality affecting Bawdwin lower village and Tiger Camp village receptors during the construction phase due to increased project-related airborne particulate matter and increased dust deposition will be of **major significance**, based on a predicted **high magnitude** of impact and the **high sensitivity** of the value of the airsheds (Table 6.88 and Table 6.89).

Table 6.88 Residual impact significance summary – construction phase – reduced air quality due to increased airborne particulate matter and increased dust deposition – affecting Bawdwin lower village

Value	**Sensitivity of value**			
Bawdwin lower village airshed – cleanliness of air and visual amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The airshed is of high importance due to it supporting amenity, human health and ecosystems.	**High** The airshed has high levels of existing particulate matter and rates of dust deposition, so has high vulnerability to amenity, health and wellbeing effects from additional air emissions	**Low** Existing airshed of Bawdwin villages experiences moderate to high concentrations of dust and pollutants. Considering the current quality of the airshed in terms of its physical and chemical properties (i.e., poor quality), there is a little capacity to withstand further adverse air quality changes.	**High**
Impact	**Magnitude of impact**			
Reduced air quality due to increased airborne particulate matter and increased dust deposition during construction	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very high Impact is expected to affect the entire receptor given the proximity to the dust generating activities, with highest impact expected within 500 m of the pit pre-stripping.	**High** There is predicted to be a notable increase in dust given the receptor's proximity to construction activities (<500 m) (parts of Bawdwin Lower village are within 500 m from pit pre-stripping). The impact will be readily detectable with respect to existing variability and dust will contain elevated heavy metals such as lead.	**Medium** Impact is medium term over the duration of the construction activities. While the impact will vary depending on the exact location of construction, and to an extent the prevailing wind and rain conditions, the increases in dust levels will be most pronounced in the dry season.	**High**
	Residual impact significance			**Major**
	Assessment of uncertainty			
	High There is an absence of air quality modelling and limited meteorological baseline. The use of general recommended separation distances has been adopted for guidance.			

Table 6.89 Residual impact significance summary – construction phase – reduced air quality due to increased airborne particulate matter and increased dust deposition– affecting Tiger Camp village

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Tiger Camp village airshed – cleanliness of air and visual amenity</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>High
The airshed is of high importance due to it supporting amenity, human health and ecosystems.</td><td>High
The airshed has high levels of existing particulate matter and rates of dust deposition, so has high vulnerability to amenity, health and wellbeing effects from additional air emissions. Additionally, the topography of the Tiger Camp means that it is situated in a valley with little opportunity for airborne particles to be dispersed by wind.</td><td>Low
Existing airshed of Tiger Camp village experiences moderate to high concentrations of dust and pollutants. Considering the current quality of the airshed in terms of its physical and chemical properties (i.e., poor quality), there is a little capacity to withstand further adverse air quality changes.</td><td>High</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact</th></tr>
<tr><td rowspan="6">Reduced air quality due to increased airborne particulate matter and increased dust deposition during construction</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Very high
Impact is expected to affect the entire receptor given the proximity to the dust generating activities</td><td>Medium
There is predicted to be a notable increase in dust from construction activities for the adjacent the Tiger Camp – Namtu access road). The dust may contain elevated heavy metals such as lead due to historic contamination.</td><td>Low
Impact is short term over the expected five months to construct the Namtu to Tiger Camp Road. While the impact will vary depending on the exact location of construction, and to an extent the prevailing wind and rain conditions, the increases in dust levels will be most pronounced in the dry season.</td><td>Medium</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>High</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">High
There is an absence of air quality modelling and limited meteorological baseline. The use of general recommended separation distances has been adopted for guidance.</td></tr>
</table>

The residual impact significance of reduced air quality during construction due to increased project-related airborne particulate matter and increased dust deposition affecting Tiger Camp farms will be of **medium significance**, based on a predicted **medium magnitude** of impact and the **medium sensitivity** of the value (Table 6.90).

Table 6.90 Residual impact significance summary – construction phase – reduced air quality due to increased airborne particulate matter and increased dust deposition – affecting Tiger Camp farms

Value	**Sensitivity of value**			
Tiger Camp farms airshed – cleanliness of air and visual amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The airshed is of high importance due to it supporting amenity, human health and ecosystems.	**Medium** The farms are close to Tiger Camp on relatively high, open terrain, meaning dust and contaminants would possibly be able to disperse and not linger in those areas. The existing airshed is likely to be less degraded and consequently less vulnerable than Tiger Camp village due to their location upslope, however dust deposition levels on the nearby Shar Toe Hill exceed guideline levels, so the airshed is still likely to be moderately degraded and have moderate vulnerability to further degradation.	**Medium** As Tiger Camp farms are expected to have slightly less degraded airsheds than Tiger Camp village, there is likely to be some capacity to cope with further increases in air emissions.	**Medium**
Impact	**Magnitude of impact**			
Reduced air quality due to increased airborne particulate matter and increased dust deposition during construction	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	High Impact is expected to affect a high proportion of the receptor given the proximity to the dust generating activities (access road, plant road and sediment dam construction) to some of the individual residences. There is only a small number of residences that are more than 500 m away, which will experience little to no impact. Chin Hill farms will be relocated prior to sediment dam construction. Tiger Camp farms on the access and plant roads will be relocated prior to road construction.	**Medium** There is predicted to be a notable increase in dust given the receptor's proximity to construction activities (several farms are within 500 m of the Namtu-Tiger Camp access road and plant access road). The impact will be readily detectable with respect to existing baseline and dust may contain elevated concentrations of heavy metals, although the impact will be transient in nature with receptors likely to be exposed to variable and fluctuating levels of dust as construction moves across the terrain.	**Low** Impact is short term over the expected five months to construct the Namtu to Tiger Camp Road. While the impact will vary depending on the exact location of construction, and to an extent the prevailing wind and rain conditions, the increases in dust levels will be most pronounced in the dry season.	**Medium**
	Residual impact significance			**Medium**
	Assessment of uncertainty			
	High There is an absence of air quality modelling and limited meteorological and air quality baseline in this area. The use of general recommended separation distances has been adopted for guidance.			

The residual impact significance of reduced air quality during construction due to increased project-related airborne particulate matter and increased dust deposition affecting Bawdwin lower village farms will be of **low significance**, based on a predicted **low magnitude** of impact and the **medium sensitivity** of the value (Table 6.91).

Table 6.91 Residual impact significance summary – construction phase – reduced air quality due to increased airborne particulate matter and increased dust deposition – affecting Bawdwin lower village farms

Value	**Sensitivity of value**			
Bawdwin lower village farms airshed – cleanliness of air and visual amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The airshed is of high importance due to it supporting amenity, human health and ecosystems.	**Medium** These farms are reasonably well removed from existing project activities and are on relatively high, open terrain meaning dust and contaminants would probably be able to readily disperse and not linger in those areas. Receptor would have medium level of vulnerability to additional dust causing amenity, health and wellbeing impacts given relatively moderate existing dust levels.	**Medium** As the lower Bawdwin village farms are likely to have a less degraded airshed than Bawdwin lower village, the airshed probably has some capacity to cope with further increases in air emissions.	**Medium**
Impact	**Magnitude of impact**			
Reduced air quality due to increased airborne particulate matter and increased dust deposition during construction	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Impact will affect a small proportion of the receptor, given most of the individual residences will be over 2 km from the Namtu-Tiger Camp access road construction and mine pre-stripping.	**Low** Given the distance from the Namtu-Tiger Camp access road (more than 500 m at its closest point) and other dust generating sources, impacts to air quality and dust deposition are expected to be of low severity with respect to baseline dust conditions.	**Medium** Impact is medium term over the expected two years of construction activities. The increases in dust levels will be most noticeable in the dry season. The increases in dust levels will be intermittent, with for example, little dust being generated in the wet season.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	High There is an absence of air quality baseline data, air quality modelling and limited meteorological baseline. The use of general recommended separation distances has been adopted for guidance.			

The residual impact of reduced air quality during the construction phase due to increased project-related airborne particulate matter and increased dust deposition affecting Nam La farms will be of **moderate significance**, based on a predicted **medium magnitude** of impact and the **medium sensitivity** of the value (Table 6.92).

Table 6.92 Residual impact significance summary – construction phase – reduced air quality due to increased airborne particulate matter and increased dust deposition – affecting Nam La farms

Value	**Sensitivity of value**			
Nam La farms airshed – cleanliness of air and visual amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The airshed is of high importance due to it supporting amenity, human health and ecosystems.	**Medium** These farms are reasonably removed from the existing mine, however there are expected to be relatively moderate existing dust levels as dust deposition at the nearby Bawdwin Reservoir (around 500 m away from the closest farm) exceeds guideline values. The airshed would have medium level of vulnerability to additional dust causing amenity, health and wellbeing impacts.	**Medium** As the farms are expected to have a relatively clean airshed compared to receptors in the upper Nam Pangyun valley, there is likely to be capacity to cope with further increases in air emissions.	**Medium**
Impact	**Magnitude of impact to value**			
Reduced air quality due to increased airborne particulate matter and increased dust deposition during construction	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Impact will affect a moderate proportion of the receptor (those individual residences near the access road to the Nam La water harvesting facility) with the remainder (i.e., those residences more than 500 m away) being either unaffected or affected to a materially lower extent.	**High** Given that the receptor is adjacent to sections of the access road to the Nam La water harvesting facility (50 m away in some sections) and some farms around 100 m from the power plant site, 200 m from the process plant site and within 500 m of the Nam La water harvesting facility, it is expected that dust will be high compared to existing conditions and compared to ambient air quality criteria.	**Low** Impact is short term (i.e., in the order of months) as construction of infrastructure near Nam La farms is completed and the receptors are resettled after 7 to 9 months after commencement of construction. The increases in dust levels will be most noticeable in the dry season.	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High There is an absence of air quality baseline data, air quality modelling and limited meteorological baseline. The use of general recommended separation distances has been adopted for guidance.			

The residual impact of reduced air quality during the construction phase due to increased project-related airborne particulate matter and increased dust deposition affecting Loi Mi village and associated farms will be of **low significance** for receptors that are resettled, based on the **low magnitude** of impact and the **medium sensitivity** of the value, and **low significance** for receptors that are not resettled, based on the **low magnitude** of impact and **medium sensitivity** of the value (Table 6.93).

Table 6.93 Residual impact significance summary – construction phase – reduced air quality due to increased airborne particulate matter and increased dust deposition – affecting Loi Mi village and associated farms

Value	**Sensitivity of value**			
Loi Mi village and associated farms airshed – cleanliness of air and visual amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The airshed is of high importance due to it supporting amenity, human health and ecosystems.	**Medium** The farms are removed from existing project activities and the airshed is likely to be less degraded than receptors within the upper Nam Pangyun valley. As the farms are on relatively high, open terrain, emissions would probably be able to readily disperse and not linger in those areas. The airshed would have medium vulnerability to additional dust causing amenity, health and wellbeing impacts given the expected relatively low existing dust levels.	**High** As the farms are expected to have a relatively clean airshed compared to receptors in the upper Nam Pangyun valley, there is likely to be capacity to cope with further increases in air emissions.	**Medium**
Impact	**Magnitude of impact to value**			
Reduced air quality due to increased airborne particulate matter and increased dust deposition during construction	**IF RESETTLED (those receptors within the Bawdwin concession area)**			
	Spatial extent	***Severity***	***Duration***	***Magnitude***
	Low Impact will affect a small proportion of the receptor (those farms and residents in the concession boundary), until they are resettled with the remainder being either unaffected or affected to a materially lower extent.	**Very low** The closest construction dust source is the TSF-B embankment, approximately 1 km away from individual Loi Moi farms not within the Bawdwin concession area (i.e., assuming those receptors within the concession area are resettled to outside the concession area). The increase in airborne particulates will is predicted to be of very low severity in the context of baseline levels of airborne dust.	**Medium** Impact is medium term over the period of TSF embankment construction (prior to resettlement). The increases in dust levels will be most noticeable in the dry season. The increases in dust levels will be intermittent, with for example, little dust being generated in the wet season.	**Low**
	Residual impact significance (if resettled)			**Low**

Impact	Magnitude of impact to value			
Reduced air quality due to increased airborne particulate matter and increased dust deposition during construction	**IF NOT RESETTLED**			
	Spatial extent	***Severity***	***Duration***	***Magnitude***
	Low Impact will affect a small proportion of the receptor (those farms and residents in the concession boundary) with the remainder being either unaffected or affected to a materially lower extent.	**Low** The closest construction dust source is the TSF-B embankment, about 500 m away from individual Loi Moi farms within the Bawdwin concession area. Most farms and Loi Mi village are approximately 1 km away from the TSF embankment. The increase in airborne particulates is predicted to be of low severity in the context of baseline levels of airborne dust.	**Medium** Impact is medium term over the period of TSF embankment construction. The increases in dust levels will be most noticeable in the dry season. The increases in dust levels will be intermittent, with for example, little dust being generated in the wet season.	**Low**
	Residual impact significance(if not resettled)			**Low**
	Assessment of uncertainty			
	High There is an absence of air quality baseline data, air quality modelling and limited meteorological baseline. The use of general recommended separation distances has been adopted for guidance.			

The residual impact of reduced air quality during the construction phase due to increased project-related airborne particulate matter and increased dust deposition affecting residents of the Nam Pangyun valley (along new site access road) will be of **moderate** significance, based on the **medium magnitude** of impact and the **medium sensitivity** of the value (Table 6.94).

Table 6.94 Residual impact significance summary – construction phase – reduced air quality due to increased airborne particulate matter and increased dust deposition – affecting residents of the Nam Pangyun valley

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Nam Pangyun valley airshed – cleanliness of air and visual amenity</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>High
The airshed is of high importance due to it supporting amenity, human health and ecosystems.</td><td>Medium
There are relatively moderate existing dust levels and dust deposition at the nearby Law Po Hill exceeding guidelines levels. The narrow valley setting may result in dusty conditions lingering in the area compared to more open terrain. Nam Pangyun valley has low topography with little opportunity for airborne particles and gaseous pollutants to be dispersed by wind.</td><td>Medium
Given the moderate existing dust levels, there is probably some capacity to cope with further increases in air emissions.</td><td>Medium</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact to value</th></tr>
<tr><td rowspan="5">Reduced air quality due to increased airborne particulate matter and increased dust deposition during construction</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Medium
This impact will affect a moderate proportion of the receptor (i.e., those individual receptors adjacent to the road) with those further away (i.e., in the order of 500 m or more) experiencing little or no impact.</td><td>High
There is predicted to be temporary increases in high intensity dust given receptor’s proximity (i.e., several residences less than 200 m away) to construction activities (i.e., Namtu to Tiger Camp access road).
The effect will be readily detectable with respect to existing variability and dust is expected to contain elevated heavy metals such as lead (see Figure 5.33).</td><td>Low
Impact will be short term (5 month road construction period) and transient along the access road length as construction progresses. The increases in dust levels will be most noticeable in the dry season, when construction is planned to occur.</td><td>Medium</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Moderate</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">High
There is an absence of air quality modelling, limited meteorological and air quality baseline and uncertainty of receptor locations. The use of general recommended separation distances has been adopted for guidance.</td></tr>
</table>

The residual impact of reduced air quality during the construction phase due to increased project-related airborne particulate matter and increased dust deposition affecting Namtu town will be of **very low significance**, based on the **very low magnitude** of impact and the **medium sensitivity** of the value (Table 6.95).

Table 6.95 Residual impact significance summary – construction phase – reduced air quality due to increased airborne particulate matter and increased dust deposition – affecting Namtu town

Value	**Sensitivity of value**			
Namtu town airshed – cleanliness of air and visual amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The airshed is of high importance due to it supporting amenity, human health and ecosystems.	**Medium** Existing airshed has a medium to high vulnerability to additional dust causing amenity, health and wellbeing impacts given relatively moderate to high existing dust levels.	**Low** Existing airshed of Namtu Town experiences moderate to high concentrations of pollutants and dust deposition near Namtu exceeds guideline values. There is likely to be only a limited degree of capacity to cope with further increases in air emissions.	**Medium**
Impact	**Magnitude of impact to value**			
Reduced air quality due to increased airborne particulate matter and increased dust deposition during construction	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very low Impact will affect a very small proportion of the receptor, due to the distance from construction activities (within the Bawdwin concession area)	**Very low** The Namtu area is expected to experience a relatively small change to its airshed given its distance to major construction sites (the Namtu-Tiger Camp access road being several kilometres from most residential areas) and with respect to existing baseline levels, the existing high levels of dust present in the air across the region, and the active dust suppression to be carried out by the project.	**Low** Impact is short term during construction near Namtu of access road. The increases in dust levels will be most noticeable in the dry season.	**Very low**
	Residual impact significance			**Very low**
	Assessment of uncertainty			
	Medium There is an absence of air quality modelling and limited meteorological baseline. The use of general recommended separation distances has been adopted for guidance.			

The residual impact of reduced air quality during the construction phase due to increased project-related airborne particulate matter and increased dust deposition affecting villages in tracts adjoining the Bawdwin concession area will be of **low significance**, based on the **low magnitude** of impact and the **medium sensitivity** of the value (Table 6.96).

Table 6.96 Residual impact significance summary – construction phase – reduced air quality due to increased airborne particulate matter and increased dust deposition – affecting villages in tracts adjoining the Bawdwin concession area

Value	**Sensitivity of value**			
Airsheds of villages in tracts adjoining Bawdwin concession area – cleanliness of air and visual amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The airshed is of high importance due to it supporting amenity, human health and ecosystems.	**Low** These villages are separated from project activities by mountainous terrain and located more than 3 km from project-related air emission sources (Ho Chet being the closest; see Figure 6.20). It is expected that the existing air quality of the airshed is relatively good and that the airshed has low vulnerability to changes to health and wellbeing due to additional dust; although amenity might be reduced.	**High** These villages are expected to have relatively good air quality and would be able to withstand some amount of additional air emissions	**Medium**
Impact	**Magnitude of impact to value**			
Reduced air quality due to increased airborne particulate matter and increased dust deposition during construction	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very low Impact will affect only a very small proportion of the receptor, with only the closest village, Ho Chet, potentially exposed to the impact (although modelling would be needed to confirm this). The remaining villages ranging from 5-10 km from project construction areas are not expected to be affected	**Very low** The regional area is expected to experience a relatively small change to its airshed given the distance to construction activities (closest receptors being more than 2.5 km from TSF-A and Nam La Dam). Impact is not expected to cause or contribute to exceedance of air quality criteria.	**Medium** Impact is medium term over the expected period of construction activities. While the impact will vary depending on the exact location of construction, and to an extent the prevailing wind and rain conditions, the increases in dust levels will be most noticeable in the dry season.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	High There is an absence of air quality baseline data, air quality modelling and limited meteorological baseline. The use of general recommended separation distances has been adopted for guidance.			

Operations Phase

During operations, the primary sources of particulate emissions to air will be mining, mine waste management and ore handling. The increase in particulate emissions will be more pronounced during dry conditions. Dust generated by mining, blasting and handling of rock and, to a lesser extent, soil is likely to comprise a significant proportion of large, non-respirable, particles. Large dust particles (i.e., larger than PM_{10}) tend to have a short atmospheric presence and are brought to the ground by gravity (Appendix G). Wind erosion of materials in the pit, TSFs, Wallah waste rock dump and soil, ore and waste rock stockpiles will be a source of ongoing dust emissions prior to rehabilitation of these areas. Dust from these sources may include high concentrations of metals. Design of these facilities and dust suppression measures to be developed during the detailed design will reduce the dust emissions from these sources.

Particulate emissions from ore and waste rock handling will occur where materials are collected, tipped into haul trucks, hauled, and disposed into stockpiles and dumps. Increases in suspended dust in the air will also occur as haul vehicles and operations supply vehicles move along unsealed roads and during ongoing wind erosion of exposed earth.

During operations, most of the dust deposition is expected to occur around the mine pit, along the haul roads and near the ROM pad. Wind erosion of the TSF embankments and Wallah waste rock dump prior to these sites being rehabilitated with vegetation cover will result in dust deposition in nearby areas. The existing context, the impact pathways and influencing factors are mostly the same as described above for construction. By the time of commencement of mining operations, 10 months after commencement of the project, Bawdwin upper village, some Tiger Camp farms and Nam La farms will be resettled and will no longer be potential receptors. Tiger Camp village will remain until 19 to 20 months after the commencement of mining operations and the remaining Tiger Camp farms and Bawdwin lower village will remain until 30-32 months after the commencement of mining operations. The Bawdwin military base will not be resettled as part of the project and may remain throughout operations. If it remains in its current location, the military base will experience increased dust from development of the TSF embankments and the haul road. The military base lies within 500 m of the TSFB and TSFC embankments.

Prior to resettlement, Bawdwin lower village and Tiger Camp farms are expected to be impacted by dust emissions during operations. At the start of mining year 3, the crest of the open pit will approach to within 100 m of Bawdwin lower village as measured horizontally. This is well within the recommended separation distance between mining activities and sensitive receptors of 500 m. Bawdwin lower village is expected to be exposed to severe dust emissions from mining.

Those of the Tiger Camp farms which are not resettled until 30 to 32 months after the commencement of mining operations may be impacted by dust from the Wallah waste rock dump. The distance between Tiger Camp farms and the Wallah waste rock dump will vary, but in some cases the distance will be less than 500 m

Tiger Camp village will be resettled 19 to 20 months after commencement of mining operations and approximately nine months before waste rock is disposed into the waste rock dump. The key source of dust to Tiger Camp village during operations will be mining but intervening topography may limit this.

The nature of the dust generating sources (i.e., locations, timing and rates of dust generation) are likely to differ during operations compared to construction as described below:

- Dust emission sources will be more constant and predictable (i.e., a progressively moving pit, scheduled blasting, and routine traffic movements and haulage of ore and waste rock to stockpiles), compared to multiple simultaneous construction sites in different locations each with different extents of dust generation.
- Dust emission sources during operations will occur over a longer period (i.e., 13 years). However, resettlement of the sensitive receptors within the Bawdwin concession area will be complete by 30 to 32 months from the commencement of mining operations.
- Dust from mining is likely to comprise coarser material compared to disturbance and handling of large quantities of soil during construction. Due to the high concentrations of heavy metals in the ore and waste

rock it is probable that the dust will have higher concentrations of lead and other metals than currently present in the dust.

The Bawdwin lower village farms are likely to experience low severity dust impacts as they are about 2 km from the open pit and are outside the general recommended separation distance of 500 m. Several Tiger Camp farms are within 500 m of the Wallah waste rock dump, within the recommended separation distance, and are therefore still expected to be affected. Some of the Loi Mi farms are within 350 m of TSF-A; within the recommended separation distance even when adjusted for topography.

Some of the settlements within the Nam Pangyun valley are located within 200 m of the Namtu-Tiger Camp access road, within the 500 m recommended separation distance. Central Namtu town is approximately 1 km from the export corridor (although outer parts of the town are in proximity to the export corridor), however this is not anticipated to be a source of dust. Namtu town is approximately 8 kilometres from the nearest dust generating source during operations, the waste rock dump. The villages in tracts adjoining the Bawdwin concession area are approximately 3 km from the nearest dust-generating source. These are both beyond the 500 m recommended separation distance and impacts are likely to be less severe than receptors within the buffer.

As outlined above for construction, active dust suppression and rainfall will attenuate the levels of airborne particulates due to the project. Prevailing wind conditions and topography will dictate the directions the dust is transported and subsequently, which receptors have their airsheds affected and for how long they are affected. During operations the sources of emissions of airborne particulates will be relatively consistent (i.e., consistent dust generation as the open pit expands, emissions associated with daily blasting of the pit and 24/7 haulage of ore and waste rock). Most of the dust will originate from the mine and mine waste areas in central Bawdwin, with minor emissions along the haul roads to the north. Dust from light vehicle movements around the broader Bawdwin concession area are negligible due to the adoption of speed limits and are not discussed further.

Operation of the diesel power station will result in the emission of particulate matter in exhaust gas with concentrations of up to 46,875 $\mu g/m^3$, providing an ongoing contribution of airborne particulate material. This material is likely to comprise predominantly finer particles such as $PM_{2.5}$, which commonly form during combustion reactions.

Table 6.97 presents the predicted emissions of particulates during operation of the diesel power station. The highest concentration of emitted particulates in exhaust gases from all operating scenarios is presented in bold. The maximum emission concentrations are compared to Myanmar air emission limits for electric power transmission and distribution (as outlined in the draft National Environmental Quality (Emission) Guidelines) and baseline concentrations measured at Bawdwin.

Table 6.97 Maximum particulate emission mass flow rates ($\mu g/m^3$) for power plant engine stack cluster

Parameter	Unit	Engine load[b]			Myanmar air emission limit[a]	Baseline range (ambient) (Bawdwin area)
		100%	75%	50%		
Particulate matter (as dry dust) - Based on dry exhaust flow rate	$\mu g/m^3$	41,667	41,322	**46,875**	50,000	3.2-266
Particulate matter (as dry dust) - Based on wet exhaust flow rate	$\mu g/m^3$	15,294	15,221	18,293		

Particulate emission rates calculated using data source: Unpublished (2020)
a. Criteria for liquid fuels for 'Reciprocating engine' and plant of '50-300 MW', which are deemed most applicable to the diesel power station proposed for the Bawdwin Project. These criteria are based on normal cubic metres ($\mu g/Nm^3$), which are analogous to $\mu g/m^3$.
b Engine load refers to percentage of maximum operating power

Table 6.97 shows that emissions of particulates from the power station exhaust will be at concentrations below the applicable Myanmar air emission limits.

As outlined above for construction impacts, the Bawdwin to Namtu region currently experiences elevated particulate concentrations in air with background ranges exceeding the adopted health screening criteria. Widespread elevated particulate lead concentrations (above health screening criteria) are currently present in airborne dust at Bawdwin.

Bawdwin lower village and Tiger Camp village, as well as farms associated with those villages, will remain in situ for various durations during operations before being resettled (see Table 6.85 and Figure 6.20). Loi Mi village and associated farms may be resettled or may remain in situ.

For these community receptors, who will eventually be resettled, impacts will be limited to the period prior to resettlement, up to 32 months after the commencement of mining operations, which is 10 months after commencement of the project. After resettlement, remaining nearby receptors (e.g., Loi Mi village and associated farms, residents of the Nam Pangyun valley, villages in tracts adjoining the Bawdwin concession area and Namtu) will generally be distant from dust generation sources. During operations, impacts will be mitigated by active dust suppression with water, progressive rehabilitation, management of tailings surfaces, ongoing air quality monitoring, community consultation and grievance mechanisms and resettlement procedures.

The impacts of dust deposition on biological values are discussed further in Section 6.8. As much of the landscape in the Nam Pangyun catchment is cleared of vegetation, highly eroded and contaminated with heavy metals, the area is of low ecosystem value and has minimal associated land and water resource beneficial values.

The residual impact of reduced air quality affecting Bawdwin military base during the operations phase due to increased project-related airborne particulate matter and increased dust deposition will be of **major significance**, based on the **high magnitude** of impact and the **high sensitivity** of the value (Table 6.98).

Table 6.98 Residual impact magnitude summary – operations phase – reduced air quality due increased airborne particulate matter and increased dust deposition – affecting Bawdwin military base

Value	**Sensitivity of value**			
Military base airshed – cleanliness of air and visual amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The airshed influences amenity, human health and ecosystems	**Medium** The airshed is likely to have moderate levels of existing particulate matter and rates of dust deposition, so has moderate vulnerability to amenity, health and wellbeing effects from additional air emissions	**Low** The airshed is not resilient to further increases in air emissions due to high levels of existing emissions.	**High**
Impact	**Magnitude of impact to value**			
Reduced air quality due to gaseous pollutants during operations	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	High The impact is likely (depending on emission scenario and weather conditions) to affect all of this receptor.	**High** The receptor is within 500 m the TSF-B and TSF-C embankments. The impact is likely be noticeable compared to baseline conditions. Dust from the TSFs (in addition to the embankments) may also be present.	**High** Impact is long term (frequently occurring) throughout operations.	**High**
	Residual impact significance			**Major**
	Assessment of uncertainty			
	Medium There is an absence of air quality modelling and limited meteorological baseline. The use of general recommended separation distances has been adopted for guidance.			

The residual impact of reduced air quality during the operations phase (prior to resettlement) due to increased project-related airborne particulate matter and increased dust deposition affecting Bawdwin lower village will be of **major significance**, based on the **high magnitude** of impact and the **high sensitivity** of the value (Table 6.99).

Table 6.99 Residual impact significance summary – operations phase – reduced air quality due to increased airborne particulate matter and increased dust deposition – affecting Bawdwin lower village prior to resettlement

Value	**Sensitivity of value**			
Bawdwin lower village airshed – cleanliness of air and visual amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The airshed influences amenity, human health and ecosystems	**High** The airshed has high levels of existing particulate matter and rates of dust deposition, so has high vulnerability to amenity, health and wellbeing effects from additional air emissions	**Low** The airshed is not resilient to further increases in air emissions due to high levels of existing emissions.	**High**
Impact	**Magnitude of impact to value**			
Reduced air quality due to increased airborne particulate matter and increased dust deposition during operations	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very high Impact is expected to affect the entire receptor given the proximity to the dust generating activities.	**High** Increased airborne and deposited dust expected to be highly noticeable at this receptor given its proximity to the open pit (less than 200 m from the main village area) where blasting and intense surface disturbance will occur, and well within the recommended separation distance of 500 m.	**Medium** Impact is medium term (frequently occurring over approximately 30-32 months of operations) prior to the receptor being resettled.	**High**
	Residual impact significance			**Major**
	Assessment of uncertainty			
	Medium There is an absence of air quality modelling and limited meteorological baseline. The use of general recommended separation distances has been adopted for guidance.			

The residual impact of reduced air quality during the operations phase due to increased project-related airborne particulate matter and increased dust deposition affecting Bawdwin lower village farms will be of **low significance**, based on the **low magnitude** of impact and the **medium sensitivity** of the value (Table 6.100).

Table 6.100 Residual impact significance summary – operations phase – reduced air quality due to increased airborne particulate matter and increased dust deposition – affecting Bawdwin lower village farms

Value	**Sensitivity of value**			
Bawdwin lower village farms airshed – cleanliness of air and visual amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The airshed influences amenity, human health and ecosystems	**Medium** These farms are reasonably well removed from existing project activities and are on relatively high, open terrain meaning dust and contaminants would probably be able to readily disperse and not linger in those areas. Receptor would have medium level of vulnerability to additional dust causing amenity, health and wellbeing impacts given relatively moderate existing dust levels.	**Medium** As the lower Bawdwin village farms are likely to have a less degraded airshed than Bawdwin lower village, the airshed probably has some capacity to cope with further increases in air emissions.	**Medium**
Impact	**Magnitude of impact to value**			
Reduced air quality due to increased airborne particulate matter and increased dust deposition during operations	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Impact will affect a small proportion of the receptor, given most of the individual receptors will be over 2 km from the open pit	**Low** The expected increase in airborne particulates and dust deposition will be of low severity given the distance of about 2 km from the existing open pit, outside the recommended separation distance, and in the context of background levels of airborne dust.	**Medium** Impact is medium term (frequently occurring over approximately 30-32 months of operations) prior to the receptor being resettled.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	High There is an absence of air quality baseline data, air quality modelling and limited meteorological baseline. The use of general recommended separation distances has been adopted for guidance.			

The residual impact of reduced air quality during the operations phase due to increased project-related airborne particulate matter and increased dust deposition affecting Tiger Camp village will be of **moderate significance**, based on the **low** of impact and the **high sensitivity** of the value (Table 6.101).

Table 6.101 Residual impact significance summary – operations phase – reduced air quality due to increased airborne particulate matter and increased dust deposition – affecting Tiger Camp village

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Tiger Camp village airshed – cleanliness of air and visual amenity</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>High
The airshed influences amenity, human health and ecosystems</td><td>High
The airshed has high levels of existing particulate matter and rates of dust deposition, so has high vulnerability to amenity, health and wellbeing effects from additional air emissions</td><td>Low
The airshed is not resilient to further increases in air emissions due to high levels of existing emissions.</td><td>High</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact to value</th></tr>
<tr><td rowspan="6">Reduced air quality due to increased airborne particulate matter and increased dust deposition during operations</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Low
Impact is expected to affect only a small proportion of the receptor given the distance of more than 2 km between the village and the open pit.</td><td>Low
There is likely to be a minor increase in airborne dust and dust deposition given the receptor’s distance to operations dust sources (more than 2 km to the open pit boundary) and this is far greater than the recommended separation distance of 500 m. Tiger Camp will be resettled prior to construction and use of the waste rock dump and sediment dams.</td><td>Medium
Impact is medium term (frequently occurring over approximately 19-20 months of operations prior to the receptor being resettled.</td><td>Low</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Moderate</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">Medium
There is an absence of air quality modelling and limited meteorological baseline. The use of general recommended separation distances has been adopted for guidance.</td></tr>
</table>

The residual impact of reduced air quality during the operations phase due to increased project-related airborne particulate matter and increased dust deposition affecting Tiger Camp farms will be of **moderate significance**, based on the **medium magnitude** of impact and the **medium sensitivity** of the value (Table 6.102).

Table 6.102 Residual impact significance summary – operations phase – reduced air quality due to increased project-related airborne particulate matter and increased dust deposition – affecting Tiger Camp farms

Value	**Sensitivity of value**			
Tiger Camp farms airshed – cleanliness of air and visual amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The airshed influences amenity, human health and ecosystems.	**Medium** The farms are close to Tiger Camp on relatively high, open terrain, meaning dust and contaminants would possibly be able to disperse and not linger in those areas. The existing airshed is likely to be less degraded and consequently less vulnerable than Tiger Camp village due to its location upslope. However, dust deposition levels on the nearby Shar Toe Hill exceed guideline levels, so the airshed is still likely to be moderately degraded and have moderate vulnerability to further degradation.	**Medium** As Tiger Camp farms are expected to have slightly less degraded airsheds than Tiger Camp village, there is likely to be some capacity to cope with further increases in air emissions.	**Medium**
Impact	**Magnitude of impact to value**			
Reduced air quality due to increased airborne particulate matter and increased dust deposition during operations	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	High Impact is expected to affect a high proportion of the receptor given the proximity to the dust generating activities to some of the individual residences. There are only a small number of residences that are more than 500 m away, which will experience little to no impact.	**Medium** There is predicted to be an increase in dust given the receptor's proximity to operations dust sources (largely within 500 m of the Wallah waste rock dump and plant road). The level of dust from plant road during operations is expected to be less than generated during construction of the road as the road will be sealed.	**Low** Impact is short-term (occurring for approximately 2-4 months of operations) prior to the receptor being resettled.	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High There is an absence of air quality modelling and limited meteorological and air quality baseline in this area. The use of general recommended separation distances has been adopted for guidance.			

The residual impact of reduced air quality during the operations phase due to increased project-related airborne particulate matter and increased dust deposition affecting Loi Mi village and associated farms will be of **low significance** for receptors that are resettled, based on the **low magnitude** of impact and **medium sensitivity** of the value, and **moderate significance** for receptors that are not resettled, based on the **medium magnitude** of impact and me**dium sensitivity** of the value (Table 6.103).

Table 6.103 Residual impact significance summary – operations phase – reduced air quality due to increased airborne particulate matter and increased dust deposition – affecting Loi Mi village and associated farms

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Loi Mi village and associated farms airshed – cleanliness of air and visual amenity</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>High
The airshed influences amenity, human health and ecosystems</td><td>Medium
The farms are removed from existing project activities and the airshed is likely to be less degraded than receptors within the upper Nam Pangyun valley. As the farms are on relatively high, open terrain, emissions would probably be able to readily disperse and not linger in those areas. Airshed would have medium vulnerability to additional dust causing amenity, health and wellbeing impacts given the expected relatively low existing dust levels.</td><td>High
As the farms are expected to have a relatively clean airshed compared to receptors in the upper Nam Pangyun valley, there is probably some capacity to cope with further increases in air emissions.</td><td>Medium</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact to value</th></tr>
<tr><td rowspan="4">Reduced air quality due to increased airborne particulate matter and increased dust deposition during operations affecting Loi Mi village and associated farms</td><td colspan="4">IF RESETTLED (those receptors within the Bawdwin concession area)</td></tr>
<tr><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Very low
Impact may affect a small proportion of the receptor (outside the Bawdwin concession area that are not resettled, with the remainder being either unaffected or affected to a materially lower extent.</td><td>Low
The closest project dust source is TSF B, which is approximately 1 km away from Loi Mi farms, which are not within the Bawdwin concession area and may elect to be resettled. There is uncertainty around how much dust the TSF may produce, however potential increases in existing levels of dust and particulate lead are likely for the farms on the hilltops closest to TSF B. The impact to Loi Mi village is expected to be less noticeable.</td><td>Medium
Impact is medium term (frequently occurring) prior to the receptors being resettled</td><td>Low</td></tr>
<tr><td colspan="3">Residual impact significance IF RESETTLED</td><td>Low</td></tr>
</table>

Table continues on the next page

Impact	Magnitude of impact to value			
Reduced air quality due to increased airborne particulate matter and increased dust deposition during operations affecting Loi Mi village and associated farms	**IF NOT RESETTLED**			
	Spatial extent	***Severity***	***Duration***	***Magnitude***
	Low Impact will affect a small proportion of the receptor (those farms and residents within the Bawdwin concession area) with the remainder being either unaffected or affected to a materially lower extent.	**Medium** The closest project dust source is TSF B which for the closest resident is less than 500 m away. There is more than 1.5 km to other major operation areas. There is uncertainty around how much dust the TSF may produce, however potential increases in existing levels of dust and particulate lead are likely for the farms on the hilltops closest to TSF B. The impact to Loi Moi village is expected to be less noticeable.	**High** Impact will be long term, affecting the receptor group throughout the course of operations (13 years).	**Medium**
	Residual impact significance IF NOT RESETTLED			**Moderate**
	Assessment of uncertainty			
	High There is an absence of air quality baseline data, air quality modelling and limited meteorological baseline. The use of general recommended separation distances has been adopted for guidance.			

The residual impact of reduced air quality during the operations phase due to increased project-related airborne particulate matter and increased dust deposition affecting residents of the Nam Pangyun valley will be of **moderate significance**, based on the **medium magnitude** of impact and the **medium sensitivity** of the value (Table 6.104).

Table 6.104 Residual impact significance summary – operations phase – reduced air quality due to increased airborne particulate matter and increased dust deposition – affecting residents of the Nam Pangyun valley

Value	**Sensitivity of value**			
Nam Pangyun valley airshed – cleanliness of air and visual amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The airshed influences amenity, human health and ecosystems	**Medium** There are relatively moderate existing dust levels and dust deposition at the nearby Law Po Hill exceeding guidelines levels. The narrow valley setting may result in dusty conditions lingering in the area compared to more open terrain.	**Medium** Given the moderate existing dust levels, there is probably some capacity to cope with further increases in air emissions.	**Medium**
Impact	**Magnitude of impact to value**			
Reduced air quality due to increased airborne particulate matter and increased dust deposition during operations affecting residents of the Nam Pangyun valley	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Impact will affect a small proportion of the receptor (i.e., those individual close to the waste rock dump, the closest source of dust approximately 2.1 km away). Concentrate trucks and road will be sealed.	**Low** There may be an increase in dust associated with use of the waste rock dump, which is approximately 2.1 km away at the closest point. Increased dust is not expected from export of concentrate as the concentrate will be in enclosed containers and the roads will be sealed.	**High** Impact is long term, occurring intermittently throughout operations (13 years) as the receptors are not being resettled.	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High There is an absence of air quality modelling, limited meteorological and air quality baseline and uncertainty of receptor locations. The use of general recommended separation distances has been adopted for guidance.			

The residual impact of reduced air quality during the operations phase due to increased project-related airborne particulate matter and increased dust deposition affecting Namtu town will be of **very low significance**, based on the **very low magnitude** of impact and the **medium sensitivity** of the value (Table 6.105).

Table 6.105 Residual impact significance summary – operations phase – reduced air quality due to increased airborne particulate matter and increased dust deposition – affecting Namtu town

Value	**Sensitivity of value**			
Namtu town airshed – cleanliness of air and visual amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The airshed influences amenity, human health and ecosystems	**Medium** Receptor would have medium vulnerability to additional dust causing amenity, health and wellbeing impacts given relatively moderate to high existing dust levels.	**Low** Existing airshed of Namtu Town experiences moderate to high concentrations of pollutants and dust deposition near Namtu exceeds guideline values. There is likely to be only a limited degree of capacity to cope with further increases in air emissions.	**Medium**
Impact	**Magnitude of impact to value**			
Reduced air quality due to increased airborne particulate matter and increased dust deposition during operations affecting Namtu town	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very low Impact will affect a small proportion of Namtu town, as the nearest source of dust will be within the Bawdwin concession area, several kilometres away.	**Very low** The Namtu area is expected to experience little noticeable change to its airshed given the dust-generating project activities will be approximately 8 km from residential areas, outside the recommended separation distance. Change is expected to be very low with respect to baseline dust conditions which are impact by existing sources in Namtu.	**High** Impact is long term (intermittent over 13 year operations period)	**Very low**
	Residual impact significance			**Very low**
	Assessment of uncertainty			
	Medium There is an absence of air quality modelling and limited meteorological baseline. The use of general recommended separation distances has been adopted for guidance.			

The residual impact of reduced air quality during the operations phase due to increased project-related airborne particulate matter and increased dust deposition affecting villages in tracts adjoining the Bawdwin concession area will be of **very low significance**, based on the **very low magnitude** of impact and the **medium sensitivity** of the value (Table 6.106).

Table 6.106 Residual impact significance summary – operations phase – reduced air quality due to increased airborne particulate matter and increased dust deposition – affecting villages in tracts adjoining the Bawdwin concession area

Value	**Sensitivity of value**			
	Importance	***Vulnerability***	***Resilience***	***Sensitivity***

Airsheds of the villages in tracts adjoining the Bawdwin concession area – cleanliness of air and visual amenity	**High** The airshed influences amenity, human health and ecosystems	**Low** These villages are separated from project activities by mountainous terrain and located approximately 2.5 km from project-related air emission sources (Ho Chet being the closest; see Figure 6.20). Receptor would have low vulnerability to changes to health and wellbeing due to additional dust; although amenity might be reduced.	**High** These villages are expected to have relatively good air quality and would be able to withstand some amount of additional air emissions	**Medium**
Impact	**Magnitude of impact to value**			
Reduced air quality due to increased airborne particulate matter and increased dust deposition during operations affecting villages in tracts adjoining the Bawdwin concession area	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very low Impact will affect only a very small proportion of the receptor, with only the closest village, Ho Chet, potentially exposed to the impact (although modelling would be needed to confirm this). The remaining villages ranging from 5-10 km from project construction areas are not expected to be affected.	**Very low** The impact is expected to be barely detectable with respect to existing variability given the distance of the villages from dust-generating activities, well beyond the recommended separation distance. The regional area is expected to experience a relatively small change to dust deposition given that the closest receptor is approximately 2.5 km from the Bawdwin concession area.	**High** Impact is long term (intermittent over 13 year operations period)	**Very low**
	Residual impact significance			**Very low**
	Assessment of uncertainty			
	High There is an absence of air quality baseline data, air quality modelling and limited meteorological baseline. The use of general recommended separation distances has been adopted for guidance.			

Closure and Post-Closure Phases

The impact sources, pathways and receptors during execution of closure activities will generally be similar to the construction phase. The rates of dust generation are likely to be lower during closure as smaller areas of earthworks and soil disturbance are required. The key difference is that the receptors that are currently within the Bawdwin concession area; i.e., Bawdwin lower village and farms, Tiger Camp village and farms, and Nam La farms, will not be present during the closure phase as they were during construction and at least the first year of operations before they were resettled. The exception is the Bawdwin military base, which may remain during closure. Rates of dust deposition are lower during closure as smaller areas of earthworks and soil disturbance are required.

Impacts to air quality and levels of dust deposition will gradually diminish once the disturbed sites become rehabilitated and covered with vegetation. The major facilities, TSFs and waste rock dump, will be covered by vegetation to reduce wind erosion and the open pit will be filled with water from the Nam Pangyun. These factors are expected to avoid long term emissions of dust, and subsequent deposition in the adjacent environment, after closure.

The residual impact of reduced air quality during the closure and post-closure phases due to increased project-related airborne particulate matter and increased dust deposition affecting the Bawdwin military base will be of **high significance** based on the **medium magnitude** of impact and the **high sensitivity** of the value (Table 6.107).

Table 6.107 Residual impact significance summary – closure and post-closure phases – reduced air quality due to increased airborne particulate matter and increased dust deposition – affecting the Bawdwin military base

Value	**Sensitivity of value**			
Military base airshed – cleanliness of air and visual amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The airshed is of high importance due to it supporting amenity and human health.	**High** The airshed has moderate to high levels of existing particulate matter and rates of dust deposition. It has moderate degree of attenuation by surrounding topography. The airshed is highly vulnerable to changes in air quality due to its close proximity to the project.	**Low** The existing airshed experiences moderate to high concentrations of dust and pollutants. Considering the current quality of the airshed in terms of its physical and chemical properties (i.e., poor quality), there is a little capacity to withstand further adverse air quality changes.	**High**
Impact	**Magnitude of impact**			
Reduced air quality due to increased airborne particulate matter and increased dust deposition during construction affecting the military base	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very high Impact is expected to affect the entire receptor given the proximity to the dust generating activities	**Medium** There is predicted to be a moderate increase in dust given the receptor's proximity to a range of construction activities (approximately 400 m of the power station and process plant sites and TSF-C embankment), which are likely to result in a cumulative contribution of dust. The rates of dust generation are likely to be lower than during construction as smaller areas of earthworks and soil disturbance are required.	**Medium** Impact is medium term over the expected two years of closure activities. The increases in dust levels will be most noticeable in the dry season.	**Medium**
	Residual impact significance			**High**
	Assessment of uncertainty			
	High There is an absence of air quality modelling and limited meteorological baseline. The use of general recommended separation distances has been adopted for guidance.			

The residual impact reduced air quality during the closure and post-closure phases due to increased project-related airborne particulate matter and increased dust deposition affecting Loi Mi village and associated farms will be of **low significance**, based on the **low magnitude** of impact and the **medium sensitivity** of the value (Table 6.108).

Table 6.108 Residual impact significance summary – closure and post-closure phases – reduced air quality due to increased airborne particulate matter and increased dust deposition – affecting Loi Mi village and associated farms

Value	**Sensitivity of value**			
Loi Mi village and associated farms airshed – cleanliness of air and visual amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The airshed influences amenity, human health and ecosystems	**Medium** The farms are somewhat removed from existing project activities and the airshed is likely to be less degraded than receptors within the Bawdwin concession area. As the farms are on relatively high, open	**High** As the farms are expected to have a relatively clean airshed compared to receptors in the upper Nam Pangyun valley, there	**Medium**

		terrain, emissions would probably be able to readily disperse and not linger in those areas. Airshed would have medium vulnerability to additional dust causing amenity, health and wellbeing impacts given relatively moderate existing dust levels.	is likely to be capacity to cope with further increases in air emissions.	
Impact	**Magnitude of impact to value**			
Reduced air quality due to increased airborne particulate matter and increased dust deposition during closure affecting Loi Mi village and associated farms	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Impact will affect a small proportion of the receptor (those farms and residents within the Bawdwin concession area) within 500 m of TSF-B, with the remainder being either unaffected or affected to a materially lower extent.	**Low** Given the distance of less than 500 m of some farms from TSFB and more than 1.5 km to other major project areas, impact is not expected to cause or contribute to significance changes to air quality and will be barely detectable with respect to the existing high levels of dust and particulate lead present in the air across the region, and the active dust suppression to be carried out by the project.	**Medium** Impact is medium term over the expected two years of closure activities. The increases in dust levels will be most noticeable in the dry season.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	High There is an absence of air quality baseline data, air quality modelling and limited meteorological baseline. The use of general recommended separation distances has been adopted for guidance.			

The residual impact reduced air quality during the closure and post-closure phases due to increased project-related airborne particulate matter and increased dust deposition affecting residents of the Nam Pangyun valley will be of **very low significance**, based on the **very low magnitude** of impact and the **medium sensitivity** of the value (Table 6.109).

Table 6.109 Residual impact significance summary – closure and post-closure phases – reduced air quality due to increased airborne particulate matter and increased dust deposition – affecting residents of Nam Pangyun valley

Value	**Sensitivity of value**			
Nam Pangyun valley airshed – cleanliness of air and visual amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The airshed influences amenity, human health and ecosystems	**Medium** There are relatively moderate existing dust levels and dust deposition at the nearby Law Po Hill exceeding guidelines levels. The narrow valley setting may result in dusty conditions lingering in the area compared to more open terrain.	**Medium** Given the moderate existing dust levels, there is probably some capacity to cope with further increases in air emissions.	**Medium**
Impact	**Magnitude of impact to value**			
Reduced air quality due to increased airborne particulate matter and increased dust deposition during closure affecting residents of the Nam Pangyun valley	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium This impact will affect a moderate proportion of the receptor (i.e., those individual receptors adjacent to the road) with those further away (i.e., in the order of 500 m or more) experiencing little or no impact	**Very low** There is predicted to be overall reductions in dust generation and deposition since use of access road will diminish during active closure and then not be used by project	**Low** Impact is short term during active closure activities. The increases in dust levels will be most noticeable in the dry season.	**Very low**
	Residual impact significance			**Very low**
	Assessment of uncertainty			
	High There is an absence of air quality modelling, limited meteorological and air quality baseline and uncertainty of receptor locations. The use of general recommended separation distances has been adopted for guidance.			

The residual impact of reduced air quality during the closure and post-closure phases due to increased project-related airborne particulate matter and increased dust deposition affecting Namtu town will be of **very low significance**, based on the **very low magnitude** of impact and the **medium sensitivity** of the value (Table 6.110).

Table 6.110 Residual impact significance summary – closure and post-closure phases – reduced air quality due to increased airborne particulate matter and increased dust deposition – affecting Namtu town

Value	**Sensitivity of value**			
Namtu town airshed – cleanliness of air and visual amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The airshed influences amenity, human health and ecosystems	**Medium** Receptor would have medium vulnerability to additional dust causing amenity, health and wellbeing impacts given relatively moderate to high existing dust levels.	**Low** Existing airshed of Namtu Town experiences moderate to high concentrations of pollutants and dust deposition near Namtu exceeds guideline values. There is likely to be only a limited degree of capacity to cope with further increases in air emissions.	**Medium**
Impact	**Magnitude of impact to value**			
Reduced air quality due to increased airborne particulate matter and increased dust deposition during closure affecting Namtu town	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very low Impact will affect a very small proportion of the receptor, with only those individual receptors along the road being affected.	**Very low** The Namtu area is expected to experience a relatively small change to its airshed given its distance to major project sites (the Namtu-Tiger Camp access road and export route being more than 1 km from most residential areas) and with respect to existing baseline, the existing high levels of dust present in the air across the region, and the active dust suppression to be carried out by the project.	**Low** Impact is short term (i.e., in the order of months in the Namtu area). The increases in dust levels will be most noticeable in the dry wet season.	**Very low**
	Residual impact significance			**Very low**
	Assessment of uncertainty			
	Medium There is an absence of air quality modelling and limited meteorological baseline. The use of general recommended separation distances has been adopted for guidance.			

The residual impact of reduced air quality during the closure and post-closure phases due to increased project-related airborne particulate matter and increased dust deposition affecting villages in tracts adjoining the Bawdwin concession area will be of **very low significance**, based on the **very low magnitude** of impact and the **medium sensitivity** of the value (Table 6.111).

Table 6.111 Residual impact significance summary– closure and post-closure phases – reduced air quality due to increased airborne particulate matter and increased dust deposition – affecting villages in tracts adjoining the Bawdwin concession area

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Airsheds of villages in tracts adjoining the Bawdwin concession area – cleanliness of air and visual amenity</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>High
The airshed influences amenity, human health and ecosystems</td><td>Low
These villages are separated from project activities by mountainous terrain and located approximately 2.5 km from project-related air emission sources (Ho Chet being the closest; see Figure 6.20). Receptor would have low vulnerability to changes to health and wellbeing due to additional dust; although amenity might be reduced.</td><td>High
These villages are expected to have relatively good air quality and would be able to withstand some amount of additional air emissions</td><td>Medium</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact to value</th></tr>
<tr><td rowspan="6">Reduced air quality due to increased airborne particulate matter and increased dust deposition during closure affecting villages in tracts adjoining the Bawdwin concession area</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Very low
Impact will affect only a very small proportion of the receptor, with only the closest village, Ho Chet, potentially exposed to the impact (although modelling would be needed to confirm this). The remaining villages ranging from 5-10 km from project construction areas are not expected to be affected</td><td>Very low
The regional area is expected to experience a relatively small change to its airshed given the distance to project activities.
Impact is not expected to cause or contribute to exceedance of air quality criteria, given that the closest receptor several kilometres from the Bawdwin concession area where closure activities will occur.</td><td>Low
Impact is short term during active closure. The increases in dust levels will be most noticeable in the dry season.</td><td>Very low</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Very low</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">High
There is an absence of complete air quality baseline data, air quality modelling and limited meteorological baseline. The use of general recommended separation distances has been adopted for guidance.</td></tr>
</table>

Increased gaseous pollutants

The project will result in emissions of gaseous pollutants, primarily from the diesel power station during project operations. Emissions from vehicles and equipment in the project area will be low and are assessed in the context of existing conditions at Namtu and along the export corridor.

Table 6.112 shows the predicted gaseous pollutant emissions from the power station during operations during three different engine loads and for two exhaust flow conditions (dry and wet) (i.e., six total operating scenarios). The highest concentrations of emitted gases from all operating scenarios are presented in bold.

Table 6.112 Maximum emission mass flow rates (µg/m^3) for power plant engine stack cluster

Parameter	Unit	Engine Load		
		100%	75%	50%
Based on dry exhaust flow rate				
Nitrogen oxides (calculated as NO_2)	µg/m^3	2,048,077	1,991,736	**2,468,750**
Carbon monoxide (CO)	µg/m^3	**105,769**	103,306	88,542
Sulphur oxides (calculated as SO_2)	µg/m^3	**419,872**	409,091	354,167
Non-methane non-ethane hydrocarbons (calculated as CH_4)	µg/m^3	105,769	**123,967**	119,792
Based on wet exhaust flow rate				
Nitrogen oxides (calculated as NO_2)	µg/m^3	751,765	733,638	963,415
Carbon monoxide (CO)	µg/m^3	38,824	38,052	34,553
Sulphur oxides (calculated as SO_2)	µg/m^3	154,118	150,685	138,211
Non-methane non-ethane hydrocarbons (calculated as CH_4)	µg/m^3	38,824	45,662	46,748

Calculated from WMM provided data source: Unpublished (2020). Data should be confirmed as part of detailed design.

Table 6.113 compares these maximum emission concentrations to Myanmar air emission limits for electric power transmission and distribution (as outlined in the draft National Environmental Quality (Emission) Guidelines), health screening criteria, and baseline concentrations measured at Bawdwin.

The Myanmar air emission limits adopted are those for liquid fuel plants of 50-30 MW capacity, which are deemed the most relevant to the proposed diesel stack power station (up to 30 MW).

Table 6.113 Maximum pollutant emissions compared to Myanmar air emission limits, health screening criteria and baseline concentration ranges

Parameter	Unit	Max predicted emission	Myanmar air emission limits[e]	Health screening criteria (ambient air)[f]	Baseline range (Bawdwin area)
Nitrogen oxides (calculated as NO_2)	µg/m^3	2,468,750	1,460,000	40[c]; 200[d]	<LOD – 1.9
Carbon monoxide (CO)	µg/m^3	105,769	-	30[g], 100[h]	N/A
Sulphur oxides (calculated as SO_2)	µg/m^3	419,872	585,000	20[b]; 500[a]	0.48-8.16[b]
Non-methane non-ethane hydrocarbons (calculated as CH_4)	µg/m^3	123,967	-	-	N/A

N/A denotes not assessed
- denotes no applicable criteria
<LOD denotes less than limit of detection
a measured as 10-minute average; b measured as 24-hour average; c measured as a 1-hour average; d measured as a 1-year average
e Criteria for liquid fuels for 'Reciprocating engine' and plant of '50-300 MW', which are deemed most applicable to the diesel power station for the Bawdwin Project. These criteria are based on normal cubic metres (µg/Nm^3), which are considered analogous to µg/m^3.
f From Ambient Air Quality Standards outlined in Myanmar Mining EIA draft guidelines 2018 except where noted
g Criterion (1-hour average) adopted from WHO (2000), h Criterion (15-minute average) adopted from WHO (2000)

Table 6.113 shows that the predicted maximum concentrations of SO_2 from power plant emissions will be below the relevant Myanmar air emission criteria apart from NO_2 emissions which will exceed the criteria. There are no relevant Myanmar emission or ambient limits for carbon monoxide (CO).

Although not directly comparable, the maximum predicted emission concentrations are compared to health screening criteria and baseline ranges in ambient air to provide indication of the level of dilution the emission would require to meet the ambient health screening criteria and baseline ranges. The data shows that maximum concentration of NO_2 in exhaust at the point of emission is predicted to be well above health screening criteria and the baseline concentration range for ambient air quality. Similarly, the predicted maximum SO_2 concentration at the point of emission will be well above the health screening criteria (24-hour average but not the 10-minute average criterion) and the baseline range for ambient air quality. The maximum concentration of CO is predicted to exceed both the 15-minute and 1-hour WHO (2000) guidelines, which have been adopted in place of no Myanmar criteria for this gas.

Gaseous emissions from the stack will be diluted in the air and in concentrations and directions that will be determined by factors such as emission rate, topography and weather conditions. Based on baseline wind monitoring and climate modelling from literature (Meteoblue, 2020), there is evidence of prevailing southerly winds in the region during the year, meaning that a dominant wind direction from the power plant could transport gaseous emission towards the north of the power station for much of the year. Nam La farms will be resettled prior to operations and so will not be impacted by this source. There are however times of the year where winds and dispersion of emissions will be variable and gaseous emission from the power station could be transported toward other receptors. Typically, depending on these factors, gaseous pollutants will disperse out from the source with concentrations of pollutants reducing over time and distance. Numerical modelling is usually undertaken to determine the concentrations of pollutants with distance from the source, in this case the power station stack. In the absence of modelling, a conservative approach has been taken for the assessment. This conservatism assumes that the maximum predicted gaseous emissions are emitted from the power plant consistently, whereas this may not be the case under all operating scenarios.

The nearest receptor (Bawdwin military base) is approximately 400 m (at the closest point) to the south of the power station (see Figure 6.20). Theoretical dilution factors in the order of 62,000; 21,000; and 4,000 would be required for NO_2, SO_2 and CO, respectively to meet the more stringent of each screening criteria (see Table 6.113 for criteria) at these locations. The dilution factors were calculated by dividing the maximum emission concentration by the criteria value. Modelling would be required to determine whether the maximum emitted concentrations would reduce down to below the criteria within the distance of 400 m (i.e., the distance to the closest receptor). This impact is assessed only for the closest receptor and represents a worst case impact scenario. The next closest receptor is the Loi Mi village and associated farms and given the distance of more than 2 km to the power plant, impacts from gaseous emissions are not expected.

The residual impact of reduced air quality during the operations phase due to gaseous pollutants from power station affecting the Bawdwin military base will be of **major significance**, based on the **high magnitude** of impact and the **high sensitivity** of the value (Table 6.114).

Table 6.114 Residual impact magnitude summary – operations phase – reduced air quality due to gaseous pollutants emission from the power station – affecting Bawdwin military base

Value	**Sensitivity of value**			
Military base airshed – cleanliness of air and visual amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The airshed is of high importance due to it supporting amenity, human health and ecosystems.	**High** The airshed has moderate to high levels of existing particulate matter and rates of dust deposition. It has moderate degree of attenuation by surrounding topography. The airshed is highly vulnerable to changes in air quality due to its close proximity to the project.	**Low** The existing airshed experiences moderate to high concentrations of dust and pollutants. Considering the current quality of the airshed in terms of its physical and chemical properties (i.e., poor quality), there is a little capacity to withstand further adverse air quality changes.	**High**
Impact	**Magnitude of impact to value**			
Reduced air quality due to gaseous pollutants during operation of power station affecting the military base	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	High The impact is likely (depending on emission scenario and weather conditions) to affect all of this receptor.	**High** Nitrogen dioxide emissions are predicted to be above Myanmar emission criteria. The impact is likely be noticeable with respect to existing variability at times. Other emissions are predicted to be below Myanmar emission criteria. The military base is approximately 400 m of the power station, and within the recommended separation distance.	**High** Impact is long term (frequently occurring) throughout operations.	**High**
	Residual impact significance			**Major**
	Assessment of uncertainty			
	High There is an absence of gaseous emission baseline data and air quality modelling. Air quality dispersion modelling would be needed to understand concentrations of gaseous pollutants at receptors and whether they concentrations will meet criteria at the nearest receptor 400 m away. During the detailed design phase WMM will refine selection of power plant generators and this will probably alter the emission calculations. Scrubbers or other equipment may be necessary to ensure that emissions meet Myanmar emission criteria.			

There are no health screening criteria or baseline ranges available for volatile hydrocarbons, so these are excluded from the assessment.

Traffic-related emissions will occur along the public road Namtu-Manton Road during early construction. Vehicles will comprise heavy (e.g., trucks) and light vehicles.

The residual impact of reduced air quality during the construction phase due to gaseous pollutant emissions affecting residents along the Namtu – Manton Road will be of **moderate significance**, based on the **medium magnitude** of impact and the **medium sensitivity** of the value (Table 6.115).

Table 6.115 Residual impact magnitude summary – construction phase – reduced air quality due to gaseous pollutants emission from construction-related vehicles along the Namtu-Manton road

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Airsheds of residents along the Namtu – Manton Road – cleanliness of air and visual amenity</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>High
The airshed is of high importance due to its capacity to support amenity, human health and ecosystems.</td><td>Medium
Villages are located near major roads and potentially experience intermittent increases in pollutants as a result of traffic. Increased air pollutants would result in noticeable reduction in amenity. The airshed would have medium vulnerability to additional pollutants causing amenity, health and wellbeing impacts.</td><td>Medium
Potentially experiences intermittent increases in gaseous emissions and dust from traffic along unsealed sections of the road due to existing traffic along the public road. These residents probably have some capacity to cope with further emissions.</td><td>Medium</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact to value</th></tr>
<tr><td rowspan="5">Reduced air quality due to gaseous pollutants during construction due to vehicle traffic along Namtu-Manton Road during construction</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Very high
Changes to air quality would probably only be noticed by all the individual receptors, which are all in close proximity to the road. Some receptors will be affected more-so than others depending on proximity to the road.</td><td>Medium
Impact will probably cause noticeable increase in exhaust gaseous pollutants at receptors due to the frequency of vehicle movements along the road.</td><td>Low
The impact is considered short term, occurring intermittently throughout construction.</td><td>Medium</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Moderate</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">High
There is an absence of gaseous emission baseline data and air quality modelling. Gaseous emissions from project vehicles in comparison to background levels, and overall cumulative impact, have not been quantified by modelling</td></tr>
</table>

Large increases in the traffic volumes are expected along the export corridor between Namtu and Lashio. Heavy vehicle movements will be frequent throughout operations and localised emissions of vehicle exhaust will probably be experienced by settlements along the route.

The numbers of trucks travelling along the route (comprising those importing consumables, reagents and fuels, and exporting concentrate) have been estimated to provide an indication of the increase in exhaust emissions due to project traffic. In year 1 of operations, an additional 20 individual truck movements (i.e., single trips in one direction) associated with the project are expected to travel along the export route per day, increasing to an additional 93 truck movements per day in year 12. Compared to baseline traffic (Valentis, 2020), truck volumes passing through Namtu and the Mansam western junction in year 12 would be 69% and 190% greater than baseline volumes, respectively.

Based on maximum truck movements of 93 per day (assumed during daylight hours; 12-hour period), this would represent between seven to eight additional truck movements on the roads every hour (on average) during the peak export traffic period. This represents up to a threefold increase in truck numbers on sections of the export corridor roads. This increase will contribute to an ongoing reduction in amenity and air quality at receptors adjacent to the corridor. It is expected that gaseous pollutants will remain in the air and result in an elevated cumulative level of air pollutants along with other traffic.

The residual impact of reduced air quality during the operations phase due to gaseous pollutant emissions affecting Namtu town will be of **moderate significance**, based on the **medium magnitude** of impact and the **medium sensitivity** of the value (Table 6.116).

Table 6.116 Residual impact magnitude summary – reduced air quality due to gaseous pollutants emission from vehicles passing Namtu town

Value	**Sensitivity of value**			
Namtu town airshed – cleanliness of air and visual amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The airshed influences amenity, human health and ecosystems	**Medium** Receptor would have medium vulnerability to additional pollutants causing amenity, health and wellbeing impacts.	**Low** Existing airshed of Namtu Town is likely to experience pollution associated with existing vehicle traffic. There is likely to be only a limited degree of capacity to cope with further increases in air emissions.	**Medium**
Impact	**Magnitude of impact to value**			
Reduced air quality due to gaseous pollutants during operations due to vehicle traffic passing Namtu town	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Changes to air quality would probably only be noticed by receptors in close proximity to the road. Some receptors will be affected more-so than others depending on proximity to the road.	**Medium** Impact will probably cause ongoing and noticeable increase in exhaust gaseous pollutants at affected receptors due to the frequency of truck movements along the export route.	**High** The impact is considered long term (13-year operations.	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High Gaseous emissions from project vehicles in comparison to background levels, and overall cumulative impact, have not been quantified by modelling			

The residual impact of reduced air quality during the operations phase due to gaseous pollutant emissions affecting villages along the export route between Namtu and Lashio will be of **moderate significance**, based on the **medium magnitude** of impact and the **medium sensitivity** of the value (Table 6.117).

Table 6.117 Residual impact magnitude summary – operations phase – reduced air quality due to gaseous pollutants emission from vehicles along the export corridor

Value	**Sensitivity of value**			
Airsheds of villages along the export corridor – cleanliness of air and visual amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The airshed is of high importance due to it supporting amenity, human health and ecosystems.	**Medium** Villages are located near major roads and are likely to have an airshed already influenced by traffic emissions. The airshed would have medium vulnerability to additional pollutants causing amenity, health and wellbeing impacts.	**Medium** Baseline air quality of these villages are unknown, however potentially experiences intermittent increases in pollutants as a result of traffic along major roads. These villages probably have some capacity to cope with further gaseous emissions.	**Medium**
Impact	**Magnitude of impact to value**			
Reduced air quality due to gaseous pollutants during operations due to vehicle traffic along export corridor	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Changes to air quality would probably only be noticed by receptors in close proximity to the road. Some receptors will be affected more-so than others depending on proximity to the road.	**Medium** Impact will probably cause ongoing and noticeable increase in exhaust gaseous pollutants at receptors due to the frequency of truck movements along the export route.	**High** The impact is considered long term (13-year operations).	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High Gaseous emissions from project vehicles in comparison to background levels, and overall cumulative impact, have not been quantified by modelling			

Summary of residual impacts

Table 6.118 provides a summary of the residual impacts to air quality and dust deposition and their significance.

Table 6.118 Summary of assessment of residual impacts to air quality

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for significance	Uncertainty
Reduced air quality due to increased airborne particulate matter and increased dust deposition during construction	Bawdwin upper village airshed – cleanliness of air and visual amenity • High sensitivity	Construction	Medium magnitude • Very high spatial extent • Medium severity • Low duration	• Dust suppression measures • Measures to limit dust generation • Revegetation and rehabilitation measures • Traffic and transport measures • Erosion and sediment control measures	High	The entirety of Bawdwin upper village is expected to be impacted prior to resettlement by detectable increases in dust which may contain heavy metals due to construction of the haul road and mine services area.	High • Absence of air quality modelling • Limited meteorological baseline
	Bawdwin military base – cleanliness of air and visual amenity • High sensitivity	Construction	High magnitude • Very high spatial extent • High severity • Medium duration	• Dust suppression measures • Measures to limit dust generation • Revegetation and rehabilitation measures • Traffic and transport measures • Erosion and sediment control measures	Major	The military base will be present through the entire construction period and is located 400 m from the process plant and power station sites, resulting in a detectable increase in dust levels which may contain elevated levels of heavy metals.	High • Absence of air quality modelling • Limited meteorological baseline
	Bawdwin lower village airshed – cleanliness of air and visual amenity • High sensitivity	Construction	High magnitude • Very high spatial extent • High severity • Medium duration	• Dust suppression measures • Measures to limit dust generation • Revegetation and rehabilitation measures • Traffic and transport measures • Erosion and sediment control measures	Major	The entire village is expected to be impacted throughout construction by increased dust which may contain elevated heavy metals, however the greatest impact will occur within 500 m of pre-pit stripping.	High • Absence of air quality modelling • Limited meteorological baseline
	Tiger Camp village airshed – cleanliness of air and visual amenity • High sensitivity	Construction	Medium magnitude • Very high spatial extent • High severity • Low duration	• Dust suppression measures • Measures to limit dust generation • Revegetation and rehabilitation measures • Traffic and transport measures • Erosion and sediment control measures	High	The entire village is expected to be impact by dust generated by the construction of the Tiger Camp-Namtu road over a five month period.	High • Absence of air quality modelling • Limited meteorological baseline
	Tiger Camp farms airshed – cleanliness of air and visual amenity	Construction	Medium magnitude • High spatia	• Dust suppression measures • Measures to limit dust generation	Medium	Some Tiger Camp farms will be resettled prior to access and plant road	High • Absence of air quality modelling

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for significance	Uncertainty
	• Medium sensitivity		l extent • Medium severity • Low duration	• Revegetation and rehabilitation measures • Traffic and transport measures • Erosion and sediment control measures		construction, and those on Chin Hill will be resettled prior to sediment dam construction. The remaining farms will largely be in proximity to dust generating activities (access and plant roads and sediment dam construction) for several months.	• Limited meteorological and air quality baseline
	Bawdwin lower village farms airshed – cleanliness of air and visual amenity • Medium sensitivity	Construction	Low magnitude • Low spatial extent • Low severity • Medium duration	• Dust suppression measures • Measures to limit dust generation • Revegetation and rehabilitation measures • Traffic and transport measures • Erosion and sediment control measures	Low	Most receptors will be over 2 km from dust generating construction activities, however those that are closer may experience low severity impacts to air quality intermittently over the construction period	High • Absence of air quality modelling • Absence of air quality baseline data • Limited meteorological baseline
	Nam La farms airshed – cleanliness of air and visual amenity • Medium sensitivity	Construction	Medium magnitude • Medium spatial extent • High severity • Low duration	• Dust suppression measures • Measures to limit dust generation • Revegetation and rehabilitation measures • Traffic and transport measures • Erosion and sediment control measures	Moderate	Farms close to the northern access road and Nam La dam may experience increased dust during construction of the road and dam prior to resettlement	High • Absence of air quality modelling • Absence of air quality baseline data • Limited meteorological baseline
	Loi Mi village and associated farms airshed – cleanliness of air and visual amenity • Medium sensitivity	Construction	Low magnitude (if resettled) • Low spatial extent • Very low severity • Medium	• Dust suppression measures • Measures to limit dust generation • Revegetation and rehabilitation measures • Traffic and transport measures • Erosion and sediment control measures	Low	A small proportion of receptors will be impacted until resettled, the closest remaining receptors are approximately 1 km form the TSF B embankment and may experience a very low severity impact during construction of the TSF.	High • Absence of air quality modelling • Absence of air quality baseline data • Limited meteorological baseline

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for significance	Uncertainty
			duration				
			Low magnitude (if not resettled) • Low spatial extent • Low severity • Medium duration	• Dust suppression measures • Measures to limit dust generation • Revegetation and rehabilitation measures • Traffic and transport measures • Erosion and sediment control measures	Low	The receptors within the Bawdwin concession area approximately 500 m from the TSF-B embankment will be mainly impacted, and may experience a low severity impact during construction of the TSF.	
	Nam Pangyun valley airshed – cleanliness of air and visual amenity • Medium sensitivity	Construction	Medium magnitude • Medium spatial extent • High severity • Low duration	• Dust suppression measures • Measures to limit dust generation • Revegetation and rehabilitation measures • Traffic and transport measures • Erosion and sediment control measures	Moderate	Individual receptors adjacent to the road will be impacted by temporary increases in dust due to the 5 month construction of the Namtu to Tiger Camp access road	High • Absence of air quality modelling • Limited meteorological and air quality baseline • Uncertainty of receptor locations
	Namtu town airshed – cleanliness of air and visual amenity • Medium sensitivity	Construction	Very low magnitude • Very low spatial extent • Very low severity • Low duration	• Traffic and transport measures	Very low	A small proportion of the receptor will be impacted as Namtu is several kilometres from the Namtu-Tiger Camp access road construction. A relatively small change in dust levels during the construction of the access road may occur.	Medium • Absence of air quality modelling • Limited meteorological baseline
	Airsheds of villages in tracts adjoining the Bawdwin concession area – cleanliness of air and visual amenity • Medium sensitivity	Construction	Low magnitude • Very low spatial extent • Very low severity • Medium duration	• Traffic and transport measures	Low	The closest village (Ho Chet) to construction activities may be affected. A small change may occur during construction of the TSF-A and Nam La dam.	High • Absence of air quality modelling • Absence of air quality baseline data • Limited meteorological baseline
Reduced air quality due to increased	Bawdwin military base	Operations	High magnitude	• Dust suppression measures	Major	The entire receptor is expected to be	Medium

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for significance	Uncertainty
airborne particulate matter and increased dust deposition during operations	• High sensitivity		• High spatial extent • High severity • High duration	• Measures to limit dust generation • Revegetation and rehabilitation measures • Traffic and transport measures • Erosion and sediment control measures		impacted throughout operations as it is located within 500 m of the TSF-B and TSF-C embankments.	• Absence of air quality modelling • Limited meteorological baseline
	Bawdwin lower village airshed – cleanliness of air and visual amenity • High sensitivity	Operations	High magnitude • Very high spatial extent • High severity • Medium duration	• Dust suppression measures • Measures to limit dust generation • Revegetation and rehabilitation measures • Traffic and transport measures • Erosion and sediment control measures	Major	The entire receptor is expected to be impacted throughout operations until resettled as it is located in proximity to the open pit where blasting and surface disturbance will occur	Medium • Absence of air quality modelling • Limited meteorological baseline
	Bawdwin lower village farms airshed – cleanliness of air and visual amenity • Medium sensitivity	Operations	Low magnitude • Low spatial extent • Low severity • Medium duration	• Dust suppression measures • Measures to limit dust generation • Revegetation and rehabilitation measures • Traffic and transport measures • Erosion and sediment control measures	Low	A small proportion of the receptor will be impacted prior to resettlement, though the impact will be limited as the farms are about 2 km from the existing pit	High • Absence of air quality modelling • Absence of air quality baseline data • Limited meteorological baseline
	Tiger Camp village airshed – cleanliness of air and visual amenity • High sensitivity	Operations	Low magnitude • Low spatial extent • Low severity • Medium duration	• Dust suppression measures • Measures to limit dust generation • Revegetation and rehabilitation measures • Traffic and transport measures • Erosion and sediment control measures	Moderate	A small proportion of the receptor will be impacted prior to resettlement, though the impact will be limited as the village is more than 2 km from the existing pit	Medium • Absence of air quality modelling • Limited meteorological baseline
	Tiger Camp farms airshed – cleanliness of air and visual amenity • Medium sensitivity	Operations	Medium magnitude • High spatial extent • Medium severity	• Dust suppression measures • Measures to limit dust generation • Revegetation and rehabilitation measures • Traffic and transport measures	Moderate	Several farms are close to dust generating sources, such as the Wallah waste rock dump, and may be impacted by increased dust prior to resettlement	High • Absence of air quality modelling • Absence of complete air quality baseline data • Limited meteorolog

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for significance	Uncertainty
			• Low duration	• Erosion and sediment control measures			ical baseline
	Loi Mi village and associated farms airshed – cleanliness of air and visual amenity • Medium sensitivity	Operations	Low magnitude (if resettled) • Very low spatial extent • Low severity • Medium duration	• Dust suppression measures • Measures to limit dust generation • Revegetation and rehabilitation measures • Traffic and transport measures • Erosion and sediment control measures	Low	There may be an increase in dust and particulate lead affecting individual receptors in hilltops closest to TSF-B however once resettled the impact to the overall receptor group will be minimal	High • Absence of air quality modelling • Absence of air quality baseline data • Limited meteorological baseline
			Medium magnitude (if not resettled) • Low spatial extent • Medium severity • High duration	• Dust suppression measures • Measures to limit dust generation • Revegetation and rehabilitation measures • Traffic and transport measures • Erosion and sediment control measures	Moderate	If receptors close to TSF-B aren't resettled they may experience increased levels of dust and particulate lead throughout operations as some are located as close as 500 m from TSF-B.	
	Nam Pangyun valley airshed – cleanliness of air and visual amenity • Medium sensitivity	Operations	Medium magnitude • Low spatial extent • Low severity • High duration	• Dust suppression measures • Measures to limit dust generation • Revegetation and rehabilitation measures • Traffic and transport measures • Erosion and sediment control measures	Moderate	The closest receptors are 2.1 km from the waste rock dump, and may experience a small increase in dust associated with dump throughout operations	High • Absence of air quality modelling • Limited meteorological and air quality baseline • Uncertainty of receptor locations
	Namtu town airshed – cleanliness of air and visual amenity • Medium sensitivity	Operations	Very low magnitude • Very low spatial extent • Very low severity • High duration	• Traffic and transport measures	Very low	Namtu is several kilometres away from dust generating project activities, small amounts of change to air quality may occur throughout operations	Medium • Absence of air quality modelling • Limited meteorological baseline
	Airsheds of villages in	Operations	Very low magnitude	• Traffic and transport measures	Very low	The nearest village (Ho Chet)	High

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for significance	Uncertainty
	tracts adjoining Bawdwin concession area – cleanliness of air and visual amenity • Medium sensitivity		• Very low spatial extent • Very low severity • High duration			is several kilometres away from dust generating project activities, small amounts of change to air quality may occur throughout operations	• Absence of air quality modelling • Absence of air quality baseline data • Limited meteorological baseline
Reduced air quality due to increased airborne particulate matter and increased dust deposition during closure	Bawdwin military base • High sensitivity	Closure and Post-Closure	Medium magnitude • Very high spatial extent • Medium severity • Medium duration	• Dust suppression measures • Measures to limit dust generation • Revegetation and rehabilitation measures • Traffic and transport measures • Erosion and sediment control measures	High	Due to its location within the Bawdwin concession area the entire receptor is expected to be impacted by a moderate increase in dust during closure activities	High • Absence of air quality modelling • Limited meteorological baseline
	Loi Mi village and associated farms airshed – cleanliness of air and visual amenity • Medium sensitivity	Closure and Post-Closure	Low magnitude • Low spatial extent • Low severity • Medium duration	• Dust suppression measures • Measures to limit dust generation • Revegetation and rehabilitation measures • Traffic and transport measures • Erosion and sediment control measures	Low	Receptors within 500 m of TSF-B may be impacted to a small amount over closure. Increased are expected to be barely detectable with respect to existing conditions.	High • Absence of air quality modelling • Absence of air quality baseline data • Limited meteorological baseline
	Nam Pangyun valley airshed – cleanliness of air and visual amenity • Medium sensitivity	Closure and Post-Closure	Very low magnitude • Medium spatial extent • Very low severity • Low duration	• Dust suppression measures • Measures to limit dust generation • Revegetation and rehabilitation measures • Traffic and transport measures • Erosion and sediment control measures	Very low	Individual receptors adjacent to the road may be impacted by a small amount during closure activities. This is expected to be a reduction in dust generation and deposition in this area compared to operations due to reduced use of the access road	High • Absence of air quality modelling • Limited meteorological and air quality baseline • Uncertainty of receptor locations
	Namtu town airshed – cleanliness of air and visual amenity	Closure and Post-Closure	Very low magnitude • Very low spatia	• Traffic and transport measures	Very low	Individual receptors along the road may be affected, however this is expected to be a short-term,	Medium • Absence of air quality modelling • Limited meteorolog

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for significance	Uncertainty
	• Medium sensitivity		l extent • Very low severity • Low duration			relatively small change.	ical baseline
	Airsheds of villages in tracts adjoining Bawdwin concession area – cleanliness of air and visual amenity • Medium sensitivity	Closure and Post-Closure	Very low magnitude • Very low spatial extent • Very low severity • Low duration	• Traffic and transport measures	Very low	The closest village (Ho Chet) may experience a relatively small change during closure, however this will be minimal due to the distance from the Bawdwin concession area and closure activities	High • Absence of air quality modelling • Absence of air quality baseline data • Limited meteorological baseline
Reduced air quality due to gaseous pollutants during operation of power station	Bawdwin military base – cleanliness of air and visual amenity • High sensitivity	Operations	High magnitude • High spatial extent • High severity • High duration	• Traffic and transport measures	Major	Due to the proximity to the power station (approximately 400 m away), increased gaseous pollutants may affect the entire receptor throughout operations. Nitrogen emissions are predicted to be above Myanmar emission criteria	High • Absence of air quality modelling • Absence of gaseous emission baseline data • Air quality dispersion modelling required
Reduced air quality due to gaseous pollutants during operations due to vehicle traffic along Namtu-Manton Road during construction	Airsheds of residents along the Namtu – Manton Road – cleanliness of air and visual amenity • Medium sensitivity	Construction	Medium magnitude • Very high spatial extent • Medium severity • Low duration	• Traffic and transport measures	Moderate	Vehicle emissions may cause a noticeable increase in gaseous pollutants affecting receptors near the road intermittently throughout construction	High • Absence of air quality modelling • Absence of gaseous emission baseline data
Reduced air quality due to gaseous pollutants during operations due to vehicle traffic passing	Namtu town airshed – cleanliness of air and visual amenity • Medium sensitivity	Construction, operations	Medium magnitude • Low spatial extent • Medium severity	• Traffic and transport measures	Moderate	There will be frequent truck movements through Namtu as this forms part of the export route. Vehicle emissions may cause a noticeable increase in gaseous	High • Gaseous emissions from project vehicles in comparison to background levels, and overall

Impact	**Value and sensitivity**	**Impact phase**	**Impact magnitude**	**Key management measure(s)**	**Impact significance**	**Justification for significance**	**Uncertainty**
Namtu town			• High duration			pollutants affecting receptors near the road throughout operations.	cumulative impact, have not been quantified by modelling • Gaseous emissions from project vehicles in comparison to background levels, and overall cumulative impact, have not been quantified by modelling
Reduced air quality due to gaseous pollutants during operations due to vehicle traffic along export corridor	Airsheds of villages along the export corridor – cleanliness of air and visual amenity • Medium sensitivity	Operations	Medium magnitude • Low spatial extent • Medium severity • High duration	• Traffic and transport measures	Moderate	There will be frequent truck movements along the export route. Vehicle emissions may cause a noticeable increase in gaseous pollutants affecting receptors near the road throughout operations.	High • Gaseous emissions from project vehicles in comparison to background levels, and overall cumulative impact, have not been quantified by modelling

6.5.5 Monitoring and inspection

The Environmental Management Plan (air quality, noise and blasting management plan) for the Bawdwin Project will provide for regular environmental monitoring and inspection to be completed for all project phases (construction, operation and closure). Monitoring will include:

- Internal audits to confirm that the Bawdwin Project's environmental management measures, including site-specific mitigation measures, are being implemented successfully and management measures are effective in minimising impacts to the environment.
- Long-term monitoring of weather.
- Monitoring of particulate matter, dust deposition from project activities and gas emissions from the power station.
- Review of community grievance register and follow-up any issues with the local communities.
- Monitoring of community health for any receptors that are in potential zones of influence.
- Adjust the monitoring program to adapt to community concerns and emission criteria exceedances.

6.5.6 Uncertainties and further work

This section outlines the key uncertainties and further work required to address these uncertainties.

Key uncertainties and further work required to address these uncertainties are outlined in Table 6.119.

Table 6.119 Uncertainties and further work in respect of air quality impacts

Uncertainty	Further work required	Purpose	Assumptions
Uncertainty with the likely levels of gas and dust emissions and deposition, since no predictive modelling has been conducted.	Predictive modelling of gas/dust emissions and dust deposition as part of detailed design phase. During the detailed design phase refine selection of power plant generators and this will probably alter the emission calculations. Confirm whether scrubbers or other equipment will be necessary to ensure that emissions meet Myanmar emission criteria.	To better understand the transport and fate of dust and gases from project sources and more accurately predict air quality impacts.	Qualitative assessment of spatial extent and severity of impacts, with reference to recommended distances to receptor from mining and mineral processing activity as per the approach outlined in the Australian Capital Territory Government Separation Distance Guidelines for Air Emissions (ACT Government 2018). Reference to meteorological and terrain conditions was also made to support the impact assessments.
Uncertainty exists around the level of dust generation from the TSF during operations and the resulting emissions to air and dust deposition levels/locations, including around operational areas and nearest sensitive receptors.	Conduct assessments regarding dust generation from the TSF during operations as part of detailed design phase. This may require further testwork on tailings samples and predictive modelling of emissions.	Determine the level of dust generation from the TSF during operations and the resulting emissions to air and dust deposition levels/locations, including around operational areas	Qualitative assessment of dust impact severity.

Uncertainty	Further work required	Purpose	Assumptions
Limited baseline meteorological data to the period, January to May 2020. A longer dataset is required to better understand seasonality.	Ongoing meteorological monitoring at site and collection of regional datasets, including longer term data.	Inform modelling of gaseous and dust emissions and allow more accurate predictions of exposure to receptors	The impact assessment makes high-level assumptions about prevailing weather conditions and how these may influence where gas and dust emissions will disperse, based on five months of meteorological data.
Uncertainty on how metal concentrations vary with dust particle size. Metals concentrations were measured for TSP and PM_{10}.	Monitor and investigate the concentrations of metals associated with a range of particle sizes in dust generated by the project	Understand relationship between dust and metal contaminants and project impact, potential health impacts. Improve understanding of the composition (and particle size fractions) of dust.	Qualitative assessment of dust impact severity.
Insufficient data is available to break down particulate emissions into PM_{10} and $PM_{2.5}$.	Conduct further sampling of dust particles at receptor locations	Quantify the relative proportions of PM_{10}, $PM_{2.5}$ and PM_{50} in dust emissions and deposition at the project site. Determine metals content and composition of PM_{10} and $PM_{2.5}$.	For the purposes of this impact assessment, dust is assumed to include particles up to PM_{50} and could include variable quantities of PM_{10} and $PM_{2.5}$.
Impacts are not assessed for all receptors (i.e., every village or settlement); instead, impacts are assessed for receptor 'groups' as outlined in Section 6.5.4. It is not feasible, in all cases, to delineate impacts for individual residences or receptors in the community.	Impacts to individual receptors will need to be managed by the project, including consultation with potentially affected receptors and reviewing results of air and dust monitoring in specific areas.	To allow understanding of high risk receptors, and allow community consultation to occur with potentially impacted receptors regarding air quality impacts and any location-specific measures that may need to be adopted.	These receptor 'groups' would experience a similar level of impact and are treated as one receptor, unless where otherwise noted. For example, some receptors are spread out over a large area and/or are resettled at different times. Where these such nuances warrant, impacts have been assessed to individual receptors separately rather than as one entire group.

6.6 Greenhouse gas impact assessment

Greenhouse gases (GHG) are gases that trap heat in the earth's atmosphere. Elevated concentrations of GHG have and continue to result in increased global temperatures. Emissions of GHG can result from both natural and man-made (anthropogenic) sources. Anthropogenic sources of GHG include:

- **Carbon Dioxide (CO_2):** an important component of the atmosphere released through natural processes such as respiration and volcanic eruptions, but also through human activities such as deforestation, land use change, burning fossil fuels (coal, natural gas and oil) and certain chemical reactions.
- **Methane (CH_4):** a hydrocarbon released through a variety of human activities such as the production and transport of fossil fuels, agricultural practices, livestock and the decay of organic waste in landfills. Methane is less abundant than CO_2.

- **Nitrous oxide (N_2O):** a gas produced by soil cultivation practices and industrial activities, the combustion of fossil fuels and biomass burning.

Over the last century, since the industrial revolution, the burning of fossil fuels has increased the concentration of CO_2 in the atmosphere. To a lesser extent, the clearing of land for agriculture, industry and other human activities has also increased GHG concentrations.

While these emissions will not adversely impact local or regional air quality, they will contribute to Myanmar's national GHG emission inventory and to global GHG concentrations. This section describes the GHG emissions of the proposed project, including the assessment method undertaken in order to:

- Identify the main potential sources of GHG emissions associated with the project.
- Estimate the annual emissions of GHGs over the life of the project for comparison against recent national inventories published for Myanmar.
- Identify potential GHG management measures and monitoring requirements.

6.6.1 Relevant legislation, guidelines and policies

This section provides an overview of the legislation, guidelines and policies relevant to GHG emissions in Myanmar.

The international response to climate change

The Intergovernmental Panel on Climate Change (IPCC) is the international body tasked with assessing scientific knowledge on climate change. It provides policy makers with regular scientific assessment of climate change, its impacts and future risks, and the mitigation and adaptation options.

In 1997, the United Nation Climate Change Conference was held in Kyoto. In August 2003, Myanmar ratified the Kyoto Protocol and it came into force on 16 February 2005. This agreement commits industrialised countries and economies in transit to limit and reduce GHG emissions in accordance with agreed individual targets.

In March 2014 the IPCC released the Fifth Assessment Report which considered new evidence of climate change based on independent analyses from observations of the climate system. This report included refined estimates of impact probability.

In December 2015, the United Nations Climate Change Conference (COP 21) was held in Paris, which encompassed the 21st Conference of Parties (COP) to the UNFCCC and the 11th session of the Meeting of Parties to the 1997 Kyoto Protocol. The conference negotiated the Paris Agreement aimed at holding the increase in global temperature to below 2°C above pre-industrial levels. The Paris Climate Change Agreement entered into force in November 2016 and was ratified by Myanmar 19 September 2017.

Myanmar is considered a vulnerable least developed country under the current change regime framed by UNFCCC. As such Myanmar may be eligible for support through various international mechanisms such as the Warsaw International Mechanism for Loss and Damage established in 2013. The mechanism aims to address loss and damages associated with the impacts of climate change, including extreme and slow-onset events in developing countries. The mechanism aims to address to following key functions:

i) enhancing knowledge and understanding of comprehensive risk management approaches to address loss and damage associated with the adverse effects of climate change;

ii) strengthening dialogue, coordination, coherence and synergies among relevant stakeholders;

iii) enhancing action and support, including finance, technology and capacity-building.

Additionally, Myanmar is to receive financial support under the Global Climate Change Alliance (GCCA) to strengthen dialogue and cooperation on climate change between the European Union and developing countries most vulnerable to climate change.

Myanmar's response to climate change

In 2012, Myanmar developed the National Adaption Programme of Action (NAPA) to Climate Change, which identifies eight priority sectors as most vulnerable to climate change: agriculture, early warning systems, forests, public health, water resources, the coastal zone, energy and industry, and biodiversity.

The Myanmar Climate Change and Action Plan (MCCSAP) 2016-2030 was developed in 2016 with the aim at supporting key sectors at the national and local levels to respond to the challenges, and benefit from opportunities associated with climate change.

The Myanmar Climate Change Policy was developed in 2019 and aims to provide long-term direction and guidance to:

- Take and promote climate change action on adaption and mitigation in Myanmar.
- Integrate climate change adaption and mitigation considerations into Myanmar's national priorities and across all levels and sectors in an iterative and progressive manner.
- Take decisions to create and maximise opportunities for sustainable, low carbon, climate resilient development, ensuring benefits for all.

Myanmar's Initial National Communication Under the UNFCCC was produced by the Myanmar Government in 2012 (MNREC 2012). This included the National Greenhouse Gas Inventory which reported Myanmar as having negative CO_2 emissions in 2000. This was because forests absorbed more CO_2 than was emitted from human activities, such as from industry, energy, transport and agriculture sectors. Myanmar's main sources of emissions were industrial production (especially cement production), transport and energy, land-use change (especially deforestation), waste and agricultural sectors (including rice production) and fertilizers.

Despite Myanmar's low emission levels, with the expected future economic and population growth, emissions are likely to rise. This includes emissions from the energy-intensive sectors, as well as from agriculture and livestock production. Furthermore, sustainable forest management is crucial for maintaining low CO_2 emission levels in the country.

The Myanmar Climate Change Alliance (MCCA) was established in 2013 with the support of the GCCA. The programme has been designed to strengthen capacity in Government, private sector and civil society sectors and to facilitate the Government in preparation of a national strategy for climate change that will result in sectoral strategies and actions to address climate change. The programme will support the development of appropriate institutional structures within Myanmar to implement climate change projects and programmes. The overall objective is to mainstream climate change into the Myanmar policy development and reform agenda.

Relevant GHG performance standards

This section describes international GHG performance standards which provide GHG emissions guidelines that are relevant to the Project.

International Finance Cooperation (IFC)

> *"The Environmental, Health and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP)."* (IFC 2007a)

The EHS Guidelines for Mining contain performance levels and measures for the mining industry. The guidelines provide common sources of GHG emissions as well as recommended management strategies. These guidelines should be applied together with the General EHS Guidelines (IFC 2007b), which provide guidance on common EHS issues to all industry sectors, including air quality.

The Greenhouse Gas Protocol Initiative

The Greenhouse Gas Protocol Corporate Standard (WRI 2004) provides companies with the requirements and guidance to prepare a GHG emissions inventory. It is based on five greenhouse gas accounting and reporting principles:

- **Relevance:** Ensure the GHG inventory appropriately reflects the GHG emissions of the company and serves the decision-making needs of users – both internal and external to the company.
- **Completeness:** Account for and report on all GHG emission sources and activities within the chosen inventory boundary. Disclose and justify any specific exclusions.
- **Consistency:** Use consistent methodologies to allow for meaningful comparisons of emissions over time. Transparently document any changes to the data, inventory boundary, methods, or any other relevant factors in the time series.
- **Transparency:** Address all relevant issues in a factual and coherent manner, based on a clear audit trail. Disclose any relevant assumptions and make appropriate references to the accounting and calculation methodologies and data sources used.
- **Accuracy**: Ensure that the quantification of GHG emissions is systematically neither over nor under actual emissions, as far as can be judged, and that uncertainties are reduced as far as practicable. Achieve sufficient accuracy to enable users to make decisions with reasonable assurance as to the integrity of the reported information.

International Organisation for Standardisation 14064

The International Organisation for Standardisation (ISO) are an organisation who have developed a set of environmental management standards, known as ISO 14000 (ISO 2018). The standards seek to guide other organisations to minimise how their operations negatively impact the environment, comply with relevant legislation and continually improve these. ISO 14064 is part of the environmental management standards; it refers to GHG emissions. The standard provides organisations with a set of tools for programs to quantify, monitor, report and verify GHG emissions.

6.6.2 Approach to GHG assessment

The Bawdwin project's GHG emissions were calculated using project-specific data and guided by the requirements of the GHG protocol and IPCC and Australian Government emission calculation methodologies. The calculation of GHG emissions from the Project has been performed in the five following stages:

- Defining the project boundary.
- Identifying emission sources within the project boundary.
- Identifying the appropriate emission calculation method for each source.
- Identifying activity data for each emission source.
- Calculating GHG emissions.

The calculated emissions were then benchmarked against Myanmar annual emissions.

Definition of the project boundary

The geographical boundary for the GHG assessment covers the mine area and mine access/export route corridor. Emissions associated with the project operational, construction and decommissioning phases are included in this assessment, including all associated mobile plant and equipment. Any emissions relating to maintenance and monitoring during the closure period are considered negligible and have been excluded.

Emissions associated with the transportation of materials and workforce to the project area have been considered (i.e. from the mine to the Myanmar-China border), as well as their movement within the project area. Potential emissions associated with international transport of staff and materials have not been included.

Emission calculation methodologies

Emission factors allow the quantity of GHG emitted by a source to be calculated from defined units of activity. Emissions were calculated based on assumptions provided by WMM. This was then converted to tonnes of CO_2 equivalent (CO_2-e) per annum. This is a term used to describe different GHGs with a common unit. For any quantity and type of GHG, CO_2-e represents the amount of CO_2 which would have the equivalent impact on climate change. This unit allows GHGs to be grouped together and allows for the comparison of project emissions to the country's total emissions. Countries required to report their national GHG emissions under the UNFCCC are required to use the UNFCCC accepted IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006) publication and the included emission factors.

Details of the emission calculation methodology are provided in Appendix A of this Chapter.

6.6.3 Potential greenhouse gas impacts

Emissions of GHG can be termed as being Scope 1, Scope 2 or Scope 3 depending on whether they are 'direct (Scope 1) or 'indirect' (Scope 2 and Scope 3).

Direct emissions (Scope 1)

The World Business Council for Sustainable Development defines direct GHG emissions as emissions from sources that are owned or controlled by the reporting entity (WRI 2004). These generally arise from:

- Generation of electricity, heat and steam.
- Manufacturing processes.
- Transportation or materials, products, waste or people.
- Fugitive emissions, both intentional and unintentional.
- On-site waste management.

Direct emissions specific to the project will result from:

- Combustion of fuel in diesel generators at the site electrical power station during the construction, operation and decommissioning phases.
- Combustion of diesel in mobile equipment, including on-road/off-road vehicles.
- On-site waste management activities through the decomposition, disposal and incineration of waste.

Scope 1 emissions can be calculated based on the average fuel consumption and activities for the Project in any one year.

Indirect emissions (Scope 2 and Scope 3)

Indirect emissions are generated in the wider economy as a consequence of an organisation's activities but are physically produced by the activities of another organisations.

Scope 2 emissions

Scope 2 emissions relate to the GHG emissions from the generation of purchased electricity consumed in owned or controlled equipment or operations. As the project will not purchase any electricity during any phase, there will be no Scope 2 emissions associated with the project.

Scope 3 emissions

Scope 3 indirect emissions are the upstream emissions generated in the extraction and production of fossil fuels and in the emissions from contracted or outsourced activities. Scope 3 emissions may be, but are not required to be, reported as part of a project's GHG emissions assessment.

The IPCC does not provide calculation methodologies for Scope 3 emissions, and they are typically not included as part of a GHG emissions assessment. As such, Scope 3 emissions are not included in this assessment.

Identification of emission sources and activities

Emission sources have been based on project activities. Table 6.120 details the sources included in the emissions inventory for the project.

Table 6.120 GHG emission sources associated with the project*

Emission source	Scope 1 GHG emissions
Fuel consumption in trucks moving materials to and from mine area.	Emissions from combustion
Fuel consumption in mine construction, operation and decommissioning fleet.	Emissions from combustion
Diesel consumption in mine power station during construction, operation and decommissioning.	Emissions from combustion (diesel fired generators
Explosive use during mine construction and operation	Emissions from explosive use
Management of solid waste and wastewater during mine construction, operation and decommissioning.	Emissions from organic material decomposition

* The Bawdwin resettlement program will generate Scope 2 emissions. However, due to uncertainty regarding resettlement site and associated power requirements and sources emissions, these are excluded from this assessment.

The amount of emission generated by each project source (Table 6.120) was calculated and then the kilo tonnes CO_2-e per annum (kt CO_2-e / annuum) calculated. The key assumptions used to calculate project emissions and key calculations are presented in Appendix A of this Chapter.

6.6.4 Proposed management measures

WMM will implement management measures to reduce the generation of GHG emissions. Many of these will be similar to air quality management measures as described in Section 6.5.

Standard management measures to minimise GHG emissions will include the following:

- Implement energy efficiency measures to minimise diesel consumption in the power station.
- Maintain plant and equipment and keep in good working order. Limit the use of diesel fuel through the optimisation of on-site driving, and measures such as establishing speed limits on site and reducing gradients where possible.
- Develop and implement a greenhouse gas management system that accurately quantifies emissions on a regular basis to allow major sources of emissions and the effectiveness of adopted measures to be continually identified, measured and indexed.

- Investigate application of renewable energy sources to the project as part of the detailed design phase.

6.6.5 Calculated GHG emissions

This section determines the project GHG emissions (identified in Section 6.6.3), after implementation of the management measures outlined in Section 6.6.4, and benchmarks against Myanmar's total annual GHG emissions.

A summary of the calculated GHG emissions results is presented in Table 6.121, with details provided in Appendix A of this Chapter.

Table 6.121 Summary of calculated greenhouse gas emissions

Phase (and duration)	**Emissions (kt CO_2-e)**	
	Scope 1 emissions per annum of phase	**Total over project life**
Construction (2 years)	63.79	127.57
Operation (13 years)	159.88	2078.48
Decommissioning (2 years)	31.73	63.45
Total		**2,269.50**

Annual emissions of GHG (Scope 1 emissions) from project construction, operation and decommissioning are estimated to be on average 133.50 kt CO_2-e / annum, generating a total of 2,269.50 kt CO_2-e over the life of the project. Most of the GHG emissions will occur during the mine's operational period (13 years).

The power station is expected to comprise approximately 66% of the total project emissions across all project phases. The second highest emissions contribution will come from vehicles, these will make up 33% of project related emissions. Explosives and waste will each comprise 0.3% of total emissions.

The project is expected to result in an overall increase in the nation's total emissions by approximately 0.06%, based on the 2016 emissions of 219.53 Mt CO_2-e (WRI 2016). Myanmar's primary source of GHG emissions stems from land use change and forestry, comprising 110.37 Mt CO_2-e (WRI 2016).

6.6.6 Monitoring

The Environmental Management Plan for the Bawdwin Project will provide for regular environmental monitoring and inspections to be completed for all project phases (construction, operation and decommissioning). Monitoring will include:

- Monitoring the emissions from diesel generators, power generation facilities and waste incinerators annually to confirm that the emission rates and stack parameters are within the estimates used in this assessment.
- Maintain a GHG emissions inventory.

6.7 Noise and vibration impact assessment

6.7.1 Approach to impact assessment

This chapter assesses the project noise and vibration impacts to the values identified in Section 5.6.

Section 5.6 described the levels of importance, vulnerability and resilience associated with each of the values in the study area.

The impact assessment approach adopted in this chapter is a 'significance assessment'. A significance assessment of air quality impacts involves:

- Identifying the nature of the impact to a noise amenity value at receptors. Receptors to noise impacts are those villages, farms and residences that may be exposed to increased noise and vibration which may affect amenity and aesthetic value.
- Determining the magnitude of the impact through an assessment of the spatial extent, severity and duration of the impact at receptors.
- Assessing the significance of the residual impact (i.e., with assumed successful implementation of avoidance and management measures). The significance (very low, low, medium, high or major) of the impact to a noise amenity value is determined by considering the importance, vulnerability and resilience of the value (as assessed in Section 5.6) and the predicted magnitude of the impact to the value. Impact magnitude (very low, low, medium, high or very high) is determined based on the spatial extent, severity and duration of the impact.

This chapter assesses impacts associated with noise, ground vibration and air blast. An air blast is the pressure wave that is produced by blasting, which is transmitted through the air. When the pressure wave meets a person or structure, it is typically experienced as noise and high air pressure.

No modelling of project noise or vibration emissions has been conducted. Therefore, the assessment of changes to ambient noise and vibration adopted a qualitative approach with associated assumptions. This chapter assesses noise and vibration impacts in terms of expected changes from existing conditions, with commentary on the influence on impact severity as a result of distance between a noise source and the nearest receptor, natural attenuation from the topography and meteorological influences. Severity of impacts was informed by making sound level estimations using literature sources for typical mining and construction equipment and by using a noise propagation equation, inverse square law (see Section 6.7.4), to estimate resulting noise levels at receptors.

This chapter assesses noise and vibration impacts to human amenity values only; those values are considered to be an ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity. Subsequent impacts to human health and flora and fauna due to noise and vibration are assessed further in Section 6.11 and 6.8. Increased vibration also has the potential to affect the structural integrity of landform, buildings and infrastructure. Impacts to landform (including vibration) are addressed in Section 6.2. Potential impacts and land stability risks to project facilities and buildings are addressed in Chapter 7 Hazard and risk.

This chapter refers to ambient noise standards under the Myanmar draft National Environmental (Emission) Quality Guidelines (2014), to provide context as to the existing levels of noise. This is important for understanding the predicted severity of impacts due to the project, as in some cases noise standards are already exceeded in the project area. Reference to the noise standards allows for understanding of the existing noise in the project area, which subsequently informs the impact severity. The Myanmar Environmental Impact Assessment Guidelines for the Mining Sector include standards for acceptable levels of ground vibration and air over-pressure due to blasting (air blast). The standards stipulate:

The maximum level for air blasting is 115 dB Linear. The level of 115 dB Linear may be exceeded on up to 5% of the total number of blasts over a period of 12 months; however, the level should not exceed 120 dB Linear at any time. Blasting is only permitted during daylight hours.

The recommended maximum level for ground vibration is 5 mm/s (peak particle velocity ppv). The ppv level of 5 mm/s may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The level should not exceed 10 mm/s at any time.

Reference to these standards is limited because changes in noise levels, potential ground vibration and potential air blast due to the project have not been modelled. Therefore, noise and vibration impacts are assessed qualitatively with supporting assumptions and a degree of inherent uncertainty.

6.7.2 Potential noise and vibration impacts

The project has the potential to increase noise and vibration above existing levels, which may reduce amenity at receptors in the vicinity of the project area. Excessive noise and vibration effects have the potential to harm human health and wellbeing, primarily due to nuisance, sleep deprivation and physical and mental stress.

The greatest sources of ground vibration will be during mining, as mining operations will be in proximity to Bawdwin lower village until that village is resettled after 30 to 32 months of mining.

At the start of mining year 3 the northern half of Bawdwin lower village will be within about 250 m of the mining operations at its closest points. As a result, this portion of the village is expected to be exposed to noise, air blast and vibration during that stage of the pit development. There is also the potential for ground vibration to affect landforms and structural integrity of buildings. In the absence of quantitative vibration modelling, it is not possible to predict how vibration from mining will affect Bawdwin lower village. Vibration modelling assessment will be required to understand this impact. Noise, vibration and air blast impacts will be dependent on several factors, such as the distance from blasting activities, the amount of explosives used, the height differential between the blasting location and receptor location, and wind direction and atmospheric pressure.

Potential key sources of increased noise include:

- Earthworks, including use of machinery and equipment during construction and operations
- Traffic (including light and heavy vehicles) during construction and operations
- Process plant and power station noise during operations
- Accommodation camp noise during construction and operations. However, no receptors have been identified in the vicinity of the camp, so impacts due to noise from this source have not been assessed.
- Blasting, drilling and excavation and equipment use during mining operations

Potential sources of increased vibration include:

- Construction earthworks
- Blasting, drilling and excavation during mining operations
- Compaction from vibratory rollers during construction
- Heavy vehicle traffic

These potential impacts are described further below. The discussion of potential impacts associated with increased noise and vibration is grouped into construction, operations and closure impacts. This is because the impact sources listed above, along with the impact location, pathways and timing, will be similar for construction and closure activities, and likewise during operations. This approach allows for the assessment of generation of increased noise and vibration to be holistic and account for combinatory effects from these multiple simultaneous sources rather than assessing each impact source in isolation.

Construction Phase

Earthworks and construction activity

During construction, the primary noise emissions will be from equipment and machinery in the form of engine noise and surface impact such as drilling, excavating and scraping. Noise will also include intermittent reverse alarms. Construction of buildings and infrastructure will emit noise from sources such as drilling, cutting and impact (e.g., hammering, nailing) activities. Diesel generators providing power to construction sites will generate ongoing noise during construction. Site earthworks will involve the use of rock breaking equipment and vibratory rollers, which will contribute to noise as well as ground vibration.

Traffic

The Bawdwin area will experience an increase in traffic along local roads, both around the mine and between Namtu and the Bawdwin concession area during construction. Trucks and other vehicles will transport construction materials and construction workers over the two-year construction period and cause increased noise along the public Namtu-Manton road and project access roads (plant access road and Namtu-Tiger Camp access road). Heavy vehicles such as haul trucks may cause ground vibration. The primary project construction traffic routes will be via the Namtu-Tiger Camp access road and the plant access road (Figure 6.1). To a lesser extent, the public Namtu–Manton Road will be used by construction traffic to access Bawdwin. Other traffic movements within the Bawdwin concession area include access roads to the accommodation camp, TSF and raw water dam.

Operations Phase

Mining activity

Mining activity will occur 24 hours a day, seven days a week. Mining will be performed by conventional open pit drill and blast methods using drill rigs, excavators, front-end loaders and articulated haul trucks. Ore and overburden will be loosened by blasting. Blasting will occur at a maximum rate of once per day and conducted during daytime hours. The use of drill rigs, excavators, front-end loaders and haul trucks will result in noise emissions mainly from engines, alarms and ground disturbance during mining. Blasting will also contribute to noise emissions as well as air blast overpressure (i.e., the pressure wave produced by blasting and transmitted through the air) and ground vibration.

Waste rock dump and TSF development

Development of the waste rock dump and TSF embankments will result in noise primarily from excavators, front-end loaders and haul trucks with noise emissions mainly from engines, alarms and ground disturbance. Once construction on the waste rock dump commences it will continue for the duration of the mine life. The TSF embankments will be constructed in phases.

Process plant and power station

During operations, the process plant and power stations will be key sources of ongoing noise. These facilities will operate day and night, 24 hours a day, seven days a week. The process plant will include crushing and milling circuits, as well as conveyor belts, pumps and mixing tanks, all of which will be the main sources of noise from that facility. The power station will comprise 26 modular diesel generator sets in multi-stack configurations housed in shipping containers. In addition, there will be five containerised fuel tanks and supporting infrastructure.

Traffic

A key source of traffic noise will be the haul trucks that transport waste rock to the Wallah waste rock dump and ore to the ROM pad. Also, conventional road-going trucks will export concentrate from Bawdwin via the plant road, the Namtu-Tiger Camp access road, then via public roads from Namtu to Lashio and onwards to its final destination. From Namtu to the project area, traffic will use private project roads. From Namtu to the remainder of the export corridor, traffic will use public roads. Regular vehicle movements on public roads will also occur during transport of people to and from the project site and during the supply of materials to the project (e.g., diesel for the power station). These vehicle movements will increase traffic related noise along the road routes.

Accommodation camp and workshops

The operations accommodation camp will be constructed by upgrading the construction accommodation camp. This camp will be expanded during operations by adding two additional two-storey accommodation blocks. The operations camp will accommodate 1,400 people and the potential noise sources will be the same as for the construction phase.

The workshop will be located at the mine services area. Key noise sources from maintenance activities at the workshop will include machinery and engine noise and impact activities such as hammering, drilling and cutting. Lower noise emissions will be associated with the office complex, crib room and light vehicle parking.

Closure Phase

Noise emissions during the active closure phase are expected to be similar to during construction – i.e., mainly from earthworks machinery and equipment, vehicle movements, accommodation camp, and from use of tools and equipment during dismantling of buildings and infrastructure.

6.7.3 Proposed mitigation and management measures

Potential noise and vibration impacts will be avoided through project design and administrative controls or reduced through development and implementation of a management measures under a project environmental management plan. Avoidance and management measures are outlined below.

Avoidance measures

The primary impact avoidance measure will be the resettlement of communities that are located in proximity to the project area where the greatest potential noise and vibration impacts will occur. The various receptors will be resettled at different times depending on their location with respect to project activities.

Figure 6.20 shows the locations of all noise and vibration receptors and Table 6.85 provides description of these receptors, including the timing of resettlement (if applicable) in relation to project works.

Standard management measures

Standard management measures to minimise impacts of noise generation will include the following:

- Use modern, well-functioning and well-maintained equipment, vehicles and plant (these have lower noise emissions than older machinery and equipment and vehicles that are not properly maintained).
- Provide the community, where potentially affected, with advanced notice of construction works.
- Where practicable, schedule high noise activities for during daytime hours and not on religious holidays or other important cultural events.
- Where practicable, limit the hours of operation of high noise and vibration activities near community receptors, where practicable.
- Restrict blasting to once per day at a consistent time during daylight hours.
- Appoint experienced and competent shotfirers to undertake blasting
- Optimise blast design to reduce noise and vibration where safe and practicable.
- Where practicable, avoid heavy vehicle movements near villages at night-time.
- Where safe to do so, minimise the use of exhaust brakes in vehicles when in proximity to villages.
- Establish and enforce speed limits on roads carrying project vehicles to minimise dust and noise generation.
- Use mufflers on vehicles and machinery to minimise noise generation.
- Develop and implement a grievance management process to allow affected villages and workers to register any issues related to noise and vibration emissions or other complaints.

6.7.4 Residual impact assessment

This section assesses the residual impacts identified in Section 6.7.2 after implementation of the management measures outlined in Section 6.7.3. The magnitude of each residual impact is assessed based on the impact's geographic extent, severity and duration, taking into consideration the existing noise and vibration conditions and the importance, vulnerability and resilience of noise amenity values to receptors. Table 6.122 presents the criteria used to determine the magnitude of each impact.

Table 6.122 Criteria used to determine the magnitude of noise impacts

	Very low	Low	Medium	High	Very high
Spatial extent	Impact affects a very small proportion of the receptor (i.e., less than 5% of individual residences in the receptor group)	Impact affects a small proportion of the overall receptor (i.e., in the order of 5-25% of individual residences in the receptor group)	Impact affects a moderate proportion of the overall receptor (i.e., in the order of 25-50% of individual residences in the receptor group)	Impact affects most of the receptor group (i.e., in the order of 50-75% of individual residences in the receptor group)	Impact affects the entire receptor group (i.e., all individual residences in the receptor group)
Severity	Impact has a very low severity and not detectable with respect to natural variability. Changes to noise are well below ambient noise standards at receptors.	Impact has a low severity and can be barely detectable with respect to natural variability. Impact does not cause or contribute to exceedance of ambient noise standards at receptors.	Impact will be readily detectable with respect to natural variability but of medium severity. Impact does not directly cause exceedance of ambient noise standards at receptors but may contribute to the exceedance when combined with existing effects.	Impact probably to be large (highly severe) with respect to natural variability. Ambient noise standards are exceeded at receptors where they were not previously.	Impact has a very high severity and a very large change with respect to natural variability. Ambient noise standards are exceeded at receptors, where they were not previously.
Duration	Impact is very short in duration (i.e., days)	Impact is short term (i.e., months or less)	Impact is medium term (1 to 2 years).	Impact is long term (3 to 15 years).	Impact is greater than 15 years or permanent.

Impact assessment context

This section provides important context for the following assessment of residual impacts. This is because there are several factors that underpin the assessment of all project noise and/or vibration impacts. Describing them here avoids repetition throughout the assessment. This section provides context regarding receptors to noise and vibration impacts and climatic influences that are likely to influence noise effects.

Receptors

For the purposes of this impact assessment, the social receptors of noise and vibration impacts are defined in Table 6.3. Figures 6.20 and 6.22 show the locations of these receptors.

It is expected that noise impacts to the health and safety of project personnel will be avoided or minimised by use of PPE (i.e., ear protection), appropriate building design and sound insulation. Impacts to amenity values for project personnel are not assessed given that the workforce will only be at Bawdwin for work purposes. Impacts to project personnel are not discussed further.

Existing sources of impact

It is important to note that existing ambient noise conditions within the Bawdwin concession area are already elevated above ambient noise standards. Baseline noise monitoring in September 2019 showed that existing noise levels throughout the Bawdwin concession area exceeded day and night-time (both 70 dBA L_{Aeq}) standards for industrial and commercial areas on at least one occasion at all monitoring sites across a 24-hour period. The monitoring also showed that existing noise exceeded the day (55 dBA L_{Aeq}) and night-time (45 dBA L_{Aeq}) standards for residential areas for Bawdwin Upper Village on four occasions across the 15-hour measurement period and exceeded the night-time standard on two occasions at Bawdwin Lower Village. Figure 6.20 shows the noise monitoring locations.

These existing noise sources have been attributed to residents socialising at nighttime, watching television, playing music, and increased traffic movement (cars and motorbikes) as people commute to and from work, with the noise levels being amplified by the villages being situated in a valley (see Section 5.6). A level of existing noise is also attributed to ongoing mining exploration activity such as drilling, machinery and vehicle movements. Typically, the quietest times were between 10:00 P.M. and 3:00 A.M. and the noisiest times were between 5:00 A.M. and 9:00 A.M.

It is within this context that the noise and vibration impacts are assessed. Further details on existing impacts are given in the sections below where relevant.

Climatic influences

Climatic conditions such as prevailing winds and temperature inversions have the potential to enhance or attenuate noise transmission to receptors. Typically, light and stable winds up to about 3 m/s enhance noise propagation downwind. Stronger winds tend to obscure most noise emissions. A temperature inversion is where a layer of cool air at the earth's surface becomes overlain by a layer of warmer air, and noise passing upwards is bent downwards towards the ground, increasing the noise levels experienced at the surface. Anecdotal evidence suggests that the Bawdwin area does not experience temperature inversions due to the steep valley gradients, which promote free gravitational movement of air down-gradient, but such inversions are relatively common at Namtu. However, no data has been collected on temperature inversions in the region, so these have not been incorporated into the assessment.

Some data has been collected on regional wind patterns. Wind data collected between January and May 2020 at Bawdwin showed prevailing regional winds to be south-southwesterly. This indicates that for at least some of the year, much of the wind-directed noise propagation would be directed towards the north and northeast of the Bawdwin concession area. It should be noted that the wind trends are based on limited data (single season only with no repeat data) collected over a nine-month period, although supplemented with regional climate models. At Namtu, the annual prevailing winds are southerly, which would to an extent attenuate noise travel from the west (i.e., Bawdwin) to Namtu. Between October to May regional prevailing wind directions are more variable and the direction of enhancement (and attenuation) of noise would also be expected to be more variable.

This information indicates that there will be periods throughout the year where noise propagation tends towards some receptors and away from others. For example, Nam La farms are located north and northeast of the proposed TSF location, where prevailing winds during January to May, may enhance noise propagation towards Na La farms during construction of the TSF. Noise experienced by the receptors is expected to fluctuate not only due to the changing source of the noise but also due to climatic influences. It is likely that noise increases at receptors will be of variable severity over a given impact time period, except for where those noise sources are proximal to the receptor (e.g., road construction adjacent to a village). As no noise modelling has been conducted, the assessment of impact severity has been based on distance from the noise emission source with commentary on how the topography and wind conditions may amplify or attenuate the noise.

Noise estimations

In the absence of noise modelling, this impact assessment makes use of typical known sound emission levels for vehicles and facilities (obtained from literature) and the inverse square law of sound propagation and decay (Extron, 2020) to estimate resulting noise levels at receptors. The inverse square law states that for noise that radiates in all directions from a source, the doubling of the distance from a sound source results in a 6 decibel (dB) reduction in sound intensity. For example, a sound pressure level of 100 dB measured at 10 m from the noise source, using the inverse square law, would result in a sound pressure level of 96 dB at 20 m from the noise source.

These estimations are considered conservative as noise reflection and attenuating factors, such as topography and ground cover, are not incorporated into the calculations. These estimations are not substitutes for noise modelling and are used for indicative purposes only, in order to inform assessment of impact severity. They are not intended to allow assessment of *compliance* with Myanmar noise standards. Estimated noise levels using this approach are compared to Myanmar ambient noise standards for residential land use to inform the assessment of impact severity. The comparison is considered indicative and conservative because it compares maximum noise emissions (as L_{Amax}) with the ambient standards, which are based on average noise levels over a given time period (as L_{Aeq}).

Construction Phase

During construction, most of the sources of noise increase will be in the central Bawdwin area where major facilities and infrastructure construction sites (i.e., open pit, TSF embankments, waste rock dump, process plant, ROM pad, mine services area and power station) and laydown areas will be located. Noise increases will also be concentrated along the Namtu-Tiger Camp access road during its construction and to a lesser extent along the Namtu to Manton public road due to some construction traffic accessing Bawdwin.

The closest receptors to construction activities will be (see Figure 6.20):

- Military base, approximately 400 m from the process plant, power station and TSF B/C embankments and 1 km from the haul road.
- Bawdwin upper village, within 1 km of mining area facilities, process plant, and access road construction, haul roads, and is near roads used during construction.
- Tiger Camp village, located approximately 700 m from the plant access road and adjacent to the terminus of the Namtu-Tiger Camp road construction and access road from Bawdwin lower village.
- Tiger Camp farms, within 500 m of the plant road, Namtu-Tiger Camp access road and Wallah waste rock dump; and in some cases adjacent to these project areas.
- Residents of Nam Pangyun valley, which will be adjacent to the Namtu-Tiger Camp access road construction.
- Residents along Namtu-Manton Road.
- Bawdwin lower village, approximately 1 km south of the haul road construction and less than 100 m south of the open pit.
- Loi Mi village and associated farms, some of which are less than 500 m southwest of the TSF B embankment.
- Nam La farms, some of which are 50 m from the northern access road, 200 m from the process plant and 100 m from the power station.

Table 6.123 outlines the receptors impacted by construction noise.

Table 6.123 Construction activities which may impact receptors due to noise and vibration

Receptor	Nearby construction activities
Military base	Process plant, power station, TSFB/C embankments and haul road construction
Bawdwin upper village	Road use by construction vehicles and construction of accommodation, mining area facilities, process plant, and access roads (within 1 km)
Tiger Camp village	Plant access road construction
Tiger Camp farms	Plant access road and Namtu-Tiger Camp road construction
Residents of Nam Pangyun valley	Namtu-Tiger Camp access road construction.
Namtu-Manton Road	Construction-related traffic
Bawdwin lower village	Haul road construction and open pit pre-stripping
Loi Mi village and associated farms	TSF B embankment construction
Nam La farms	Northern access road, TSF-A, process plant and power station construction

Road construction equipment will include dozers, graders, rollers, excavators, front end loaders and articulated dump trucks. The noise will be a combination of relatively continuous engine noise with regular impact (e.g., scraping/grading, rolling, drilling and excavating) noise. Intermittent reversing alarms will also be part of the noise. The overall noise experienced will gradually increase, then peak, then gradually reduce at each receptor as the construction spread passes. Road construction noise impacts to receptors will be temporary and transient over the two-year construction period as road construction progresses across the landscape. Road construction will also probably result in ground vibration due to the use of graders and rollers.

Noise from construction of facilities will comprise a combination of a background of engine and generator noise, with intermittent impact activities (e.g., drilling, cutting and hammering) and alarms. Some blasting will probably be required during ground preparations and these will contribute to noise emissions. Localised vibration will probably occur during site grading and rolling and blasting during ground preparation; however, vibration is not predicted to be noticeable at the closest receptors. The key noise and vibration sources will be relatively fixed (or localised) in their locations throughout the construction of major project facilities and will form an overall combined ongoing and variable noise source from numerous activities occurring in parallel.

A maximum noise emission level of 85 dBA for construction noise emissions has been assumed. This level is based on literature values for a range of equipment types, specifically the emission specification for pneumatic tools, dozers, excavators and graders at a distance of 15 m outlined in the US Department of Transportation Construction Noise Handbook (US DoT, 2018).

Using the inverse square law, the Myanmar ambient noise criteria of 55 dBA (day) would be met at a distance of 480 m from the noise source (Figure 6.23). Using the same law, the night-time ambient noise criteria of 45 dBA would be met 1,500 m from the construction noise source. However, construction will be limited to daytime hours only. No night time noise impacts due to construction are predicted.

The highest noise and vibration emissions from construction of facilities will originate from the upper central part of the Bawdwin concession area, where the process plant, power station, ROM pad, mine services area and TSF embankments sites are located. With the exception of the TSF embankments, most of these sites are on elevated topography. This indicates that while in-valley sound amplification may be minimal, noise emissions may travel further across the landscape (than if the noise source was within the lower valley) without surrounding mountains to attenuate the noise. Noise levels at receptors will probably fluctuate depending on wind conditions.

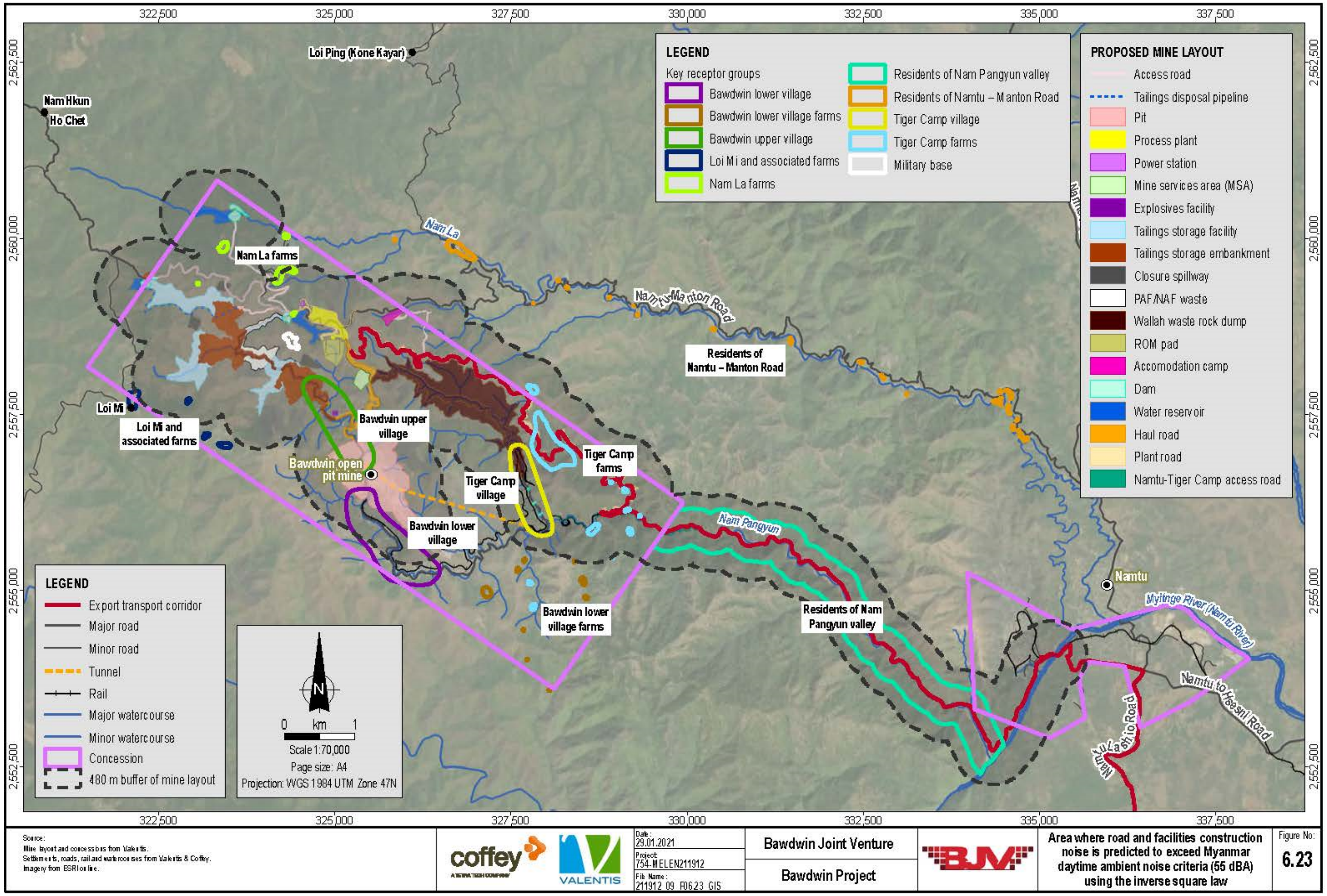


Figure 6.23 (F185) Area where road and facilities construction noise is predicted to exceed Myanmar daytime ambient noise criteria (55 dBA) using the inverse square law

Impacts will be partially mitigated by appropriate scheduling of noisier activities and emissions attenuation equipment on sources where practicable. A robust complaints and grievance mechanism will also be in place. It is probable that people in Bawdwin villages are somewhat tolerant or resilient to some level of industrial-type noise and heavy vehicle traffic due to their experience over the previous periods of mine operations at Bawdwin, and during more recent mineral exploration activity. The character of the construction noise is likely to be consistent with noise sources the communities have been exposed to in the past.

During construction, there will be an increase in traffic on public and project access roads as vehicles transport materials and personnel to and from the construction sites and accommodation camp. Project traffic will comprise trucks, buses and light vehicles and will vary in frequency. Most of the early works construction traffic will be via the existing public Namtu – Manton road, with traffic accessing the major construction sites via the Namtu-Tiger Camp access road and plant road once constructed. Traffic movements on public roads will occur during daylight hours only, for safety reasons.

Noise will be largely in the form of engine noise as drivers will be instructed to minimise the use of exhaust brakes in village areas where safe to do so. Occasional use of horns will also contribute to the noise. Localised ground vibration may occur when heavier vehicles travel on the roads; although, this will be a minor contributor to the overall disturbance to amenity due to increased noise.

A review was made of values for noise emissions outlined in the UK Department for Environment Food and Rural Affairs noise database for prediction of noise on construction and open sites (DEFRA, 2005). Based on this review, a maximum sound pressure level of 86 dBA generated by a 35-t articulated dump truck has been adopted as representative of the likely maximum noise emission for construction machinery at Bawdwin. The adoption of this sound source is considered conservative since construction traffic will also include smaller and quieter light vehicles.

The sound levels provided in the DEFRA source database are based on a distance of 10 m from the source. Using the inverse square law, the Myanmar ambient noise criteria of 55 dBA (day) would be met at a distance of 360 m from the truck noise source (i.e., the road). These estimates indicate that ambient noise criteria are predicted to be exceeded at the nearest receptors (Bawdwin upper and lower villages, Tiger Camp village, Tiger Camp farms and residents of the Nam Pangyun valley) during the day. As traffic will pass by in proximity to these receptors during day and night, there is the potential for night-time amenity to be reduced and sleep disturbed.

The Bawdwin military base will experience noise from construction of the process plant, power station, TSF B and TSB C embankments and haul road. This receptor will not be resettled by the project. The residual impact of increased noise and vibration to the Bawdwin military base during the construction phase is considered to be of **high significance**, based on the **high magnitude** of impact and the **medium sensitivity** of the receptor (Table 6.124).

Table 6.124 Residual impact significance summary – construction phase – increased noise and vibration levels due to construction of process plant, power station, TSF B and TSB C embankments and haul road – affecting the Bawdwin military base

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Bawdwin military base - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>Medium
Although this military base is located close to the current mine, operations have been in care and maintenance and current noise levels exceed Myanmar standards at this receptor. A medium level of importance is placed on the value of the ambient noise environment for amenity and health during the day and night.</td><td>High
The military base is vulnerable to increased noise emissions due to its location in proximity to the project area. Current noise levels exceed Myanmar standards at times and the Military Base is vulnerable to any additional increases in noise-generating project activities.</td><td>Medium
It is expected that this receptor would have medium resilience to increased noise emissions, on the basis that it is a military base.</td><td>Medium</td></tr>
<tr><td>Impact</td><td colspan="4">Magnitude of impact</td></tr>
<tr><td rowspan="6">Increased noise and vibration levels due to construction of process plant, power station, TSF-B and TSB-C embankments and haul road</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>High
While noise and vibration emissions have not been modelled, it is anticipated that noise and vibration would affect most of the receptor, given the receptor is a relatively small area surrounded by a range of noise sources.</td><td>High
Noise levels are expected to exceed the Myanmar daytime standard of 55 dBA, given the receptor is less than 480 m from construction of the process plant and TSF embankments. Additional noise sources from haul road construction and power station construction will combine to form cumulative noise increases at this receptor, resulting in high severity.</td><td>Medium
While noise and vibration emissions have not been modelled, it is anticipated that noise and ground vibration will be relatively constant (although variable in its intensity) over the construction period.</td><td>High</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>High</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">High
No noise and vibration quantitative modelling has been done and this limits the accuracy of the assessment. This uncertainty is relatively high given the distance between the receptor and the noise source (where climatic conditions and terrain factors are likely to play a greater role in noise propagation) compared to those which are in proximity to the noise source. The assessment is based on the use of literature values for typical noise sources and these values adopted may differ from actual project equipment and vehicle noise levels.</td></tr>
</table>

Bawdwin upper village will experience noise from construction of accommodation, mining area facilities, process plant, and access roads which are within 1 km of this receptor. The residual impact of increased noise and vibration to Bawdwin upper village during the construction phase is considered to be of **moderate significance**, based on the **medium magnitude** of impact and the **medium sensitivity** of the receptor (Table 6.86).

Table 6.125 Residual impact significance summary – construction phase – increased noise and vibration levels due to construction of mining area facilities, process plant, and access roads, and construction related traffic – affecting Bawdwin upper village

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Bawdwin upper village - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>Medium
Although Bawdwin upper village is located close to the current mine, operations have been in care and maintenance and existing noise sources have been limited. Current noise levels exceed Myanmar standards at this receptor. A medium level of importance is placed on the value of the ambient noise environment for amenity and health during the day and night.</td><td>High
Bawdwin villages are vulnerable to increased noise emissions due to their location in proximity to the project area and noise-generating project activities. Current noise levels exceed Myanmar standards and the villages are vulnerable to any additional increases in noise-generating project activities.</td><td>Medium
It is expected that this receptor would have medium resilience to increased noise emissions, on the basis that it is a village established to support mining operations and is located in an existing mining concession area.</td><td>Medium</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact</th></tr>
<tr><td rowspan="6">Increased noise and vibration levels due to construction of roads and facilities and construction-related traffic</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Medium
While noise and vibration emissions have not been modelled, it is anticipated that noise and vibration would affect a moderate proportion of the receptor (i.e., those residences in the northern portion of the village within about 1 km of the haul road). Residences further away to the south are likely to experience little or no impact.</td><td>Medium
Noise levels at Bawdwin upper village due to construction noise are expected to be moderate and cumulative from a range of simultaneous sources. Impact severity is expected to be low at most of the receptors given most are more than 1 km from the construction activities. A small section of the haul road passes within 100-200 m of the central and north portions of the receptor group and noise will probably be elevated above ambient noise criteria during these times, although short term.</td><td>Low
While noise and vibration emissions have not been modelled, it is anticipated that noise and ground vibration will be relatively constant (although variable in its intensity) over a 7-9 month period prior to this receptor being resettled.</td><td>Medium</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Moderate</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">High
No noise and vibration quantitative modelling has been done and this limits the accuracy of the assessment. This uncertainty is relatively high given the distance between the receptor and the noise source (where climatic conditions and terrain factors are likely to play a greater role in noise propagation) compared to those which are in proximity to the noise source. The assessment is based on the use of literature values for typical noise sources and these values adopted may differ from actual project equipment and vehicle noise levels.</td></tr>
</table>

Bawdwin lower village may experience some increase in noise levels due to construction of the haul road about 1 km to the north. Bawdwin lower village, given its distance of 1 km from the haul road construction, is unlikely to experience ground vibration. Bawdwin lower village is within 3 km of major construction sites (e.g. process plant, power station, mine services area and accommodation camp), located down in the valley at a much lower elevation than the key noise sources (construction sites). As a result of this distance, lower Bawdwin village will also probably experience low noise levels from construction in upper central Bawdwin. The significance of increased noise and vibration to Bawdwin lower village during the construction phase is considered to be of **low significance**, based on the **low magnitude** of impact and the **medium sensitivity** of the impact (Table 6.126).

Table 6.126 Residual impact significance summary – construction phase - increased noise and vibration levels due to construction of haul road and facilities and construction-related traffic – affecting Bawdwin lower village

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Bawdwin lower village - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>Medium
Although Bawdwin upper village is located close to the current mine, operations have been in care and maintenance and existing noise sources have been limited. Current noise levels exceed Myanmar standards at this receptor. A medium level of importance is placed on the value of the ambient noise environment for amenity and health during the day and night.</td><td>High
Bawdwin villages are vulnerable to increased noise emissions due to their location in proximity to the project area and noise-generating project activities. Current noise levels exceed Myanmar standards and the villages are vulnerable to any additional increases in noise-generating project activities.</td><td>Medium
It is expected that this receptor would have medium resilience to increased noise emissions, on the basis that it is a village established to support mining operations and is located in an existing mining concession area.</td><td>Medium</td></tr>
<tr><td>Impact</td><td colspan="4">Magnitude of impact</td></tr>
<tr><td rowspan="6">Increased noise and vibration levels due to construction of roads and facilities and construction-related traffic</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Low
While noise and vibration emissions have not been modelled, it is anticipated that noise and vibration would affect a small proportion of the receptor (i.e., those residences in the northern portion of the village within about 1 km of the haul road). Residences further away are likely to experience little or no impact.</td><td>Low
Noise levels at Bawdwin lower village due to haul road construction are expected to be low given it is more than 1 km from the haul road construction.</td><td>Medium
While noise and vibration emissions have not been modelled, it is anticipated that noise and ground vibration will be relatively constant (although variable in its intensity) over the construction period.</td><td>Low</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Low</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">High
No noise and vibration quantitative modelling has been done and this limits the accuracy of the assessment. This uncertainty is relatively high given the distance between the receptor and the noise source (where climatic conditions and terrain factors are likely to play a greater role in noise propagation) compared to those which are in proximity to the noise source. The assessment is based on the use of literature values for typical noise sources and these values adopted may differ from actual project equipment and vehicle noise levels.</td></tr>
</table>

Traffic noise emissions will occur along the public road Namtu-Manton Road and through Namtu during early construction from light and heavy vehicles. The significance of increased noise and vibration to Namtu during the construction phase is considered to be of **low significance**, based on the **medium magnitude** of impact and the **medium sensitivity** of the impact (Table 6.127). The residual impact of increased noise and vibration to residents along Namtu-Manton Road during the construction phase is considered to be of **moderate significance**, based on the **medium magnitude** of impact and the **medium sensitivity** (Table 6.128).

Table 6.127 Residual impact significance summary – construction phase – increased noise and vibration levels due to construction traffic through Namtu

Value	**Sensitivity of value**			
Namtu town - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium Due to the number of manufacturing and industrial operations in Namtu elevated noise levels are expected to occur from time to time. However, residential areas are likely to have some reliance on low background noise levels for amenity.	**Medium** Namtu has current noise levels that exceed Myanmar standards and the town is vulnerable to any additional increases in noise-generating activities.	**Medium** It is expected that this receptor would have some resilience to mining, traffic and construction related noise and has some capacity to adapt to increased noise levels.	**Medium**
Impact	**Magnitude of impact**			
Increased noise and vibration levels due to construction traffic through Namtu	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low While noise and vibration emissions have not been modelled, it is anticipated that noise and vibration would only affect the settlements in proximity to the main transport route.	**Medium** Noise levels through Namtu due to construction-related traffic are expected to be moderate. Construction traffic will not occur at night and the Myanmar ambient noise criteria of 55 dBA (day) would be met at a distance of 360 m from the noise source (based on the inverse square law). Impact severity is expected to be moderate at this receptor given the existing level of noise.	**Medium** While noise and vibration emissions have not been modelled, it is anticipated that noise and ground vibration will be intermittent and variable in intensity over project construction.	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High No noise and vibration quantitative modelling has been done and this limits the accuracy of the assessment. There is also no baseline noise data for this area. The assessment is based on the use of literature values for typical noise sources and these values adopted may differ from actual project equipment and vehicle noise levels.			

Table 6.128 Residual impact significance summary – construction phase – increased noise and vibration levels due to construction traffic along Namtu-Manton Road – affecting residents along Namtu-Manton Road

Value	**Sensitivity of value**			
Residents along Namtu - Manton Road - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium The area is likely to experience some level of noise due to existing traffic noise along this public road. The receptor is likely to have moderate reliance on low background noise levels to maintain amenity.	**High** Receptor is in proximity to the Namtu-Manton Road (i.e., within 1 km), with little to no mountainous terrain between noise sources and receptor. Increased noise would result in noticeable reduction in amenity.	**Medium** Receptor has some capacity to adapt to increased noise levels given they are based along a public road.	**Medium**
Impact	**Magnitude of impact**			
Increased noise and vibration levels due to construction traffic along Namtu-Manton Road	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	High While noise and vibration emissions have not been modelled, it is anticipated that noise and vibration would affect most of the residents in proximity to the Namtu-Manton Road. These are largely stand-alone houses alongside the road and no large settlements.	**Medium** Noise levels at villages along the Namtu to Manton Road due to construction-related traffic are expected to be moderate. Construction traffic will not occur at night and the Myanmar ambient noise criteria of 55 dBA (day) would be met at a distance of 360 m from the noise source (based on the inverse square law). Impact severity is expected to be moderate at this receptor given several houses are located within 360 m of the Namtu-Manton road which will be used during construction.	**Medium** While noise and vibration emissions have not been modelled, it is anticipated that noise and ground vibration will be intermittent and variable in intensity over a medium term duration (about 1 year) until the plant road and Namtu-Tiger Camp access road are constructed.	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High No noise and vibration quantitative modelling has been done and this limits the accuracy of the assessment. There is also no baseline noise data for this area. The assessment is based on the use of literature values for typical noise sources and these values adopted may differ from actual project equipment and vehicle noise levels.			

Tiger Camp village will experience noise impacts during construction of the Namtu-Tiger Camp road and plant road. Namtu-Tiger Camp road will be completed from Namtu to the intersection with the plant road prior to resettlement of Tiger Camp. After resettlement, the road will be extended to allow access to the base of Wallah Valley to construct the sediment dams. Tiger Camp village is located at the terminus of the Namtu-Tiger Camp access road and as close as 700 m from the southern end of plant road construction, and is located down in the valley at a much lower elevations than key noise sources (construction sites). There is possibly a lower degree of mountain barrier attenuation of some construction noise as the valley runs down from the plant road construction areas to the village. Construction traffic will also increase noise at Tiger Camp village once the plant road is complete and provides traffic access to the project area. Tiger Camp village will be resettled prior to construction of the waste rock dump, so that impact pathway is not considered. The residual impact of increased noise and vibration to Tiger Camp village during the construction phase is considered to be of **moderate significance**, based on the **medium magnitude** of impact and the **medium sensitivity** of the receptor (Table 6.129).

Table 6.129 Residual impact significance summary – construction phase – increased noise and vibration levels due to construction of haul road and facilities and construction-related traffic – affecting Tiger Camp village

Value	**Sensitivity of value**			
Tiger Camp village – ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium Although Tiger Camp is located close to the current mine facilities, operations have been in care and maintenance and existing noise sources have been limited. Current noise levels exceed Myanmar standards at these receptors. A medium level of importance is placed on the value of the ambient noise environment for amenity and health during the day and night.	**High** Tiger Camp is vulnerable to increased noise emissions due to its location in proximity to the project area and noise-generating project activities. Current noise levels exceed Myanmar standards and the village is vulnerable to any additional increases in noise-generating project activities.	**Medium** It is expected that this receptor would have medium resilience to increased noise emissions, on the basis that it is a village established to support mining operations and is located in an existing mining concession area.	**Medium**
Impact	**Magnitude of impact**			
Increased noise and vibration levels due to construction of roads and facilities and construction-related traffic, affecting Tiger Camp village	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low While noise and vibration emissions have not been modelled, it is anticipated that noise and ground vibration will disturb a small proportion of the receptor (i.e., those individual receptors adjacent to the road and in the northern portion of the receptor, with those further away (i.e., in the order of 500 m or more) experiencing little or no impact. Once the roads are constructed, traffic during the construction phase is expected to affect a moderate proportion of the receptor given roads will be located near the south, east and north of this receptor.	**Medium** While noise levels are anticipated to exceed ambient noise criteria during the day when construction is in the vicinity, works will be avoided at night-time. Road construction is anticipated to provide a moderate contribution to the overall impact to amenity primarily caused by noise. Impacts caused by traffic on the roads will be moderate.	**Medium** It is anticipated that increased noise and ground vibration will be medium term (throughout the entire construction period) until 29-30 months after commencement of construction, being relatively constant (although variable in its intensity) over that period. The valley topography is likely to transmit noise within the valley during construction of these roads, so noise levels may remain high at Tiger Camp for a period after the construction spread moves away.	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	Medium No noise and vibration quantitative modelling has been done and this limits the accuracy of the assessment. This uncertainty would be greater for receptors further away from the noise source (where climatic conditions and terrain factors are likely to play a greater role in noise propagation) compared to those which are in proximity to the noise source. The assessment is based on the use of literature values for typical noise sources and these values adopted may differ from actual project equipment and vehicle noise levels.			

It is predicted that Tiger Camp farms (those that are not resettled prior to construction commencing) will experience high levels of noise impact during construction of the Namtu-Tiger Camp road and plant access road. Tiger Camp farms are within 3 km of the major construction sites, and somewhat lower in the terrain than these sites, with considerable mountainous landscape between the construction sites and the receptor. Noise emissions from major construction works in those areas are therefore likely to be largely attenuated by the terrain, reducing sound levels experienced at these receptors. Construction traffic will increase noise at Tiger Camp farms as they will be located within 500 m of the main access route to the project area (plant access road and Namtu-Tiger Camp access road), although those receptors directly along the plant access road will be resettled prior to road construction. Considering resettlement of the closest receptors prior to road construction, the residual impact of increased noise and vibration to Tiger Camp farms during the construction phase is considered to be of **low significance**, based on the **medium magnitude** of impact and the **medium sensitivity** of the impact (Table 6.130).

Table 6.130 Residual impact significance summary – construction phase – increased noise and vibration levels due to construction of haul road and facilities and construction-related traffic – affecting Tiger Camp farms

Value	**Sensitivity of value**			
Tiger Camp farms - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium A medium level of importance is placed on the value of the ambient noise environment for amenity and health during the day and night given the farms rural setting and their location in the mining concession area.	**Medium** Tiger Camp farms are vulnerable to increased noise emissions due to its location in proximity to the project area and noise-generating project activities.	**Medium** It is expected that this receptor would have some resilience to mining, traffic and construction related noise and has some capacity to adapt to increased noise levels.	**Medium**
Impact	**Magnitude of impact**			
Increased noise and vibration levels due to construction of roads and facilities and construction-related traffic, affecting Tiger Camp farms	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium While noise and vibration emissions have not been modelled, it is anticipated that noise and ground vibration will disturb a moderate proportion of the receptor as the Namtu-Tiger Camp access road and the plant access road pass adjacent to much of the individual residences and construction of the sediment dams is within 1 km of several farms. Farms more than 1 km away are unlikely to experience impact.	**Medium** While noise levels are anticipated to exceed ambient noise criteria during the day when construction is in the vicinity, works will be avoided at night-time which is when amenity and health values are more sensitive. Impacts to those receptors closest to the road will be avoided as they will be resettled prior to road construction. For those receptors further form the road, the topography is expected to significantly attenuate the noise from construction.	**Medium** While vibration emissions have not been modelled, it is anticipated that ground vibration will be relatively constant over the two-year construction period, though with varying degrees of intensity.	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	Medium No noise and vibration quantitative modelling has been done and this limits the accuracy of the assessment. This uncertainty would be greater for receptors further away from the noise source (where climatic conditions and terrain factors are likely to play a greater role in noise propagation) compared to those which are in proximity to the noise source. The assessment is based on the use of literature values for typical noise sources and these values adopted may differ from actual project equipment and vehicle noise levels.			

It is predicted that Nam La farms will experience high noise levels during construction of the northern access road. Additionally, Nam La farms are the closest receptor to the major construction sites, some of which are within 200 m of the process plant and power station and 1 km from the TSF-B embankment. The residual impact of increased noise and vibration to Nam La farms prior to their resettlement 7 to 9 months after commencement of the construction phase, , is considered to be of **high significance**, based on the **medium magnitude** of impact and **high sensitivity** of the receptor (Table 6.131).

Table 6.131 Residual impact significance summary – construction phase – increased noise and vibration levels due to construction of haul road and facilities and construction-related traffic – affecting Nam La farms

Value	**Sensitivity of value**			
Nam La farms - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High It is likely that this area currently experiences relatively low levels of ambient noise since it is remote from existing industrial and traffic noise sources. The receptor is likely to have high reliance on low background noise levels to maintain amenity.	**High** Receptor is in proximity to the project area (i.e., within 1 km), with little to no mountainous terrain between noise sources and receptor and is vulnerable to increased noise.	**Medium** Receptor has limited capacity to adapt to increased noise levels given its remote setting likelihood of amenity value being based on low levels of background noise.	**High**
Impact	**Magnitude of impact**			
Increased noise and vibration levels due to construction of roads and facilities and construction-related traffic	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium While noise and vibration emissions have not been modelled, it is anticipated that noise and ground vibration will disturb a moderate proportion of the receptor (i.e., those individual receptors adjacent to the road and within 500 m of the power station/process plant) with those further away (i.e., in the order of 750 m or more) experiencing little or no impact	**Medium** While noise levels are anticipated to exceed ambient noise criteria during the day when construction is in the vicinity, works will be avoided at night-time which is when amenity and health values are more sensitive. Road construction is anticipated to provide a moderate contribution to the overall impact to amenity primarily caused by noise.	**Low** It is anticipated that ground vibration and noise will be being relatively constant (although variable in its intensity) over the construction period prior to this receptor being resettled 7-9 months after construction.	**Medium**
	Residual impact significance			**High**
	Assessment of uncertainty			
	Medium No noise and vibration quantitative modelling has been done and this limits the accuracy of the assessment. This uncertainty would be greater for receptors further away from the noise source (where climatic conditions and terrain factors are likely to play a greater role in noise propagation) compared to those which are in proximity to the noise source. The assessment is based on the use of literature values for typical noise sources and these values adopted may differ from actual project equipment and vehicle noise levels.			

Loi Mi village and associated farms are within 1 to 2 km from TSF-B embankment construction site, situated lower in the terrain than the major construction sites, with considerable mountainous landscape between the construction sites and the receptor. Noise emissions are therefore likely to be largely attenuated by the terrain, reducing sound levels experienced at these receptors. No roads will be constructed in proximity to the Loi Mi village and associated farms, and no increase in traffic on nearby roads is expected. The residual impact of increased noise and vibration to Loi Mi village and associated farms during the construction phase is considered to be of **low significance**, based on the **low magnitude** of impact and the **medium sensitivity** of the receptor (Table 6.132).

Table 6.132 Residual impact significance summary – construction phase – increased noise and vibration levels due to construction of facilities – affecting Loi Mi village and associated farms

Value	Sensitivity of value			
Loi Mi village and associated farms - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The area is likely to experience relatively low levels of ambient noise given it being remote from existing industrial and traffic noise sources. The receptor is likely to have high reliance on low background noise levels to maintain amenity.	**Medium** Receptor is moderately removed from the project area (1 to 2 km), with mountainous terrain between noise sources and receptor and has a moderate level of vulnerability to increased noise.	**Medium** Receptor has some limited capacity to adapt to increased noise levels given its remote setting and likelihood of amenity value being based on low levels of background noise.	**Medium**
Impact	**Magnitude of impact**			
Increased noise and vibration levels due to facilities construction	**IF RESETTLED (those receptors within the Bawdwin concession)**			
	Spatial extent	***Severity***	***Duration***	***Magnitude***
	Low Impact is likely to affect only a small portion of the receptor (those farms and residents in the concession boundary) with the remainder being either unaffected or affected to a materially lower extent	**Very low** Noise levels are predicted to be below ambient noise standards given the distance of farms outside the Bawdwin concession area more than 1 km from closest construction activities and significant attenuation by the topography.	**Medium** Impact is medium term (over the construction period prior to resettlement), being relatively constant over that period.	**Low**
	Residual impact significance			**Low**
	IF NOT RESETTLED			
	Spatial extent	***Severity***	***Duration***	***Magnitude***
	Low Impact is likely to affect only a small portion of the receptor (those farms and residents within the Bawdwin concession area) with the remainder being either unaffected or affected to a materially lower extent	**Low** Noise levels are predicted to be below ambient noise standards given the distance of approximately 500 m from closest construction activities to farms within the Bawdwin concession area.	**Medium** Impact is medium term (over the construction period), being relatively constant over that period.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Medium No noise and vibration quantitative modelling has been done and this limits the accuracy of the assessment. While there is material uncertainty in the quantitative predictions made using the inverse square low, the overall impact rating would have low likelihood of changing given the large distance from noise source to receptor and expected very low noise levels reaching the receptor.			

High levels of noise impact due to road construction are predicted to affect residents Nam Pangyun valley during construction of the Namtu-Tiger Camp access road. Additionally, construction traffic will increase noise in the Nam Pangyun valley, as the main access route to the project area travels down the Nam Pangyun valley adjacent to the river and nearby residents. The residual impact of increased noise and vibration to residents of the Nam Pangyun valley during the construction phase is considered to be of **moderate significance**, based on the **medium magnitude** of impact and the **medium sensitivity** of the receptor (Table 6.133).

Table 6.133 Residual impact significance summary – construction phase – increased noise and vibration levels due to road construction and construction-related traffic – affecting residents of the Nam Pangyun valley

Value	**Sensitivity of value**			
Residents of the Nam Pangyun valley - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium The majority of the receptors along the valley are remote from existing industrial and traffic noise sources and would probably experience low background noise levels.	**High** Receptor is in a narrow valley with limited sources of existing noise and is vulnerable to increased noise sources within the valley.	**High** It is expected that this receptor would have some resilience to mining, traffic and construction related noise and has some capacity to adapt to increased noise levels. Many of the individual receptors are known to be transient in their locations and so would have some capacity to temporarily relocate from high noise and vibration emissions when in the vicinity.	**Medium**
Impact	**Magnitude of impact**			
Increased noise and vibration levels due to road construction	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium While noise and vibration emissions have not been modelled, it is anticipated that noise and ground vibration will disturb a moderate proportion of the receptor (i.e., those individual receptors adjacent to the road) with those further away (i.e., in the order of 500 m or more) experiencing little or no impact	**Medium** Noise levels are anticipated to exceed ambient noise criteria during the day when construction is in the vicinity, works will be avoided at night-time which is when amenity and health values are more sensitive. With driver training, speed restrictions and community consultation in place, impacts will be somewhat mitigated	**Low** It is anticipated that ground vibration will be short term and frequently occurring over the first year of construction. While noise levels may lower as construction moved from one area to another, the valley topography is likely to amplify noise within the valley during construction of these roads, so noise levels may remain high at the receptors for a period after the construction spread moves away.	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	Medium No noise and vibration quantitative modelling has been done and this limits the accuracy of the assessment and there is no baseline data for this area. This uncertainty would be greater for receptors further away from the noise source (where climatic conditions and terrain factors are likely to play a greater role in noise propagation) compared to those which are in proximity to the noise source. The assessment is based on the use of literature values for typical noise sources and these values adopted may differ from actual project equipment and vehicle noise levels.			

Operations Phase

During the operations phase, the main noise sources will be at the mining operation, the haul road, the ROM pad and crusher, the process plant, the power station and the waste rock dump. Ground vibration and air blast will be generated by blasting during mining. Noise will also occur due to traffic on access and haul roads to the waste dump and between the major facilities (camp, mine services area, ROM pad, etc). Noise increases will also be associated with traffic along the export corridor which comprises the plant access road and the Namtu-Tiger Camp access road. From Namtu, concentrate will be trucked via Lashio on public roads before being transported to its final destination. The export corridor will also be used for operations traffic during movements of materials and personnel to/from the project.

The closest receptors to operations activities will be (see Figure 6.20):

- Bawdwin military base, which will be less than 500 m from the process plant, power station and TSFB and C embankments and about 1 km from the haul road.
- Residents of the Nam Pangyun valley, which will be adjacent to the Namtu-Tiger Camp access road (part of the export corridor).
- Loi Mi village and associated farms, the closest of which will be approximately 500 m from the TSF-B embankment.
- Bawdwin lower village, which will be within 100 m of the open pit at its closest point.
- Tiger Camp farms, which will be as close as 150 m to the Wallah waste rock dump and adjacent to the export corridor.
- Namtu and other townships along the export route (see Figure 6.22). All of these receptors are outside the Bawdwin concession area.

Table 6.134 outlines the operations activities which may impact receptors due to noise and vibration.

Table 6.134 Operational activities which may impact receptors due to noise and vibration

Receptor	Nearby operation activities
Military base	Process plant and power station operation, TSF embankment development and haul road use
Residents of the Nam Pangyun valley	Namtu-Tiger Camp access road (part of the export corridor)
Loi Mi village and associated farms	TSF-B embankment development
Bawdwin lower village	Open pit mining
Tiger Camp village	Open pit mining
Tiger Camp farms	Wallah waste rock dump, concentrate export
Namtu and other townships along the export route	Concentrate export

Mining activity

Mining will occur 24 hours a day, seven days a week over the 13 years of mining operations. The key noise and vibration sources will be from vehicle and equipment engine noise, along with impact activities such as drilling, excavating and blasting. Section 4.5.3, outlines the primary and auxiliary mining equipment to be used. The noise character will be a relatively continuous background of engine noise with intermittent impact noises as overburden and ore is drilled and excavated. Vehicle reversing alarms will also frequently contribute to the overall noise. Blasting will represent an impulsive noise source and will occur at a maximum rate of one blast per day at a time as agreed by the local community and WMM management. The blast time will either be during the production mining lunch hour or at shift change to minimise blasting disruption to production schedule achievement.

Bawdwin lower village, Tiger Camp village, Tiger Camp farms and Loi Mi village and associated farms will be resettled at different stages during operations (see Figure 6.20). Bawdwin upper village and Nam La farms will be resettled prior to mining operations.

Bawdwin lower village will be resettled approximately 30 to 32 months after mining operations commence. At the start of year 2 of mining a small proportion of the village (northern section) will be within 500 m of the mining operations and is expected to be exposed to high noise, air blast and ground vibration. At the start of year 3 of mining, most of the receptor will be within 500 m of mining operations. With mining activity taking place in a deep pit with a final depth of 495 m below the surface, most of the noise emissions will be attenuated by the pit walls. However, noise from mining excavation is expected to be noticeable at Bawdwin lower village during the day and night, and air blast and vibration from blasting is expected to be noticeable during the day. Noise and vibration modelling would be needed to accurately predict the noise and ground vibration levels at Bawdwin lower village and how the levels compare to the Myanmar standards for noise and ground vibration. Noise estimations using the inverse square law are not appropriate for mining noise, given the noise emissions will be deep within the open pit and surrounded by the pit walls. Use of the inverse square law is applicable to noise propagation in open environments where soundwaves spread radially without interference.

Overall, the residual impact of disturbed amenity at Bawdwin lower village due to mining noise and ground vibration during the operations phase is assessed to be of **high significance**, based on the **high magnitude** of impact and the **medium sensitivity** of the value (Table 6.135). However**,** there is high uncertainty in the absence of noise and ground vibration modelling.

Table 6.135 Residual impact significance summary – operations phase – increased noise and vibration levels due to mining activity – affecting Bawdwin lower village

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Bawdwin lower village - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>Medium
An elevated level of ambient noise is reasonably expected to occur due to the extensive mining operations that have shaped Bawdwin. However, the last decade has seen relatively lower noise levels. Although existing noise levels exceed Myanmar standards at this receptor, there is still a level of importance placed on amenity during the day and night.</td><td>High
Bawdwin villages are vulnerable to increased noise emissions due to their location in proximity to the project area and noise-generating project activities. There is little in the way of terrain barriers (i.e., hills and mountains) between the receptor and many project noise sources, particularly once mining is over the crest of the hill.</td><td>High
It is expected that this receptor would have high resilience to mining, traffic and construction related noise given its existence is based on servicing such industrial purposes.</td><td>Medium</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact</th></tr>
<tr><td rowspan="6">Increased noise levels due to mining activity</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Very High
Impact is expected to impact the entire receptor given the intensity of noise and proximity of the pit to Bawdwin lower village.</td><td>High
Noise levels are likely to exceed ambient standards during the day and night given the intensity of noise sources and proximity to the receptor. Vibration is also likely to be noticeable during the day when blasting occurs.
Noise is expected to be attenuated to some degree by the pit walls.</td><td>Medium
Increased noise and ground vibration will be frequent over a 30 to 32-month period prior to resettlement of the receptor.</td><td>High</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>High</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">High
No noise and ground vibration quantitative modelling has been done and this limits the accuracy of the assessment. This impact is expected to be of high severity and modelling would be required to understand the intensity and frequency of noise and vibration and how levels at the receptor will compare to the Myanmar ambient standards for noise and vibration. The level of attenuation of noise and vibration from the pit walls would also need to be factored in to modelling.</td></tr>
</table>

It is considered that air blast and ground vibration will not be a material impact to the amenity at the receptors further away than Bawdwin lower village; the next closest being Loi Mi village and associated farms more than 1.5 km away, and Tiger Camp village and Tiger Camp farms more than 2 km away, all separated from the pit area by steep terrain. Mining noise may be audible at these receptors during the day and night and sound levels will vary depending on where in the pit the works are being conducted and on prevailing wind conditions. However, noise modelling would be required to determine the noise levels experienced at receptors, the frequency of occurrence and how the noise compares to ambient standards.

Overall, the residual impact of disturbed amenity at Loi Mi village and associated farms that are resettled due to mining noise during the operations phase is assessed to be of **very low significance**, based on the **very low magnitude** of impact and the **medium sensitivity** of the receptor (Table 6.136). For receptors that are not resettled, the residual impact is assessed to be of **low significance**, based on the **low magnitude** of impact and the **medium sensitivity** of the receptor (Table 6.136).

Table 6.136 Residual impact significance summary – operations phase – increased noise levels due to mining activity – affecting Loi Mi village and associated farms

Value	**Sensitivity of value**			
Loi Mi village and associated farms - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High It is likely that this area currently experiences relatively low levels of ambient noise given it being remote from existing industrial and traffic noise sources. The receptor is likely to have high reliance on low background noise levels to maintain amenity.	**Medium** These receptors are moderately removed from the project area (1 to 2 km), with mountainous terrain between noise sources and receptor. Increased noise would result in some reduction of amenity but impacts to human health unlikely.	**Medium** Receptor has some limited capacity to adapt to increased noise levels given its remote setting and likelihood of amenity value being based on low levels of background noise.	**Medium**
Impact	**Magnitude of impact**			
Increased noise levels due to mining activity	**IF RESETTLED (those receptors within the Bawdwin concession area)**			
	Spatial extent	***Severity***	***Duration***	***Magnitude***
	Low Impact is likely to affect only a small portion of the receptor (those farms and residents within the Bawdwin concession area) with the remainder being either unaffected or affected to a materially lower extent	**Very low** Noise levels are likely to be below ambient standards and attenuated further by the mountainous terrain between the noise sources and receptor.	**Medium** Increased noise and vibration will be frequent over a one-year period prior to resettlement of the receptor.	**Very low**
	Residual impact significance			**Very low**
	IF NOT RESETTLED			
	Spatial extent	***Severity***	***Duration***	***Magnitude***
	Low Impact is likely to affect only a small portion of the receptor (those farms and residents within the Bawdwin concession area) with the remainder being either unaffected or affected to a materially lower extent	**Very low** Noise levels are likely to be below ambient standards and attenuated further by the mountainous terrain between the noise sources and receptor.	**High** Increased noise and vibration will be frequent over the lifetime of the mine.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Medium No noise and vibration quantitative modelling has been done and this limits the accuracy of the assessment. While there is material uncertainty in the quantitative predictions of noise and vibration reaching this receptor, the overall impact rating would have low likelihood of changing given the large distance from noise source to receptor and expected very low noise and vibration levels reaching the receptor.			

Overall, the residual impact of disturbed amenity at Tiger Camp village due to mining noise during the operations phase is assessed to be of **moderate significance**, based on the **medium magnitude** of impact and the **medium sensitivity** of the receptor (Table 6.137). The residual impact to Tiger Camp farms due to mining noise is assessed to be of **low significance**, based on the **low magnitude** of impact and the **medium sensitivity** of the receptor (Table 6.138).

Table 6.137 Residual impact significance summary – operations phase – increased noise levels due to mining activity – affecting Tiger Camp village

Value	**Sensitivity of value**			
Tiger Camp village - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium An elevated level of ambient noise is reasonably expected to occur due to the extensive mining operations and industrial activity that have previously occurred at Tiger Camp. However, the last decade has seen relatively lower noise levels. Although existing noise levels exceed Myanmar standards at this receptor, there is still a level of importance placed on amenity during the day and night.	**High** Tiger Camp is vulnerable to increased noise emissions due to its location in proximity to the project area and noise-generating project activities. There is little in the way of terrain barriers (i.e., hills and mountains) between the receptor and many project noise sources.	**High** It is expected that this receptor would have high resilience to mining, traffic and construction related noise given its existence is based on servicing such industrial purposes.	**Medium**
Impact	**Magnitude of impact**			
Increased noise levels due to mining activity	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Impact is likely to affect a moderate portion of the receptor, given they are all roughly the same distance from the impact source; although there will probably be some variability due to shielding from the terrain.	**Low** Noise levels are likely to be below ambient standards. Additionally, the mountainous terrain between the pit and these receptors will further attenuate noise travelling across the landscape. It is considered that noise will not materially impact the amenity at this receptor, particularly when these communities are notified of scheduled blasting, which is the noise source with the highest likelihood of being audible.	**Medium** Increased noise and vibration will be frequent over the operations period prior to resettlement of the receptor after 19 to 20 months of operations.	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	Medium No noise and vibration quantitative modelling has been done and this limits the accuracy of the assessment. While there is material uncertainty in the quantitative predictions of noise and vibration reaching this receptor, the overall impact rating would have low likelihood of changing given the large distance from noise source to receptor and expected very low noise and vibration levels reaching the receptor.			

Table 6.138 Residual impact significance summary – operations phase – increased noise levels due to mining activity – affecting Tiger Camp farms

Value	**Sensitivity of value**			
Tiger Camp farms - ambient noise and vibration levels that support human health and wellbeing, sleep	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium An elevated level of ambient noise is reasonably expected to occur due to the extensive mining operations	**Medium** Tiger Camp farms is vulnerable to increased noise emissions due to its location in proximity to	**Medium** It is expected that this receptor would have some resilience to mining, traffic and	**Medium**

Value	Sensitivity of value			
and enjoyment of amenity	and industrial activity that have previously occurred at Tiger Camp. However, the last decade has seen relatively lower noise levels. Although existing noise levels exceed Myanmar standards at this receptor, there is still a level of importance placed on amenity during the day and night.	the project area and noise-generating project activities. There are some terrain barriers (i.e., hills and mountains) between the receptor and project noise sources.	construction related noise and has some capacity to adapt to increased noise levels.	
Impact	**Magnitude of impact**			
Increased noise levels due to mining activity	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Impact is likely to affect only a small portion of the receptor (i.e., probably only those farms closer to Tiger Camp village) with the remainder being either unaffected or affected to a materially lower extent due to them being an extra 500 m away from the noise source	**Low** Noise levels are likely to be below ambient standards. Additionally, the mountainous terrain between the pit and these receptors will further attenuate noise travelling across the landscape. It is considered that noise will not materially impact the amenity at this receptor, particularly when these communities are notified of scheduled blasting, which is the noise source with the highest likelihood of being audible. The closest receptors will be resettled prior to mining operations.	**Medium** Increased noise and vibration will be frequent over the operations period prior to resettlement of the receptor after 30 to 32 months of operations.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Medium No noise and vibration quantitative modelling has been undertaken and this limits the accuracy of the assessment. While there is material uncertainty in the quantitative predictions of noise and vibration reaching this receptor, the overall impact rating would have low likelihood of changing given the large distance from noise source to receptor and expected very low noise and vibration levels reaching the receptor.			

Process plant and power station

The process plant and power station will be located adjacent to one another, so the overall noise emission impacts from these sources are assessed together. With resettlement of Nam La farms prior to operations, the nearest receptor will be the military base. Loi Mi village and associated farms and Tiger Camp farms will be more than 3 km from the process plant and power station.

Based on advice from WMM, the maximum sound levels from the process plant and power station will be approximately 90 dBA at 1 m from the noise source. Using the inverse square law, the daytime noise standard of 55 dBA would be met at 60 m from the power and the night-time standard of 45 dBA would be met at 180 m. This estimate indicates that ambient noise standards would be met at the nearest receptor (Bawdwin military base) approximately 400 m away.

As the process plant and power station will be modern facilities equipped with noise attenuation equipment and housing, any noise reaching the nearest receptor is expected to be very low. These sites are elevated in the topography so the noise may travel considerable distance towards receptors during periods where wind favours propagation in those directions. Notwithstanding, any such instances where noise is audible at the closest receptors it is likely to be at low sound levels that will not affect amenity or sleep. Using the inverse square law noise levels are estimated to be 41 dB at the military base 400 m from the process plant and 21 dBA at the Loi Mi and Tiger Camp farms receptors approximately 3 km away; levels of which are below the day and night noise standards of 55 dBA and 45 dBA, respectively.

Overall, the residual impact of disturbed amenity at the Bawdwin military base due to operation of the process plant and power station is assessed to be of **moderate significance** based on the **medium magnitude** and **medium sensitivity** of the receptor (Table 6.139).

Table 6.139 Residual impact significance summary – all project phases – increased noise and vibration levels due to operation of the process plant and power station – affecting the Bawdwin military base

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Military base - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>Medium
An elevated level of ambient noise is reasonably expected to occur due to the extensive mining operations that have shaped Bawdwin. However, the last decade has seen relatively lower noise levels. There is still a level of importance placed on amenity during the day and night.</td><td>High
Military base is vulnerable to increased noise emissions due to its location in proximity to the project area and noise-generating project activities. There is little in the way of terrain barriers (i.e., hills and mountains) between the receptor and many project noise sources.</td><td>High
It is expected that this receptor would have high resilience to industrial noise given its existence is based on servicing such industrial purposes.</td><td>Medium</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact</th></tr>
<tr><td rowspan="6">Increased noise and vibration levels due to operation of process plant, power station, TSFB and TSBC embankments and haul road</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>High
While noise and vibration emissions have not been modelled, it is anticipated that noise and vibration would affect most of the receptor, given the receptor is a relatively small area.</td><td>Low
Noise levels are not expected to exceed the Myanmar daytime or night time ambient noise standards based on inverse square law calculations. However, depending on wind conditions, it is conceivable that the night time standard of 45 dB could be exceeded under certain conditions. Although the intensity and frequency of this would need to be confirmed by noise modelling.</td><td>High
While noise and vibration emissions have not been modelled, it is anticipated that noise will be relatively constant (although variable in its intensity) over the operations period of 13 years.</td><td>Medium</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Moderate</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">High
No noise and vibration quantitative modelling has been done and this limits the accuracy of the assessment. No baseline noise data exists for this receptor. The assessment is based on the use of literature values for typical noise sources and these values adopted may differ from actual project equipment and vehicle noise levels.</td></tr>
</table>

Overall, the residual impact of disturbed amenity due to process plant and power station operation (all project phases) for Loi Mi village and associated farms that are resettled is assessed to be of **very low significance**, based on the very low magnitude of impact and the medium sensitivity of the receptor. For receptors that are not resettled, the residual impact is assessed to be **low significance**, based on the **low magnitude** of impact and the **medium sensitivity** of the receptor (Table 6.140).

Table 6.140 Residual impact significance summary – all project phases – increased noise levels due to processing plant and power station operations, affecting Loi Mi village and associated farms

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td></td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
</table>

<table>
<tr><td>Value</td><td colspan="4">Sensitivity of value</td></tr>
<tr><td>Loi Mi village and associated farms - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity</td><td>High
The area is likely to experience relatively low levels of ambient noise given it being remote from existing industrial and traffic noise sources. The receptor is likely to have high reliance on low background noise levels to maintain amenity.</td><td>Medium
Receptor is moderately removed from the project area (1 to 2 km), with mountainous terrain between noise sources and receptor. Increased noise would result in some reduction of amenity but impacts to human health unlikely.</td><td>Medium
Receptor has limited capacity to adapt to increased noise levels given its remote setting likelihood of amenity value being based on low levels of background noise.</td><td>Medium</td></tr>
<tr><td>Impact</td><td colspan="4">Magnitude of impact</td></tr>
<tr><td rowspan="9">Increase noise levels due to processing plant and power station operations, affecting Loi Mi village and associated farms</td><td colspan="4">IF RESETTLED (those receptors within the Bawdwin concession area)</td></tr>
<tr><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Low
Impact is likely to affect only a small portion of the receptor (those farms and residents within the Bawdwin concession area) with the remainder more than 500 m further away being either unaffected or affected to a materially lower extent.</td><td>Very low
Ambient noise standards are estimated to be met at this receptor and given the distance and steep terrain between the receptor and noise source, the noise experienced is expected to be very low.</td><td>Medium
Increased noise and vibration will be frequent over a one-year period prior to resettlement of the receptor.</td><td>Very low</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Very low</td></tr>
<tr><td colspan="4">IF NOT RESETTLED</td></tr>
<tr><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Low
Impact is likely to affect only a small portion of the receptor (those farms and residents within the Bawdwin concession area) with the remainder more than 500 m further away being either unaffected or affected to a materially lower extent</td><td>Very low
Ambient noise standards are estimated to be met at this receptor and given the distance and steep terrain between the receptor and noise source, the noise experienced is expected to be very low.</td><td>High
Increased noise and vibration will be frequent over the lifetime of the mine prior to resettlement.</td><td>Low</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Low</td></tr>
<tr><td colspan="4">Assessment of uncertainty

Medium
No noise quantitative modelling has been done and this limits the accuracy of the assessment. While there is material uncertainty in the quantitative predictions of noise this receptor, the overall impact rating would have low likelihood of changing given the large distance from noise source to receptor and expected very low noise and vibration levels reaching the receptor.</td></tr>
</table>

Overall, the residual impact of disturbed amenity at Tiger Camp farms due to operation of the process plant and power station is assessed to be of **low significance**, based on the **low magnitude** of impact and the **medium sensitivity** of the receptor (Table 6.141).

Table 6.141 Residual Impact significance summary - increased noise levels due to operation of the processing plant and power station – affecting Tiger Camp farms

Value	**Sensitivity of value**			
	Importance	***Vulnerability***	***Resilience***	***Sensitivity***

Value	**Sensitivity of value**			
Tiger Camp farms - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity	**Medium** An elevated level of ambient noise is reasonably expected to occur due to the extensive mining operations and industrial activity that have previously occurred at Tiger Camp. However, the last decade has seen relatively lower noise levels. Although existing noise levels exceed Myanmar standards at this receptor, there is still a level of importance placed on amenity during the day and night.	**Medium** Tiger Camp farms is vulnerable to increased noise emissions due to its location in proximity to the project area and noise-generating project activities. There are some terrain barriers (i.e., hills and mountains) between the receptor and project noise sources.	**Medium** It is expected that this receptor would have some resilience to mining, traffic and construction related noise and has some capacity to adapt to increased noise levels.	**Medium**
Impact	**Magnitude of impact**			
Increase noise levels due to processing plant and power station operations, affecting Tiger Camp farms	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Impact is likely to affect only a small portion of the receptor (those farms and residents in the northwestern portion of this receptor group approximately 3 km from the noise sources) with the remainder more than an additional 1 km further away probably being unaffected.	**Very low** Ambient noise standards are estimated to be met at this receptor and given the distance and steep terrain between the receptor and noise source, the noise experienced is expected to be very low.	**Medium** Increased noise will be frequent during operations prior to resettlement of the receptor after 30-32 months of operations	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Medium No noise and vibration quantitative modelling has been done and this limits the accuracy of the assessment. While there is material uncertainty in the quantitative predictions of noise and vibration reaching this receptor, the overall impact rating would have low likelihood of changing given the large distance from noise source to receptor and expected very low noise and vibration levels reaching the receptor.			

Traffic

Export of concentrate will require a total of 9,885 concentrate container movements per year by road, equating to an average of 27 trucked containers per day in each direction. This equates to a total average concentrate traffic movement of 54 movements per day. Additional traffic movements will occur to import consumables and fuel to Bawdwin. Throughout operations the total average daily truck movements will range from 20 to 92 across operations years. Trucks will range in size from 20 to 60 t capacity and will emit noise from engines, brakes and horns. Vehicles will use the export corridor route described earlier in this section. In some years, the increase in truck traffic volumes will represent an increase in between 150 to 190% of trucks on public roads.

While some of the Bawdwin to Namtu regional communities are likely to be accustomed to traffic comprising trucks and heavy vehicles due to industrial activity, the increases in truck traffic on public roads are significant and will be noticeable. Travel along the export route will be restricted to daylight hours due to the road safety risks associated with winding and narrow roads between Lashio and Namtu and between Namtu and Bawdwin. The noise from the trucks will occur during the day and may reduce amenity at villages as they pass by.

As outlined for traffic during construction, using literature values for noise emissions from a 29-t truck and estimating noise propagation using the inverse square law, the Myanmar day ambient noise criteria of 55 dBA would be met at a distance of 600 m from the truck noise source.

The key receptors impacted will be residents of Namtu, and other towns and villages along the public roads as shown in Figure 6.22. Overall, the residual impact of traffic noise on amenity at Namtu and the other villages along the export corridor due to project truck movements corridor is assessed to be of **moderate significance**, based on the **medium magnitude** of impact and the **medium sensitivity** of the receptors (Table 6.142 and Table 6.143).

Traffic along project access roads within the Bawdwin concession area (e.g., those between the ROM pad, process plant, power station and mine waste facilities) is not predicted to result in material noise impacts to receptors and are not assessed.

Table 6.142 Residual impact significance summary – operations phase – increased noise levels due to vehicle traffic during operations – affecting Namtu

Value	**Sensitivity of value**			
Namtu - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium Due to the number of manufacturing and industrial operations in Namtu elevated noise levels are expected to occur from time to time. However, residential areas are likely to have some reliance on low background noise levels for amenity.	**Low** Namtu is located more than 2 km from most project-related noise emission sources with mountainous terrain between most noise sources and Namtu.	**Medium** It is expected that this receptor would have some resilience to mining, traffic and construction related noise and has some capacity to adapt to increased noise levels.	**Medium**
Impact	**Magnitude of impact**			
Increased noise levels due to vehicle traffic during operations, affecting Namtu	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Impact will affect a small proportion of Namtu residences (i.e., those adjacent to and within about 600 m of the export route)	**Medium** Impact severity will be reduced with vehicle speed restrictions in place, the use of modern and well-maintained vehicles, driver training around exhaust braking and community consultation regarding project traffic impacts. While ambient noise standards are predicted to be intermittently exceeded at all villages within about 600 m of the export route through Namtu, in the context of existing traffic noise, additional noise impacts due to project traffic are assessed to be of medium severity.	**High** The impact will occur over operations (13 years)	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	Medium No noise and vibration quantitative modelling has been done and this limits the accuracy of the assessment. This uncertainty would be greater for receptors further away from the noise source (where climatic conditions and terrain factors are likely to play a greater role in noise propagation) compared to those which are in proximity to the noise source. The assessment is based on the use of literature values for typical noise sources and these values adopted may differ from actual project equipment and vehicle noise levels.			

Table 6.143 Residual impact significance summary – operations phase – increased noise levels due to vehicle traffic during operations – affecting villages along the export route

Value	**Sensitivity of value**			
Villages along the export route - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium As these receptors are based along a network of existing public roads, a level of ongoing traffic noise would be expected by the receptors with limited reliance on low background noise for amenity.	**High** Increased noise, particularly during the night, could result in noticeable reduction in amenity and potential effects to wellbeing.	**Medium** It is expected that this receptor would have some resilience to traffic related noise and has some capacity to adapt to increased noise levels.	**Medium**
Impact	**Magnitude of impact**			
Increase noise levels due to vehicle traffic during operations, affecting villages along the export route	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very low Impact will only affect a very small proportion of residences along the route (i.e., only those within about 2 km)	**Medium** Impact severity will be reduced with vehicle speed restrictions in place, the use of modern and well-maintained vehicles, driver training around exhaust braking and community consultation regarding project traffic impacts. Ambient noise standards are predicted to be intermittently exceeded at all villages within about 600 m of the export corridor during the day and night.	**High** The impact will occur over operations (13 years)	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	Medium No noise and vibration quantitative modelling has been done and this limits the accuracy of the assessment. This uncertainty would be greater for receptors further away from the noise source (where climatic conditions and terrain factors are likely to play a greater role in noise propagation) compared to those which are in proximity to the noise source. The assessment is based on the use of literature values for typical noise sources and these values adopted may differ from actual project equipment and vehicle noise levels.			

Accommodation camp and workshops

As assessed for construction, the residual impact from accommodation camp and workshops noise is assessed to be negligible with the closest receptors being more than 2 km away. This residual impact is negligible and is not assessed further.

Closure Phase

As Bawdwin lower village and farms, Tiger Camp village and farms, Nam La farms and select Loi Mi farms are being resettled during the operations phase, these areas will not be impacted by noise and vibration associated with closure activities. The remaining receptors, residents of Nam Pangyun valley, Loi Mi village, Namtu, villages in tracts adjoining the Bawdwin concession area may be impacted during the closure phase. Noise and vibration impacts to the remaining receptors during closure are anticipated to be similar to and no worse than those for construction. Therefore, impacts to the remaining receptors (i.e., military base, residents along the Namtu-Manton Road, residences of the Nam Pangyun valley and Namtu) assessed for construction are also applicable to closure.

Summary of residual impacts

Table 6.144 provides a summary of the residual noise and vibration impacts and their significance

Table 6.144 Summary of assessment of residual noise and vibration impacts

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Increased noise and vibration levels due to construction of process plant, power station, TSF-B and TSB-C embankments and haul road	Bawdwin military base - ambient noise and vibration levels that supports human health and wellbeing, sleep and enjoyment of amenity • Medium sensitivity	Construction	High magnitude • High spatial extent • High severity • Medium duration	• Traffic and transport measures • Scheduling and timing measures for noise generating activities	High	Noise levels at the Bawdwin military base are expected to exceed Myanmar standards due to the high existing noise levels and proximity of the receptor to construction of infrastructure, especially the process plant and TSF embankments. Noise and vibration are anticipated to affect most of the receptor throughout the construction period	High • Absence of noise and vibration modelling • Use of literature values for typical noise sources which may differ from actual noise sources
Increased noise and vibration levels due to construction of roads and facilities and construction-related traffic	Bawdwin upper village – ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity • Medium sensitivity	Construction	Medium magnitude • Medium spatial extent • Medium severity • Low duration	• Traffic and transport measures • Scheduling and timing measures for noise generating activities	Moderate	Residents in the northern part of the village are located close to the haul road and may be affected by increased noise and vibration during construction of the haul road. Overall, noise and vibration emissions prior to resettlement will be moderate and cumulative from a range of construction related sources.	High • Absence of noise and vibration modelling • Use of literature values for typical noise sources which may differ from actual noise sources
	Bawdwin lower village - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity • Medium sensitivity	Construction	Low magnitude • Low spatial extent • Low severity • Medium duration	• Traffic and transport measures • Scheduling and timing measures for noise generating activities	Low	Residents in the northern part of the village are located close to the haul road and may experience slightly increased noise and vibration during its construction. Overall, noise and vibration emissions during construction will be low severity, affecting a small proportion of residences.	High • Absence of noise and vibration modelling • Use of literature values for typical noise sources which may differ from actual noise sources

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Increased noise and vibration levels due to construction traffic through Namtu	Namtu town - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity • Medium sensitivity	Construction	Medium magnitude • Medium spatial extent • Medium severity • Medium duration	• Traffic and transport measures	Moderate	Existing noise levels exceed Myanmar standards so any increase in levels is expected to have an impact. Impacts are anticipated to affect settlements in proximity to the main transport route, however, will not occur at night and will be variable throughout construction.	High • Absence of noise and vibration modelling and baseline data • Use of literature values for typical noise sources which may differ from actual noise sources
Increased noise and vibration levels due to construction traffic along Namtu-Manton Road	Residents along Namtu - Manton Road - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity • Medium sensitivity	Construction	Medium magnitude • High spatial extent • Medium severity • Medium duration	• Traffic and transport measures	Moderate	Most of the residents in proximity to the road will be impacted by construction related traffic during the day until the plant road and Namtu-Tiger Camp access road are constructed (about 1 year). Noise and levels are expected to be moderate given the distance of some houses (within 360 m) of the road.	High • Absence of noise and vibration modelling and baseline data • Use of literature values for typical noise sources which may differ from actual noise sources
Increased noise and vibration levels due to construction of roads and facilities and construction-related traffic	Tiger Camp village - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity • Medium sensitivity	Construction	Medium magnitude • Low spatial extent • Medium severity • Medium duration	• Traffic and transport measures • Scheduling and timing measures for noise generating activities	Moderate	Until resettled, Tiger Camp village may be impacted by noise and vibration from the construction of roads and facilities. Noise from construction is likely to have minimal impact, however construction-related traffic may contribute to a moderate portion of the receptor located near roads impacted during the day.	Medium • Absence of noise and vibration modelling • Use of literature values for typical noise sources which may differ from actual noise sources

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Increased noise and vibration levels due to construction of roads and facilities and construction-related traffic	Tiger Camp farms - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity Medium sensitivity	Construction	Medium magnitude • Medium spatial extent • Medium severity • Medium duration	• Traffic and transport measures • Scheduling and timing measures for noise generating activities	Moderate	Some residences will be resettled prior to construction in the area, however the remaining residences may be impacted by noise and vibration from construction of the Namtu-Tiger Camp access road and plant road, and sediment dams. Further from construction the impact is somewhat attenuated by topography, however noise may also be amplified within the valley.	Medium • Absence of noise and vibration modelling • Use of literature values for typical noise sources which may differ from actual noise sources
	Nam La farms - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity • High sensitivity	Construction	Medium magnitude • Medium spatial extent • Medium severity • Low duration	• Traffic and transport measures • Scheduling and timing measures for noise generating activities	High	Noise and ground vibration from construction of the power station and power plant may impact individual receptors within 500 m until they are resettled.	Medium • Absence of noise and vibration modelling • Use of literature values for typical noise sources which may differ from actual noise sources
	Loi Mi village and associated farms - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity • Medium sensitivity	Construction	Low magnitude (if resettled) • Low spatial extent • Very low severity • Medium duration	• Traffic and transport measures • Scheduling and timing measures for noise generating activities	Low	Only a small portion of receptors are expected to be impacted during construction prior to resettlement. Noise levels are not predicted to be high outside the Bawdwin concession area due to the distance from construction activities and topographic attenuation.	Medium • Absence of noise and vibration modelling
			Low magnitude (if not resettled) • Low spatial extent • Low severity • Medium duration	• Traffic and transport measures • Scheduling and timing measures for noise generating activities	Low	Only a small portion of receptors are expected to be impacted over the construction period. Noise levels are not predicted to be high due to the distance from construction activities and topographic attenuation, however, will have a greater impact on receptors within the Bawdwin concession area.	

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Increased noise and vibration levels due to road construction and construction-related traffic	Residents of the Nam Pangyun valley - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity • Medium sensitivity	Construction	Medium magnitude • Medium spatial extent • Medium severity • Low duration	• Traffic and transport measures • Scheduling and timing measures for noise generating activities	Moderate	Individual receptors adjacent to the road may be impacted during the day while construction is occurring nearby in the first year of construction.	Medium • Absence of noise and vibration modelling and baseline data • Use of literature values for typical noise sources which may differ from actual noise sources
Increased noise and vibration levels due to mining activity	Bawdwin lower village - ambient noise and vibration levels that support supports human health and wellbeing, sleep and enjoyment of amenity • Medium sensitivity	Operations	High magnitude • Very high spatial extent • High severity • High duration	• Traffic and transport measures • Scheduling and timing measures for noise generating activities • Blasting management measures	High	The entire receptor is expected to be impacted prior to resettlement (30 to 32 months after commencement of construction) due to mining noises such as blasting, drilling and excavation. While the noise may be attenuated by pit walls, the proximity and existing noise levels contribute to the significance of this impact.	High • Absence of noise and vibration modelling • Modelling is required to understand impact further
	Loi Mi village and associated farms - ambient noise and vibration levels that support supports human health and wellbeing, sleep and enjoyment of amenity • Medium sensitivity	Operations	Very low magnitude (if resettled) • Low spatial extent • Very low severity • Medium duration	• Traffic and transport measures • Scheduling and timing measures for noise generating activities • Blasting management measures	Very low	Only a small portion of receptors are expected to be impacted by mining noises, particularly blasting, prior to resettlement. Noise levels are not predicted to be high outside the Bawdwin concession area due to the distance from construction activities and topographic attenuation.	Medium Absence of noise and vibration modelling

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Increased noise and vibration levels due to mining activity	Loi Mi village and associated farms - ambient noise and vibration levels that support supports human health and wellbeing, sleep and enjoyment of amenity • Medium sensitivity	Operations	Low magnitude (if not resettled) • Low spatial extent • Very low severity • High duration	• Traffic and transport measures • Scheduling and timing measures for noise generating activities • Blasting management measures	Low	Only a small portion of receptors are expected to be impacted by mining noises, particularly blasting, over the life of the mine. Noise levels are not predicted to be high due to the distance from construction activities and topographic attenuation, however, will have a greater impact on receptors within the Bawdwin concession area.	Medium • Absence of noise and vibration modelling and baseline data • Use of literature values for typical noise sources which may differ from actual noise sources
	Tiger Camp village - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity • Medium sensitivity	Operations	Low magnitude • Medium spatial extent • Low severity • Medium duration		Low	Tiger Camp village may be affected by increased noise from mining activities prior to resettlement. The impact will be attenuated by the distance and terrain between the village and the open pit.	
	Tiger Camp farms - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity • Medium sensitivity	Operations	Low magnitude • Low spatial extent • Low severity • Medium duration		Low	Tiger Camp farms may be affected by increased noise from mining activities prior to resettlement. The impact will be attenuated by the distance and terrain between the village and the open pit. Some receptors will be resettled prior to commencement of mining operations.	
Increased noise and vibration levels due to operation of process plant, power station, TSFB and TSFC embankments and haul road	Military base - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity • Medium sensitivity	Operations	Medium magnitude • High spatial extent • Low severity • High duration	• Traffic and transport measures • Scheduling and timing measures for noise generating activities	Moderate	The military base is located near the process plant, power station and TSFs, and may experience increased noise and vibration over the life of the mine. Noise levels are not expected to exceed Myanmar standards, however, may be exceed at night during certain conditions.	High • Absence of noise and vibration modelling • Use of literature values for typical noise sources which may differ from actual noise sources

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Increase noise levels due to processing plant and power station operations	Loi Mi village and associated farms - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity • Medium sensitivity	Operations	Very low magnitude (if resettled) • Low spatial extent • Very low severity • Medium duration	• Traffic and transport measures • Scheduling and timing measures for noise generating activities	Very low	Only a small portion of receptors are expected to be impacted by the operation of the process plant and power station, prior to resettlement. Noise levels are not predicted to be high outside the Bawdwin concession area due to the distance from these facilities and topographic attenuation.	Medium • Absence of noise modelling
			Low magnitude (if not resettled) • Low spatial extent • Very low severity • High duration	• Traffic and transport measures • Scheduling and timing measures for noise generating activities	Low	Only a small portion of receptors are expected to be impacted by operation of the process plant and power station, over the life of the mine. Noise levels are not predicted to be high due to the distance from these facilities and topographic attenuation, however, will have a greater impact on receptors within the Bawdwin concession area.	Medium • Absence of noise modelling
	Tiger Camp farms - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity • Medium sensitivity	Operations	Low magnitude • Low spatial extent • Very low severity • Medium duration	• Traffic and transport measures • Scheduling and timing measures for noise generating activities	Low	Only a small portion of the receptor group are expected to be impacted by increased noise from operation of the process plant and power station, prior to resettlement, however noise standards are estimated to be met due to the distance from these facilities.	Medium • Absence of noise modelling
Increased noise levels due to vehicle traffic during operations	Namtu - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity • Medium sensitivity	Operations	Medium magnitude • Low spatial extent • Medium severity • High duration	• Traffic and transport measures	Moderate	Residences within 600 m of the main traffic route may be impacted throughout operations due to project-related vehicle traffic. The severity is limited to a degree by the implementation of management measures, however ambient noise standards are predicted to be intermittently exceeded.	Medium • Absence of noise and vibration modelling • Use of literature values for typical noise sources which may differ from actual noise sources

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
	Villages along the export route - ambient noise and vibration levels that support human health and wellbeing, sleep and enjoyment of amenity • Medium sensitivity	Operations	Medium magnitude • Very low spatial extent • Medium severity • High duration	• Traffic and transport measures	Moderate	A small proportion of residences close to the export route may be impacted throughout operations due to project-related vehicle traffic. The severity is limited to a degree by the implementation of management measures, however ambient noise standards are predicted to be intermittently exceeded.	Medium • Absence of noise and vibration modelling • Use of literature values for typical noise sources which may differ from actual noise sources

6.7.5 Monitoring

No specific noise or vibration monitoring is proposed, although under the environmental and social management plan, the project will record and act upon community grievances in relation to noise and vibration issues.

6.7.6 Uncertainties and further work

The key uncertainties and further work required to address these uncertainties is outlined in Table 6.145.

Table 6.145 Uncertainties and further work in respect of noise and vibration impacts

Uncertainty	Further work required	Purpose	Assumptions
Lack of noise emission predictions	Modelling, incorporate climatic influences and ground surface and topography.	To determine noise level increases at receptors for impacts assessed to be of moderate and high significance and to predict noise and vibration emissions to estimate levels, direction and extent at the point of exposure for receptor groups of concern. To assess noise levels quantitatively against the Myanmar ambient noise standards and determine whether project noise will meet ambient noise standards outlined in the Myanmar draft National Environmental (Emission) Quality Guidelines (2014). To quantify the sound levels at receptors and whether ambient standards will be exceeded during the day and night.	Noise emission levels were estimated based on literature values and the inverse square law.
Vibration emissions have not been modelled. Assessment of vibration impacts is accompanied by a relatively high degree of uncertainty. Assessment of vibration impacts to Bawdwin lower village due to mining is not possible until modelling is conducted.	Modelling will be required to understand the impact of ground vibration and air blast compared to Myanmar vibration standards as well as potential ground vibration impacts to land stability and structural integrity of buildings.	To determine whether project vibration emissions will meet the standards outlined in the Myanmar draft National Environmental (Emission) Quality Guidelines (2014)	Impacts have been assumed based on distance from project activities
Baseline data has not been collected in the vicinity of all receptors. Also the baseline noise data was collected over a maximum of 24-hour period in September 2019 at each noise monitoring station. There is uncertainty on how the existing noise levels change over time and the baseline noise ranges at each receptor assessed.	Establish pre-construction baseline for noise at representative sites for sensitive receptors that are likely to have operational exposure.	To allow better understanding of existing noise levels, which will allow better understanding of predicted changes to ambient noise at receptors.	Existing noise levels have been assumed.

6.8 Biological impact assessment

6.8.1 Approach to impact assessment

This section assesses the project impacts to the biological values identified in Section 5.7. Section 5.7 described the levels of importance, vulnerability and resilience associated with each of the biological values in the study area.

The impact assessment approach adopted in this section is a 'significance assessment'. The significance assessment method is described in Section 6.1. A significance assessment of biological impacts involves:

- Identifying the nature of the impact to a biological value in the project area.
- Determining the magnitude of the impact through an assessment of the spatial extent, severity and duration of the impact.
- Assessing the significance of the residual impact (i.e., with assumed successful implementation of avoidance and management measures). The significance (very low, low, moderate, high or major) of the impact to a biological value is determined by considering the importance, vulnerability and resilience of the value (as assessed in Section 5.7.6) and the predicted magnitude of the impact to the value. Impact magnitude (very low, low, medium, high or very high) is determined based on the spatial extent, severity and duration of the impact.

Context for impact assessment

Mining at Bawdwin commenced in the 1400s. Prior to that, the area would have consisted of hill and temperate evergreen forests, primarily comprised of sub-tropical mixed hill and savannah. However, these forests have been significantly reduced by deforestation (primarily for firewood and charcoal to enable ore smelting), the phytotoxic effects of smelting fumes, and to a lesser extent cattle grazing and small-scale agriculture. As a result of these historical disturbances, it is likely that topsoils in the area have been largely eroded from hills and steep-sided slopes, leaving poor quality soils with low organic material. More intact vegetation is present on valley floors and along watercourses, particularly along the Nam La stream.

The dominant terrestrial vegetation in the project area now consists of grasslands dominated by grasses belonging to *Andropogon*, *Pennisetum*, *Phragmites*, *Sporobolus*, and *Coix* genera. It is considered that this vegetation represents a modified or degraded community. Patches of bamboo are also scattered around the Bawdwin concession area and are likely to represent re-colonised (or planted) communities as opposed to the intact forests in the region. Biological surveys for the project recorded 177 plant species including 49 herbs, 37 trees, 35 shrubs, 25 small trees, 17 climbers, 8 grasses, 5 bamboos and 1 epiphyte during the study. These included two species of conservation significance listed on the IUCN Red List (*Cycas pectinata* (Vulnerable) and Burmese blackwood (*Dalbergia cultrate*) (Near Threatened)). The highest diversity of plant species was found in more intact sub-tropical mixed hill forest in the northwest of the Bawdwin concession area, followed by areas near Tiger Camp. Riparian vegetation is found around the Nam Pangyun Reservoir, and along riverbanks of the upper Nam Pangyun and most of the Nam La.

A depauperate fauna community was recorded within the study area, with most records restricted to areas of mixed hill forest and to a lesser extent bamboo forest. Interviews with hunters reported that some hunting targeting deer and wild pigs still continues (although is decreasing), particularly during the wet season. However, hunters reported that wild animals are becoming increasingly rare due to deforestation and agricultural practices. Interviews of residents of Bawdwin reported that larger mammals such as tiger, leopard and Asian black bear once inhabited the vicinity of Bawdwin, but no longer occur locally.

In terms of aquatic ecosystems, the Nam Pangyun catchment in which the project is mostly situated has been heavily influenced by previous anthropogenic activities. The stream, particularly downstream of the Bawdwin open pit, is characterised by very poor water quality due to interaction with mineralised areas and discharge from the Tiger Tunnel, direct sewage discharge from Bawdwin and Tiger Camp villages, as well as direct disturbance of aquatic habitats as a result of sedimentation, aggradation, and in-stream physical modification. The aquatic habitat of the Nam Pangyun has also been impacted from historical mining activities over a number of centuries as well as ongoing alluvial mining of the riverbed. As a result, aquatic ecosystems of the Nam Pangyun in the mid and lower reaches represent a highly degraded ecosystem.

The Nam La catchment, in which some project elements are located, experiences lower levels of anthropogenic disturbance although it does pass a number of villages, small-scale agricultural areas and plantations, and runs adjacent to the Namtu to Manton Road. The Nam La is therefore a higher quality aquatic habitat with a more intact aquatic ecosystem in comparison to the Nam Pangyun. The Nam Pangyun and Nam La both discharge into the Myitnge River. The Myitnge River is relatively undisturbed compared to the streams in the Project area, however, is subject to degradation and ongoing impacts from discharge of the poor-quality Nam Pangyun.

6.8.2 Sources of potential impact

Impacts on terrestrial ecosystems and species have the potential to occur as result of:

- Physical disturbance of terrestrial habitats caused by construction of infrastructure and earthworks, mining and mine waste placement (into both waste rock dumps and tailing storage facilities (TSFs), including:
  - vegetation clearance.
  - excavation and earthworks resulting in smothering of vegetation.
  - erosion and sedimentation.
- Introduction of invasive species, including pests and weeds.
- Discharges and emissions, including:
  - emissions to air, including dust and sulphur dioxide, and generation of noise and vibration.
  - lighting causing disturbance.
  - accidental spills and leaks of hazardous materials.
- Traffic movements causing direct mortality.

These potential sources of impact are described further below.

Impacts on aquatic ecosystems have the potential to occur as a result of:

- Physical disturbance of surface water habitats caused by modification of drainage channels during construction and operations, construction of water crossings, diversion of the Nam Pangyun during operations and construction of infrastructure, including:
  - In-stream erosion, sediment deposition and aggradation.
  - Direct physical loss.
- Changes to surface water flow:
  - Diversion of the Nam Pangyun through the open pit mine during operations.
  - Increased seepage of water from the Nam Pangyun to the underlying rock due to dewatering around the mine pit during operations.
  - Reduced stream flow due to water abstraction from the Nam Pangyun and Nam La for project use during construction and operations.
  - Changes to landform and surface drainage during construction, operations and after closure.

- Changes to water quality due to increased sediment loads and turbidity, increased metals (metalloids), chemicals and hydrocarbons and decreased organic pollutants due to cessation of human and domestic waste discharges. Potential causes of water quality degradation include seepage, runoff and discharges from mine waste storage facilities (waste rock dump and TSFs), construction areas, the open pit, operational areas, dewatering discharge, discharge of project effluents, total suspended solids (TSS) and turbidity increases from site erosion, and accidental spills and leaks.
- Reduced bed sediment quality in downstream rivers due to mobilisation of waste rock material and contaminated soils containing high metals concentrations.

Potential impacts to surface water features and the mechanisms of change that may impact aquatic ecosystems are described in detail in Section 6.4.

Physical disturbance

Physical disturbance is defined as the vegetation clearance, excavation and earth movements (e.g., stockpiling or cut and fill) required to construct infrastructure and operate the mine. Large scale land and vegetation clearance and removal of soil will take place during project construction and mining operations. Following the clearance of vegetation, earthworks will be required to create suitable surfaces for facilities and infrastructure. While most physical disturbance will occur during the construction phase of the project, it will also occur progressively for some infrastructure components, such as the TSFs, which will be constructed progressively over the mine life. This will largely occur in an extensively modified landscape from centuries of previous mining and processing activity.

The consequence of most physical disturbance will be the loss of habitat. Vegetation clearing and earthworks may also bury or smother flora and fauna or displace fauna.

The degree to which physical disturbance will impact biological values is dependent on the nature and scale of disturbance and also the existing sensitivity of the biological environment. Vegetation clearance for the development of project infrastructure will result in the loss of vegetation and some natural habitats, and this may directly impact individual plants and some less-mobile animals during clearance activities.

Edge effects and fragmentation

Linear clearings such as those for roads, pipelines and powerlines have the potential to act as barriers for fauna movement and migration. This has the potential to fragment fauna populations. Given the highly modified landscape of the project area, which now largely consists of low grasslands, fragmentation effects are not expected to be produced by the project.

In addition to direct physical loss, vegetation clearance during construction may also result in the degradation of remaining habitats. This will occur through an ecological process known as ‘edge effect’ (Saunders, et al. 1991). This is when intact habitat edges become exposed to modified conditions due to vegetation clearance. Edge effects create conditions that facilitate the invasion of exotic species, increase the susceptibility to fire and, in the case of forests, increased sunlight (causing drying of the forest understorey) and wind (causing drying and wind damage). Considering that the vast majority of vegetation in the project area is already highly modified, clearance of the remaining grassland areas is unlikely to produce any material edge effects. The flora and fauna occurring in these habitats consisting of generalist and resilient species, as opposed to fauna that typically vulnerable to edge effects such as frogs, interior birds and invertebrates adapted to dark humid habitats.

Erosion, sedimentation and side-casting

Disturbance and erosion of soils and subsequent loss or degradation of soil during earthworks or stockpiling of spoil may reduce the capacity of soils to support vegetation. Ground disturbance reduces soil permeability and breaks down soil aggregates. The erosion of soils or soil compaction caused by ground disturbance can also affect germination, subsequently affecting the structure and diversity of naturally regenerated forest. Erosion and deposition of eroded sediment can occur beyond the area of disturbance, with the potential to affect habitat and smother vegetation and tree stems, which can reduce tree root aeration leading to plant death.

During construction of infrastructure, particularly roads, most of the excess spoil will be side-cast, whereby excavated material will be tipped downslope of the area being excavated. Side-cast material is uncompacted and eventually stabilises at a natural angle of repose. In high rainfall areas, side-cast areas can be eroded over time. Side-casting is not preferred in locations where the side- cast material will affect the natural flow of drainage channels, creeks and rivers or in proximity to occupied villages. In steep terrain that is not suitable for long term stability of large volumes of side-cast material, excess spoil will be hauled a short distance to a suitable location where the material will be co-located with other side-cast material.

The terrain in the project area and surrounding region is mountainous, with many slopes in excess of 20%. Soils on steep slopes are particularly susceptible to erosion. Historical degradation and clearing of hill forests in the Bawdwin area exposed soils, with subsequent erosion leaving poor quality soils with low organic material. This probably contributed to the historical conversion of vegetation from primarily forests to the more tolerant grasses and bamboo vegetation types now dominant in the Bawdwin mine area.

Introduction of invasive species

There is potential for exotic species to be introduced and adversely impact the project biological values. This may occur when project vehicles and equipment arrive at site carrying the seeds or spores of invasive species. Invasive pests may out-compete or eat local flora and fauna and lead to degradation of habitat. Establishment of invasive species can cause permanent changes in the structure and function of ecosystems as a result of competition or directly mortality.

The Bawdwin biodiversity study found two exotic (non-native) flora species, *Ageratina adenophora* and *Mikania micrantha* were common throughout the study area. *Ageratina adenophora* is a species of flowering plant in the daisy family native to Mexico and Central America but has become invasive into farmland and bushland worldwide. *Mikania micrantha* is a species of vine that is a multi-stemmed perennial creeper and climber native to the Americas. It chokes and smothers areas it has colonized and is a serious weed in South-East Asia, Indonesia, the Pacific Islands and Australia. Another invasive species, *Lantana aculeata* was recorded in the baseline study, and is also considered a fencing species, supporting ecosystem services. No invasive pests (fauna) were identified in the biodiversity study.

The likelihood of introductions of invasive species is influenced by the effectiveness of quarantine and hygiene practices, the number of vehicles and machinery moving through the project area, and logistics routes from other parts of Myanmar and internationally.

Discharges and emissions

Emissions to air

Emissions to air that may impact biodiversity values directly and indirectly during the project include fugitive dust and sulphur dioxide. Dust may be generated during dry periods by earthmoving machinery during site clearing, construction and operational activities such as drilling and blasting, from crushing and, traffic, and wind erosion of open areas, stockpiles, TSFs and waste rock dumps.

Fugitive dust can smother vegetation and block leaf stomata, reducing photosynthetic efficiency and compromising the plant. This may indirectly impact fauna due to potential reduced fruit yields. Terrestrial fauna may also be directly impacted through reduced habitat conditions.

Dust may have indirect impacts on terrestrial biodiversity through the contamination of soils. Elevated heavy metal concentrations (lead, arsenic and nickel) in soils in the area may be due to air pollution from dust occurring in association with historic mining activities. Soil contamination can inhibit rehabilitation as growth reduction from changes in physiological and biochemical processes in plants grown in soils contaminated by heavy metals has been recorded (Chibuike and Obiora 2014). Contamination of soils is discussed further in Section 6.2.

Sulphur dioxide emissions from on-site power generation may directly impact terrestrial flora by inhibiting photosynthesis. Historically, acid rain due to sulphur dioxide emissions and other emissions from the Namtu smelter complex have contributed to deforestation in hilly areas downwind of the smelter. The project has committed to meeting Myanmar emission discharge criteria and therefore the likelihood of broad scale impacts due to emissions of sulphur dioxide are very low.

Lighting and noise

Temporary and permanent sources of light may affect the behaviour of animals, both for diurnal and nocturnal species. Lighting can interfere with nocturnal birds and birds that migrate at night, alter the reproductive behaviour of frogs, focus the foraging activities of insectivores such as micro-bats, increase the likelihood of predation for some species (e.g., insects attracted to lights) and affect foraging activities of prey species. The impacts of extended periods of lighting are not detrimental to all species and some, particularly insectivorous predators (e.g., micro-bats that feed on insects attracted to lights), may derive a benefit.

Project-related activities will generate noise from a number of sources. In addition to increased traffic levels, blasting will take place and will generate high levels of instantaneous sound and pressure waves. Excessive noise emissions have the potential to adversely affect some fauna species. The severity of the impact will vary depending on the proximity to the activities, individual species sensitivity (and their ability to habituate), and the efficacy of proposed avoidance and management measures.

Hazardous materials

A variety of gaseous, liquid and soil contaminants (e.g., hydrocarbons and process chemicals) will be used by the project and have the potential to be released accidentally, for example a spill. If not properly managed and stored, these may impact biodiversity through direct mortality, reductions in reproductive output and reduced survivability.

Traffic movement

The increased traffic on roads within the Bawdwin concession area and on local roads increase the risk of direct mortality of slow-moving fauna via vehicle strikes. Most vertebrate fauna are mobile and are able to move away from construction sites and avoid vehicles easily. Birds are generally only impacted at fast vehicle speeds and as such the risk of a vehicle strike is low for the project. Frogs and reptiles are generally more susceptible to vehicle strike than other fauna. However, most traffic will occur during the day while many amphibians and reptile species are more active at night. The degree by which biodiversity will be impacted by traffic will depend largely on the volume of vehicle movements as well as the location of roads and construction sites in relation to fauna habitat.

In-migration and land use changes

Indirect processes linked to social change may also have effects on biodiversity values. The construction and operations phases of the project are expected to increase economic activity in the local area. These factors can result in the in-migration of people into the area, as commonly experienced around mines in similar contexts. In-migration into the Bawdwin concession area is unlikely to occur, but it may occur in Namtu, along roads and along the lower Nam Pangyun valley, where artisanal miners already reside in temporary settlements. This has the potential to lead to increased impacts to forest clearing for building and shifting cultivation, and an increased frequency of patch-burning for shifting cultivation, firewood collection, small-scale logging and hunting. The expansion of shifting cultivation and the establishment of new settlements elsewhere have been shown to cause additional and longer-lasting or permanent biological impacts. Due to the proximity of the public Namtu to Manton road there is potential for informal settlements to be created adjacent to the road and near to the project infrastructure e.g., accommodation camp. Access roads constructed for the project (for example to the Nam La water harvesting facility and the TSF access road) may facilitate indirect forest clearance of more intact vegetation that occurs in this area.

The resettlement of the existing Bawdwin villages also has the potential to negatively affect biodiversity values. While the site(s) for the resettlement locations are currently uncertain it is difficult to predict the magnitude of any impacts. However, it is likely that there will be some disturbance of vegetation to create the resettlement village and forest clearing for agricultural purposes around the area may occur.

Summary of potential sources of impact

Table 6.146 presents a summary of potential direct and indirect sources of impact to biodiversity values during project construction, operation and closure. The nature of the impact mechanism is described, including the project phase in which it is concentrated, whether it is increasing, enduring or ameliorating, and in relation to road accidents and accidental spills and leaks, whether the risk is heightened.

Table 6.146 Summary of potential direct and indirect sources of impact during project construction, operation and decommissioning

Mechanism of change	Construction	Operation	Closure
Physical disturbance leading to vegetation clearance, edge and barrier effects.	X_I	X_A	X_A
Physical disturbance leading to sedimentation or altered hydrology and subsequent vegetation loss or degradation.	X_C	X_A	X_A
Physical disturbance leading burial of habitat, and fauna entrapment and displacement.	X_C	X_A	-
Introduction and/or spread of invasive weeds, pests or pathogens.	X	X	X_E
Accidental spills of hazardous materials or wastes leading to exposure of fauna.	X_M	X_C	-
Emissions of dust from disturbed areas leading to coating of vegetation.	X_C	X	X_A
Emissions of noise and light leading to disturbance to fauna.	X_C	X	X_A
Traffic movements leading to collisions of fauna with project vehicles and machinery.	X_H	X	X_L
Sediment-laden runoff and sedimentation leading to physical disturbance (in-stream erosion, sediment deposition and aggradation)	X_C	X	X_A
Construction of mine infrastructure and diversion of Nam Pangyun leading to physical disturbance (direct physical loss) of surface water habitats	X_C	X_C	X_A
Abstraction from Nam La and Nam Pangyun leading to reduced surface water flows	X_L	X_C	
Runoff and seepage from contaminated sites (including TSF and WRD) causing reduced surface water quality		X_M	X_A
Discharge of poor-quality water from mine dewatering causing reduced surface water quality		X_C	
Mobilisation of waste rock material and contaminated soil leading to reduced streambed sediment quality	X	X	X

X – occurring in this phase; X_C – occurring and concentrated in this phase; X_I – occurring and possibly increasing in this phase; X_H – occurring at a high level or higher risk of occurrence in this phase; X_M – occurring at a moderate level or moderate risk of occurrence in this phase; X_L – occurring at a low level or lower risk of occurrence in this phase; X_A – persists in this phase but ameliorates over time; X_E – endures during this phase.

6.8.3 Management measures

WMM is committed to minimising any potential impacts to the biological environmental from the project. This can be achieved firstly through design, by selecting project sites that have been previously disturbed and thus will have as little impact as possible. When utilising undisturbed sites is unavoidable, WMM will minimise disturbance through site-specific mitigation and management measures.

Physical disturbance

Vegetation clearance and earthworks are the principal cause of habitat loss as a direct result of project activities. Measures aim to reduce impacts of physical disturbance include:

- Minimise vegetation clearing by using previously disturbed or degraded areas as a first preference for locating infrastructure and mine activities.
- Minimise the width of clearing required for linear infrastructure as far as practicable.
- Design road alignment approaches to watercourses as close to right angles as practicable to limit disturbances to the banks of watercourses.
- Preserve riparian vegetation to the greatest extent practical and create a buffer of natural vegetation between watercourses and construction areas, where practicable.
- Mark the extent of vegetation to be cleared on technical drawings and mark in the field. Do not clear beyond design limits.
- Avoid compaction of topsoil and disturbance by restricting vehicle, plant and equipment movement to designated tracks, as far as practicable.

Erosion, side-cast and sedimentation

Project earthworks, side-casting, stockpiling and soil compaction could reduce the capacity of soils to support terrestrial ecosystems via smothering, loss of soils, or altering the existing hydrology. Measures aim to reduce the potential for, and extent of, soil erosion and will:

- Reduce the volume of material to be side-cast, as far as practicable.
- Avoid side-casting in locations that could impact the natural flow of drainage channels, creeks and rivers.
- Implement and maintain erosion and sediment controls, including site specific measures as necessary. Typical controls to be implemented include:
  - Locate and design infrastructure to limit runoff to watercourses.
  - Install structures to intercept sediment-laden surface runoff to reduce sediment delivery to watercourses.
  - Install diversion drains to intercept uncontaminated surface runoff and divert away from cleared areas, where practicable.
  - Stockpile spoil and/or topsoil materials away from watercourses (i.e., maintain a minimum of 10 m from watercourse banks), where practicable.
  - Stabilise areas that will be exposed for a substantial period of time using measures such as temporary grass or hydromulch.
  - Grade access roads adjacent to watercourses to drain away from watercourses.
  - Install specific soil stabilisation measures on side hill cuts to prevent slumping and/or erosion.
  - Minimise the extent, and time, that ground surfaces and stockpiles are exposed through staged works wherever possible.
  - Progressively rehabilitate disturbed areas.
  - Schedule major earthworks in dry season where feasible.
- Discharge water in a manner that prevents scouring and erosion.

Dust

To minimise the generation of dust measures that will be implemented include:

- Minimise the extent, and time, that ground surfaces and stockpiles are exposed through staged works wherever possible.
- Undertake progressive rehabilitation and revegetation of disturbed areas (including the TSFs and waste rock dump) to minimise the length of time that disturbed areas are exposed to wind and erosion.
- Maintain roads to a suitable and safe standard to minimise dust generation.
- Establish and enforce speed limits on roads carrying project vehicles to minimise dust and noise generation.
- Use water to suppress dust in areas that have high potential for dust generation including construction sites, the open pit, ore stockpiles, waste rock dumping and on the haul roads, but not in a manner that causes a safety hazard to haul road and village road users.

Surface water management and hydrology

Surface water management measures involve maintaining flows and connectivity of the watercourses, as well as minimising any reductions in water quality. Measures that will be implemented include:

- Design and construct linear infrastructure so as to maintain the original drainage patterns of the habitat as far as practicable.
- Establish a minimum passing flow threshold at the point of water extraction from the Nam La, in consultation with key stakeholders, that preserves potable water supply requirements for Namtu are met and maintains minimum environmental flows.
- Maintain adequate base water supply for Namtu from the Nam La. This may be achieved by establishing infrastructure to divert small spring flows of suitable quality to the Nam La flume during periods of low flow.
- Maintain minimum environmental flows in the Nam Pangyun downstream of the project area.
- Maintain hydraulic connectivity along linear infrastructure corridors for pipelines and roads (e.g., install culverts and drains where required).
- Reduce erosion and sedimentation on riverbanks by adoption of surface water diversion structures.
- Design and construct watercourse crossings so that they will not divert streamflow out of the stream channel and down the road alignment.
- Where practicable, divert upstream surface water flows from undisturbed catchment areas around the project and discharge into adjacent or downstream surface water drainage lines.
- Ensure TSF supernatant water (including captured seepage), seepage/run-off from the Wallah waste rock dump and water from pit dewatering meet discharge criteria prior to discharging into the downstream environment, by treating the water if necessary.
- Capture disturbed catchment runoff through a diversion channel downstream of earthworks during construction in the Nam La catchment and allow sediment to settle.
- Design post closure surface water management to ensure long term physical and chemical stability.
- Install structures to intercept sediment-laden surface runoff to reduce sediment delivery to watercourses.

Revegetation

Revegetation will aid in the rehabilitation of disturbed areas. Management measures concerning revegetation include:

- Undertake progressive rehabilitation and revegetation of disturbed areas (including the TSFs and waste rock dump) to minimise the length of time that disturbed areas are exposed to wind and erosion.
- Revegetate disturbed riverbanks by indigenous seedlings or by natural colonisation as soon as possible.
- Use local species for revegetation activities.
- Stabilise cleared banks to facilitate regeneration of riparian vegetation.
- Implement a general revegetation program in the Bawdwin concession area, focussing on stabilising and covering areas of exposed land to minimise erosion and generation of dust.

Weeds and pests

Preventing introduction of weeds, pests and pathogens is more effective than control and elimination. Measures that are essential to achieve this goal include:

- Establish and enforce a project-wide quarantine program using a risk-based approach.
- Create a weed and plant pathogen identification manual for contractors and personnel, and provide training in its use.
- Visually inspect vehicles, plant and equipment for soil, seeds and weed material.
- Wash down vehicles, plant and equipment before arrival at site and away from watercourses, using a risk-based approach.
- Monitor and manage washdown areas to avoid weed establishment.

Accidental spills and leaks

A range of measures will be implemented to reduce the potential for accidental leaks and spills to occur. These include:

- Conduct a hazard and operability study (HAZOPS), which is a structured and systematic examination of a complex planned or existing process or operation in order to identify and evaluate hazards that may represent risks to personnel, equipment or the environment.
- Establish protocols for handling, transport, transfer, storage and disposal of hazardous materials, including fuel, which comply with all Myanmar regulations and good international practice.
- Train personnel involved in the handling, transportation and storage of hazardous materials in hazardous materials management, transfer procedures and spill prevention and emergency response ...
- Develop a risk-based spill prevention and response plan that encompasses project-specific work areas and activities including measures to reduce risks to as low as reasonably practical, for example:
    - Service vehicle and machinery using measures to contain spills (e.g., drip trays) and in appropriate locations (e.g., away from watercourses and drainage lines).
    - Conduct inspections to evaluate the presence and condition of spill prevention measures and replacing measures as required.
    - Conduct regular emergency spill drills to practice timely and effective spill response, involving relevant site personnel.
    - Keep adequate quantities of spill response materials such as absorbent materials and pH buffer solutions adjacent to hazardous material storage areas and in vehicles transporting hazardous materials.

- Establish arrangements to mobilise additional resources for responding to larger spills and strategies for deployment.

Traffic

Management measures aimed at minimising the impact of traffic on biological values include:

- Implement road safety initiatives to prevent accidents which may cause a spill, damage vegetation and flora, or injure/kill fauna, for example.
  - Use sealed concentrate containers for transport.
  - Conduct safety training for all vehicle operators.
  - Establish and enforcing speed limits for project vehicles.
  - Conduct regular vehicle inspections.
  - Hire experienced vehicle operators.

Fauna management

Fauna management measures will be implemented to minimise impacts caused by project activities. These include:

- Manage waste in a manner that discourages animal access.
- Rescue fauna that fall into open trenches, TSFs, dams etc, where safe and practicable to do so
- Maintain WAD cyanide concentration in TSF supernatant water quality below 50 ppm, which is generally acknowledged internationally as the value below which water birds will not be negatively affected by cyanide (Donato et al., 2007),
- Prohibit feeding, hunting, collecting, purchasing or harassing of wildlife, keeping wildlife as pets and/or the possession and/or transport of wildlife products by workers.
- Conduct training for project personnel on protecting wildlife and flora.

6.8.4 Residual impact assessment

Notwithstanding the expected successful and full implementation of the management measures described in Section 6.8.3, a number of residual impacts to biological values will remain, of varying significance. These impacts to biological values may be caused by a number of activities or effects as described in Section 6.8.2, which are often inter-related and can be cumulative.

The biological values that may be impacted have been defined at three scales:

- Habitat or ecosystem types consisting of the key terrestrial and aquatic habitat types.
- Terrestrial and aquatic flora and fauna assemblages as a whole.
- Populations of conservation significant species.

This section assesses the residual impacts identified in Section 6.8.2 after implementation of the management measures outlined in Section 6.8.4. The magnitude of each residual impact is assessed based on the impact's geographic extent, severity and duration, taking into consideration the existing conditions of the features and their importance, vulnerability and resilience. Table 6.3 presents the criteria used to determine the magnitude of each impact.

Table 6.147 Criteria used to determine the magnitude of biological impacts

Factor	Magnitude Ratings				
	Very low	**Low**	**Medium**	**High**	**Very high**
Spatial extent	Impact affects a very small area within the project footprint	Impact is entirely within existing disturbance areas Impact affects a localised area	Impact is partly within existing disturbance areas but also within previously undisturbed (or low-level disturbance) areas Impact affects a moderate area	Impact is completely within previously undisturbed (or low-level disturbance) areas Impact affects a widespread area	Impact extent is very high
Severity	Impact has a very low severity and will probably recover on its own or require minimal rehabilitation effort. Effect not detectable with respect to natural variability	Impact can be avoided, remedied or rehabilitated using standard management measures Effect barely detectable with respect to natural variability.	Impact can be partly avoided, remedied or rehabilitated. Effect will be readily detectable with respect to natural variability but not severe.	Impact is very difficult to avoid or rehabilitate. Effect likely to be large (severe) with respect to natural variability.	Impact has a very high severity and cannot be avoided or rehabilitated. Effect likely to be very large (severe) with respect to natural variability.
Duration	Impact is very short in duration (i.e., days)	Impact is short term (i.e., months or less)	Impact is medium term (1 to 2 years).	Impact is long term (3 to 15 years).	Impact is greater than 15 years or permanent.

Habitat loss and degradation

Habitat loss and degradation has the potential to occur as a result of:

- Direct physical disturbance (vegetation clearance causing direct removal of habitat) from earthworks to enable the construction of project infrastructure.
- Deposition of eroded or side-casted sediments (by either wind or water) particularly during the construction of the project.
- Contamination caused by accidental spills of hazardous materials.
- Project emissions to air and water.

Due to the combined and interactive nature of these processes, this assessment takes a holistic approach whereby the overall significance of changes to each habitat is assessed as opposed to rating each individual process.

The broad habitat types assessed in this section are grassland and bamboo, sub-tropical mixed hill forest, and riparian vegetation. Impacts to smaller communities and individuals which may occur within (or not within) these broader habitats are discussed in subsequent sections.

Habitat loss and degradation of aquatic habitats (Nam Pangyun, Nam La and Myitnge River) are discussed in the surface water impact assessment. But the majority (94%) of physical disturbance will occur in the Nam Pangyun catchment. A total of 25 hectares (ha) of physical disturbance is predicted within the Nam La mainly as a result of constructing the Nam La water harvesting facility, the accommodation camp, a portion of the process plant and sections of access roads.

The most significant cause of habitat loss is vegetation clearance. The project will result in the removal of vegetation in order to expand the existing mine pit and construct infrastructure, including the TSFs, diversion dam and Nam La water harvesting facility, waste rock dump and roads. The extent of habitat loss caused by direct vegetation removal is summarised in Table 6.148. The project will result in around 458.2 ha of habitat to be lost in total.

Table 6.148 Summary of habitat loss caused by direct vegetation clearance

Habitat	Area to be Lost (within project infrastructure footprint) (ha)	Proportion of mapped project footprint
Grassland	209.9	46%
Bamboo	126.6	28%
Bare land	61.5	13%
Residential area	24.6	5%
Shrub land	17.1	4%
Sub-tropical mixed hill forest	11.8	3%
Agricultural land	3.6	1%
Waterbody	3.2	1%
Total	**458.2**	**100%**

Note: approximately 10.4 ha were not mapped

Habitats most likely to be impacted by direct vegetation removal are grassland, bamboo, bare land and sub-tropical mixed hill forest. Grassland occurs widely in the mountainous areas surrounding the Bawdwin concession area and as such will be the vegetation most affected by the project with approximately 210 ha cleared for project infrastructure. Bamboo vegetation will also be impacted by vegetation clearance, with approximately 127 ha to be removed. The removal of grassland and bamboo in additional to already bare land or urban areas equates to more than 92% of the total area of disturbance.

The project footprint is superimposed over the mapped vegetation types and condition categories and is shown in Figure 6.24.

Grassland

At a regional level, the project is located within an area that has been broadly mapped as sub-tropical mixed hill and savannah vegetation, with elements of mixed deciduous forest, tropical semi evergreen and tropical wet evergreen forests. However, forested areas in and surrounding the Bawdwin concession area have largely been cleared due to historical mining activities, with most deforestation likely to have occurred centuries ago during the Chinese mining era. By the 20th century the entire area represented a denuded landscape that now consists of grasslands from *Andropogon*, *Pennisetum*, *Phragmites*, *Sporobolus*, and *Coix* genera covering the mountainous topography. Continued seasonal burning to promote fodder for cattle grazing has largely ensured that the landscape remains a grassland environment.

The project will result in the direct loss of more than 200 ha of this modified grassland vegetation. In addition, side-casting on very steep slopes (e.g., for road construction) and sedimentation resulting from erosion (either by air or water) is likely to increase the extent of habitat losses, at least temporarily.

As discussed, in Section 6.2, the landform of the project area and surrounding region is steep with the majority of the terrain having a slope in excess of 20%, and approximately half of the terrain having a slope in excess of 30%.

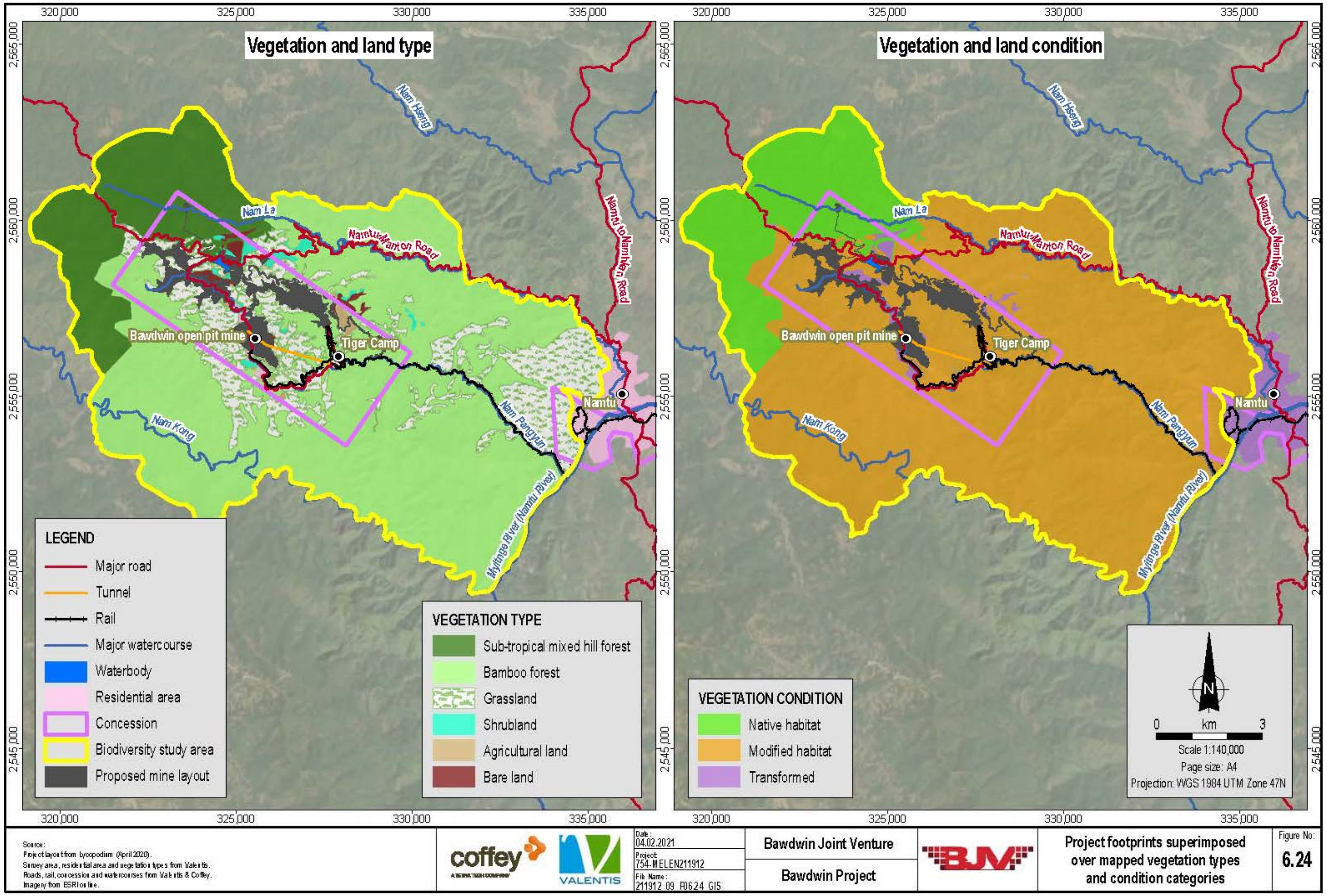


Figure 6.24 Project footprints superimposed over mapped vegetation types and condition categories

Historical forest clearing is likely to have exposed topsoils resulting in significant erosion of soils. Soils are typically shallow, with a very thin organic layer. Another aspect of the soils is the elevated mineral concentrations, with soil sampling showing elevated concentrations of lead, arsenic, and nickel around the former Bawdwin mine (see Section 5.1). It is likely that the grassland vegetation present in the area is adaptable and resilient species with high colonising abilities.

Project activities may result in increased levels of dust deposition. Dust deposition is expected to be highest closer to sources of dust generation, primarily around the open pit, waste dump, TSFs, haul roads and near any stockpiles. Fugitive dust can impact vegetation growth particularly in more exposed open areas that are currently grasslands as described in Section 6.8.2. Dust deposition monitoring for the project found that large quantities of dust are currently being deposited in the Bawdwin area, with levels ranging between 3.6 g/m^2 near the Bawdwin village (13 miles) and 29.9 g/m^2 at Namtu town near the 32 Mile bridge. Considering the baseline conditions, it is likely that grassland vegetation in the project area may be resilient to some degree from dust deposition. The residual impact of habitat loss and degradation of grassland habitat is considered to be of **low significance**, based on the **high magnitude** of impact and the **very low sensitivity** of the feature (Table 6.149).

Table 6.149 Residual impact significance summary – construction and operations phases – habitat loss and/or degradation of grassland habitat due to vegetation clearance

Value	Sensitivity of value			
Grassland habitat	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Grassland has lower diversity of species compared to more intact sub-tropical mixed hill forest and does not provide critical habitat to identified flora and fauna species of conservation significance in the project area.	**Very low** Grassland is a dominant vegetation type present in previously disturbed areas	**High** grassland is capable of recolonising previously disturbed areas	**Very low**
Impact	**Magnitude of impact to value**			
Habitat loss and degradation due to vegetation clearance and dust deposition	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	High 209.9 ha of grassland will be removed, equivalent to 46% of the project infrastructure footprint	**Medium** Temporary vegetation clearance can be rehabilitated. Regionally the severity of the impact would be low due to the wide distribution of grassland habitat beyond the Bawdwin concession area.	**Very high** Areas cleared temporarily will be impacted long-term until rehabilitated. Permanently cleared areas will be impacted permanently as rehabilitation will not be possible and the habitat will be permanently lost.	**High**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Low Mapping of this habitat type used satellite imagery combined with field surveys.			

Bamboo and shrubland

In the Bawdwin area, bamboo growth is dominated by species belonging to Bambusa and Dendrocalamus species. Bamboo is the dominant vegetation on lower slopes and valley bottoms. These areas are probably most prevalent due to deeper soils with higher moisture content. Bamboo is a resilient vegetation type that can rapidly colonise land and is widely distributed regionally and nationally. It was assessed that the bamboo vegetation is likely to represent a recolonising vegetation community as opposed to the indigenous/remnant vegetation that occurred prior to human settlement and mining activities in the region. Bamboo is also a useful plant for the local communities, therefore some of these patches of bamboo may have been intentionally planted. This residual impact is considered to be of **low significance**, based on the **medium magnitude** of impact and the **low sensitivity** of the feature (Table 6.150).

Table 6.150 Residual impact significance summary – construction and operations phases – habitat loss and/or degradation of bamboo habitat due to vegetation clearance

Value	**Sensitivity of value**			
Bamboo habitat	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Bamboo has lower diversity of species compared to more intact sub-tropical mixed hill forest and does not provide critical habitat to identified flora and fauna species of conservation significance in the project area	**Low** Bamboo habitat widely distributed regionally and nationally	**High** Bamboo habitat can rapidly colonise previously disturbed areas	**Low**
Impact	**Magnitude of impact to value**			
Habitat loss and degradation due to vegetation clearance and dust deposition	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium 126 ha of bamboo habitat will be lost, representing 27% of the vegetation lost in the project footprint	**Medium** Bamboo habitat that is only temporarily lost can be rehabilitated. Regionally the severity of the impact would be low due to the wide distribution of bamboo habitat beyond the Bawdwin concession area.	**Very high** Areas cleared temporarily will be impacted long-term until rehabilitated. Permanently cleared areas will be impacted permanently as rehabilitation will not be possible and the habitat will be permanently lost.	**Medium**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Low Mapping of this habitat type used satellite imagery combined with field surveys.			

Sub-tropical mixed hill forest

Sub-tropical mixed hill forest is found approximately 4 km northwest of the mine pit, and 11.8 ha is expected to be cleared during the project primarily due to the construction of the TSFs (approximately 3% of the total project footprint). Lateral seepage from the TSFs has the potential to cause additional impacts if this seepage were to reach areas of intact forest on the northwestern edges of these facilities. Section 6.3 discusses TSF seepage and potential contaminant dispersal.

There is the potential that the project to introduce or spread invasive species into the region. This could impact forested areas beyond the Bawdwin concession area and therefore would be of greater magnitude. The importation of vehicles and machinery from other parts of Myanmar particularly for earth moving activities is known to present a hazard for the introduction of invasive plant species. In addition, there are a number of invasive plants that already occur in the area including *Ageratina adenophora* and *Mikania micrantha*. With the implementation of management measures particularly quarantine and hygiene measures these risks can be limited, but not eliminated and the impact is considered to be of **moderate significance**, based on the **low magnitude** of impact and the **high sensitivity** of the feature (Table 6.151).

Table 6.151 Residual impact significance summary – construction and operations phases – habitat loss and/or degradation of sub-tropical mixed hill forest habitat due to vegetation clearance, contamination and introduction of invasive species

Value	**Sensitivity of value**			
Sub-tropical mixed hill forest habitat	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium The habitat supports a higher diversity of flora and fauna compared to other habitats in the area including several rare or threatened species	**High** This forest type is susceptible to clearing for land conversion and collection of wood	**Low** the habitat has experienced significant deforestation and is and degraded with lower growth rates and a more complex structure	**High**
Impact	**Magnitude of impact to value**			
Habitat loss and degradation due to vegetation clearance, contamination and introduction of invasive species - sub-tropical mixed hill forest habitat	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low 11.8 ha is expected to be cleared, representing approximately 3% of the total project footprint	**Medium** Targeted rehabilitation undertaken during operation of the project to regenerate this habitat type around Bawdwin has the potential to increase the extent of this habitat type locally. While the severity is considered medium in the context of the Bawdwin concession area, regionally the severity would be low.	**Very high** Impacts will last beyond the immediate life of the mine due to the longer regeneration time of the sub-tropical mixed hill forest compared to the modified grassland and bamboo. Impacts will be permanent in the case of vegetation cleared for infrastructure construction	**Medium**
	Residual impact significance			**High**
	Assessment of uncertainty			
	Low Mapping of this habitat type used satellite imagery combined with field surveys.			

Riparian and aquatic habitat

Riparian vegetation of varying quality occurs along the Nam Pangyun and Nam La streams. This habitat is known to be ecologically important and can act as a refuge for fauna which may move into these habitats in drier parts of the year or hot times of the day, such as birds. Additionally, riparian vegetation can also act as a form of filter limiting downstream siltation downstream of areas of disturbance. Therefore, loss of riparian habitat upstream can result in increased sedimentation downstream.

Riparian vegetation alongside the Nam Pangyun and to a lesser extent Nam La will be removed during construction of the project associated with construction of watercourse crossings for roads and pipelines, and in areas immediately adjacent to waterways. In terms of watercourse crossings, the Namtu – Tiger Camp access road crosses the Nam Pangyun four times and the plant road crosses it once. The plant road also has seven crossings of smaller tributaries. Abstraction and damming of Nam La also has the potential to result in hydrological modifications that could cause localised impacts to these habitats. Increased erosion and sedimentation may also impact riparian vegetation due to sediment-laden runoff into watercourses.

No impacts to riparian habitat are predicted for the Myitnge River as a result of the project.

With measures implemented to limit disturbance to riparian habitat, maintain hydrological connectivity, minimise sedimentation and revegetate disturbed areas, the residual impact to the Nam Pangyun riparian habitat is considered to be of low significance, based on the low magnitude of impact and the low sensitivity of the feature (Table 6.152). With measures implemented to limit disturbance to riparian habitat, maintain stream flows and revegetate disturbed areas, the residual impact to the Nam La riparian habitat is considered to be of low significance, based on the low magnitude of impact and the low sensitivity of the feature (Table 6.153).

Table 6.152 Residual impact significance summary – construction and operations phases – habitat loss and/or degradation of aquatic habitat of the Nam Pangyun due to vegetation clearance, reduced stream flow and sedimentation

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Nam Pangyun riparian and aquatic habitat</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>Low
The Nam Pangyun has few beneficial uses or biological value as it is a highly modified and degraded ecosystem due to legacy mining impacts</td><td>Low
The ecosystem is highly degraded with tolerant and resilient organisms present</td><td>Medium
The diversity of species present are highly adaptable</td><td>Low</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact to value</th></tr>
<tr><td rowspan="5">Habitat loss and degradation due to vegetation clearance, reduced stream flow and sedimentation</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Low
Localised losses for more than 10 watercourse crossings and some downstream degradation</td><td>Medium
The increased sedimentation and the potential for reduced stream flow particularly during the dry season will impact the downstream environment. The impact severity is not expected to be significant considering that riparian vegetation is along this watercourse is variable, often in poor condition due to the existing legacy mining impacts</td><td>Very high
The impact will be potentially last longer than the immediate life of the mine due to the time taken to rehabilitate cleared vegetation</td><td>Medium</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Low</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">High
There are a range of uncertainties relating to the assessment of surface water impacts including the prediction of impacts to water quality and stream flows see Section 6.4.</td></tr>
</table>

Table 6.153 Residual impact significance summary – construction and operations phases – habitat loss and/or degradation of aquatic habitat of the Nam La due to vegetation clearance, reduced stream flow and sedimentation

Value	**Sensitivity of value**			
Nam La riparian and aquatic habitat	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium The Nam La ecosystem is largely undisturbed, with aquatic habitat and pollution-sensitive species present	**Medium** The ecosystem was assessed to be in moderate to good condition and moderately sensitive to change	**Medium** The Nam La catchment is mostly unmodified and has limited resilience to changes in the dry season	**Medium**
Impact	**Magnitude of impact to value**			
Habitat loss and/or degradation of aquatic habitat due to vegetation clearance, reduced stream flow and sedimentation	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Localised impacts and some downstream degradation due to increased sedimentation and the potential for reduced stream flow during the dry season.	**Medium** Localised losses of habitat and the potential for reduced stream flow during the dry season.	**Very high** The impact will be potentially last longer than the immediate life of the mine due to the time taken to rehabilitate cleared vegetation	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High There are a range of uncertainties relating to the assessment of surface water impacts including the prediction of impacts to water quality and stream flows see Section 6.4.			

Flora and fauna assemblages and populations

Terrestrial

It is predicted that there will be reduced abundance and/or diversity of flora and fauna populations as a consequence of:

- Changes to available habitat (including food sources, shelter and nesting or roosting sites) due to habitat loss and degradation (described above).
- Injury, death or displacement of flora and fauna from vegetation clearing and earthworks, collision with vehicles and predation by exotic species.
- Increased disturbance (through project-related noise, vibration and lighting) disrupting the behaviour of fauna and potentially reducing reproductive success.

The extent to which flora and fauna populations would be impacted by the project (either directly or indirectly) depends on their abundance and distribution, demographics, and ecology and how this relates to processes affected by the project.

As described above, most impacts are predicted to occur within the grassland and bamboo habitats. Based on field surveys completed for the project, these habitats represent degraded or secondary regrowth communities and as such comprise a flora and fauna assemblage dominated by common, adaptable and wide-spread species.

Responses to habitat loss or degradation may affect the demographic structure of individual populations or the composition of communities. Species that prefer forest interiors and mature forest (particularly in montane ecosystems), and taxa that are subject to other threatening processes are most likely to suffer population declines. In contrast species that occur on modified environments are likely to have a degree of resilience.

Injury, death or displacement causing reduced abundance and/or diversity of species due to vegetation clearing and earthworks and collisions with vehicles. The construction of new access roads and haul roads, and subsequent use of these roads and the export corridor during operations increases the possibility of direct mortality of fauna by collisions with vehicles. Additionally, the vegetation clearance and earthworks during construction may cause direct mortality of slow-moving fauna.

Disrupted behaviour and reproductive success, for example from increased industrial noise, blasting, vibration and lighting, may cause reduced local abundance and/or diversity of species due to increased project-related noise and light emissions. Herpetofauna and nocturnal birds are more susceptible to this impact, however as the impact will be localised, the impact to the overall fauna community is considered to be negligible.

Overall, reduced abundance and/or diversity of the flora and fauna population in the grassland habitat is considered to be a residual impact of **low significance**, based on the **medium magnitude** of impact and the **very low sensitivity** of the feature (Table 6.154).

Table 6.154 Residual impact significance summary – construction and operations phases – reduced abundance and/or diversity of the flora and fauna population in the grassland habitat

Value	**Sensitivity of value**			
Grassland habitat flora and fauna population	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Grassland has lower diversity of species compared to more intact sub-tropical mixed hill forest and does not provide critical habitat to identified flora and fauna species of conservation significance in the project area	**Very low** Grassland is a dominant vegetation type present in previously disturbed areas	**High** Grassland is capable of recolonising previously disturbed areas	**Very low**
Impact	**Magnitude of impact to value**			
Reduced abundance and/or diversity of flora and fauna population	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium The grassland habitat is the most prevalent habitat type in the Bawdwin concession area, so a larger area may be impacted than other habitat types	**Low** Losses of individual plants and animals located in these areas unlikely to affect regional populations	**Very high** The impact to the community will be last beyond the immediate life of the mine	**Medium**
	Residual impact significance			**Very low**
	Assessment of uncertainty			
	Low While field surveys are unlikely to have recorded all species present within the habitat, ecological impacts can be predicted with a degree of confidence given the distribution of the habitat in the region.			

Overall, reduced abundance and/or diversity of the flora and fauna population in the bamboo habitat is considered to be a residual impact of **low significance**, based on the **low magnitude of impact** and the **low sensitivity** of the feature (Table 6.155). Due to the higher sensitivity, the residual impact to the sub-tropical mixed hill forest habitat is considered to be of **moderate significance**, based on the **low magnitude** of impact and the **high sensitivity** of the feature (Table 6.156).

Table 6.155 Residual impact significance summary – construction and operations phases – reduced abundance and/or diversity of the flora and fauna population in the bamboo habitat

Value	**Sensitivity of value**			
Bamboo habitat flora and fauna population	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Bamboo has lower diversity of species compared to more intact sub-tropical mixed hill forest and does not provide critical habitat to identified flora and fauna species of conservation significance in the project area	**Low** Bamboo habitat widely distributed regionally and nationally	**High** Bamboo habitat can rapidly colonise previously disturbed areas	**Low**
Impact	**Magnitude of impact to value**			
Reduced abundance and/or diversity of the flora and fauna population	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low The bamboo habitat is less extensive than the grassland habitat, so the area able to be impacted is more limited	**Low** Losses of individual plants and animals located in these areas unlikely to affect regional populations	**Very high** The impact to the community will be last beyond the immediate life of the mine	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Low While field surveys are unlikely to have recorded all species present within the habitat, ecological impacts can be predicted with a degree of confidence given the distribution of the habitat in the region.			

Table 6.156 Residual impact significance summary – construction and operations phases – reduced abundance and/or diversity of the flora and fauna population in the sub-tropical mixed hill forest habitat

Value	**Sensitivity of value**			
Sub-tropical mixed hill habitat flora and fauna population	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium The habitat supports a higher diversity of flora and fauna compared to other habitats in the area including several rare or threatened species	**High** This forest type is susceptible to clearing for land conversion and collection of wood	**Low** the habitat has experienced significant deforestation and is and degraded with lower growth rates and a more complex structure	**High**
Impact	**Magnitude of impact to value**			
Reduced abundance and/or diversity of the flora and fauna population	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very low The sub-tropical mixed hill forest habitat makes up a small area of the project footprint, so only a small area may be impacted	**Low** The sub-tropical mixed hill forest habitat supports more specialist species however the proportion of habitat to be impacted will not result in notable loss of abundance or diversity.	**High** The impact to the community will be long term	**Low**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	Medium Due to logistical limitation there were few survey sites located within this habitat and therefore there is a moderate degree of uncertainty regarding the composition of the flora and fauna that it supports.			

Aquatic flora and fauna assemblage

Nam Pangyun Stream

The Nam Pangyun stream will be impacted by the construction and operation of the project, as discussed in Section 6.4. These changes have the potential to impact the aquatic flora and fauna assemblage of the Nam Pangyun stream. The aquatic ecosystem in the Nam Pangyun has very low biological value due to the highly degraded existing condition of the stream, primarily due to legacy mining impacts. The biological survey (discussed in Section 5.7) recorded aquatic habitats and fauna in the less degraded upper Nam Pangyun stream. The aquatic flora and fauna assemblage is limited, lacking in flora species present in the Nam La stream and exhibiting an absence of pollution sensitive species such as caddisflies and blackflies. Highly tolerant and resilient organisms such as midges were present, and these are probably somewhat adaptable to further degradation.

Key processes that may impact this value include:

- Physical disturbance of aquatic habitat due to direct removal or smothering of instream and riparian habitat.
- Surface water flow changes due to the Nam Pangyun stream diversion, water abstraction and landform and drainage changes causing reduced flows.
- Reduced water quality (total and dissolved metals, TSS, cyanide, turbidity and acidity) as a result of runoff and seepage from contaminated sites (including the TSFs and WRD) and discharge of poor-quality water into the Nam Pangyun.

With measures implemented to minimise impacts to aquatic habitats by limiting and mitigating reductions in surface water flows, minimising increased sediment input into the watercourse and minimising further degradation of water quality the residual impact to the Nam Pangyun flora and fauna population is considered to be of **low significance**, based on the **medium magnitude** of impact and the **low sensitivity** of the feature (Table 6.157).

Table 6.157 Residual impact significance summary – construction and operations phases – reduced abundance and/or diversity of the flora and fauna population in the Nam Pangyun

Value	**Sensitivity of value**			
Nam Pangyun flora and fauna population	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low The Nam Pangyun has few beneficial uses or biological value as it is a highly modified and degraded ecosystem due to legacy mining impacts	**Low** The ecosystem is highly degraded with tolerant and resilient organisms present	**Medium** The diversity of species present are highly adaptable	**Low**
Impact	**Magnitude of impact to value**			
Reduced abundance and/or diversity due to physical disturbance from direct removal or smothering of aquatic and riparian habitat, surface water flow changes and reduced water quality	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Effects are predicted to occur from the headwaters of the stream to the lower reaches	**Low to medium** Implementation of management measures and consideration of the natural variability of flows and quality of the surface water feature will minimise further potential impacts.	**Very high** Long term effects are predicted to extend beyond the immediate mine life	**Medium**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Medium There are a range of uncertainties relating to the assessment of surface water impacts including the prediction of impacts to water quality and stream flows see Section 6.4.			

Nam La

The Nam La stream will be impacted by the construction and operation of the project as discussed in Section 6.4. These changes have the potential to further impact the aquatic flora and fauna assemblage of the Nam La ecosystem. The aquatic ecosystem in the Nam La stream has higher biological importance than that of the Nam Pangyun stream. The aquatic flora and fauna assemblage included six species of aquatic plants, four fish species, and a range of macroinvertebrates. Macroinvertebrates sampling identified highly tolerant and resilient organisms such as midges, which are probably somewhat adaptable to further degradation, and pollution sensitive organisms such as caddisflies and mayflies which may be less adaptable (see Section 5.7).

Key processes that may impact this value include:

- Physical disturbance of aquatic habitat for construction of the Nam La water harvesting facility causing downstream sedimentation.
- Reduced water quality as a result of runoff and sedimentation effects during construction of the process plant and accommodation camp access road.
- Water abstraction with the potential to reduce surface water flows.
- Post closure drainage of TSF A (and TSF B via TSF A) into the Nam La stream.

Flows in the stream are expected to be maintained by compensation flows offsetting water abstraction, and physical disturbance is expected to be limited by rehabilitation of disturbed areas (including dam embankments), and recovery of flows and dispersal of sediment after construction is complete.

With implementation of management measures that aim to minimise impacts by limiting and mitigating reductions in surface water flows, minimising increased sediment input into the watercourse and minimising further degradation of water quality, the residual impact to the Nam La flora and fauna population is considered to be of **moderate significance**, based on the **medium magnitude** of impact and the **medium sensitivity** of the feature (Table 6.158).

Table 6.158 Residual impact significance summary – construction and operations phases – reduced abundance and/or diversity of the flora and fauna population in the Nam La stream

Value	**Sensitivity of value**			
Nam La flora and fauna population	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium The Nam La ecosystem is largely undisturbed, with aquatic habitat and pollution-sensitive species present	**Medium** The ecosystem was assessed to be in moderate to good condition and moderately sensitive to change	**Medium** The Nam La catchment is mostly unmodified and has limited resilience to changes in the dry season	**Medium**
Impact	**Magnitude of impact to value**			
Reduced abundance and/or diversity due to physical disturbance of aquatic habitat from sedimentation and surface water flow changes - Nam La	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Effects predicted to primarily occur in the headwaters of the stream	**Medium** The severity of effects to aquatic ecosystems of the Nam La stream as a result of water abstraction during operations and post closure water discharge from TSF A is more difficult to predict, but is conservatively assessed as medium, provided an appropriate cover design is constructed and any necessary compensatory flows are provided to avoid downstream impacts.	**High** Impacts will occur mostly during construction, however long term effects are predicted to extend for the life of the mine due to water abstraction, and into the post-closure period due to TSF drainage	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High There are a range of uncertainties relating to the assessment of surface water impacts including the prediction of impacts to water quality and stream flows see Section 6.4.			

Myitnge River

The Myitnge River will be impacted by the construction and operation of the project as discussed in Section 6.4. These changes have the potential to further impact the aquatic flora and fauna assemblage of the Myitnge River ecosystem. The value of the aquatic ecosystem in the Myitnge River relates to its ecological importance in the region, with aquatic vegetation providing habitat for aquatic fauna.

Key processes that may impact this value include:

- Physical disturbance of aquatic habitat from sediment-rich discharge from the Nam Pangyun stream causing downstream sedimentation and reduction of streambed sediment quality.
- Reduced water quality due to metal and sediment-rich discharge from the Nam Pangyun stream.

With the implementation of management measures the residual impact to the Myitnge River flora and fauna population is considered to be of **low significance**, based on the **low magnitude** of impact and the **medium sensitivity** of the feature (Table 6.159).

Table 6.159 Residual impact significance summary – construction and operations phases – reduced abundance and/or diversity of the flora and fauna population in the Myitnge River

Value	**Sensitivity of value**			
Myitnge River flora and fauna population	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium The aquatic ecosystem in the Myitnge is of regional importance, with turtles and several species of fish present. Additionally, instream and riparian plants provide a habitat for aquatic fauna	**High** The existing condition of the aquatic ecosystem is moderate and is threatened by anthropogenic impacts	**Medium** The river has some flushing capacity and resilience to change	**Medium**
Impact	**Magnitude of impact to value**			
Reduced abundance and/or diversity of the flora and fauna population in the Myitnge River	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low The effects are predicted to be localised to the confluence with the Nam Pangyun	**Low** The existing natural variability of water quality in the Myitnge River and implementation of management measures to limit contaminants entering the Nam Pangyun, and by extension the Myitnge River	**Very high** Physical disturbance and reduced water quality of the Nam Pangyun stream discharge is expected to occur throughout construction and operations. Long term effects are predicted to extend beyond the immediate life of the mine	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	High There are a range of uncertainties relating to the assessment of surface water impacts including the prediction of impacts to water quality and stream flows see Section 6.4.			

Threatened species

Flora

Two flora species of conservation significance were identified in the biological study area (Section 5.7.2). These are the palm *Cycas pectinata* and Burmese blackwood (*Dalbergia cultrate*), both of which are listed as Vulnerable and Near Threatened on the IUCN respectively. One specimen of the palm (*Cycas pectinata)* was located to the northwest of the proposed location of the process plant. One specimen of the Burmese blackwood was located on the proposed haul road between near the proposed location of the process plant.

Cycas pectinata occurs in hill forests of northeastern India, Nepal, Bhutan, Bangladesh. It also extends into northern Myanmar and Yunnan Province in southern China, and south and east into northern Thailand, Lao PDR, Vietnam and northeastern Cambodia. It has been recorded from a variety of substrates and typically occurs in medium to tall, closed forest on deep, often clay-rich and more fertile soils, usually as part of the general shrub understory in moderate to deep shade.

Loss or degradation of the habitat of this species may reduce the abundance within the project area. The residual impact to the *Cycas pectinata* population is considered to be of **low significance**, based on the **low magnitude** of impact and the **medium sensitivity** of the feature (Table 6.160).

Table 6.160 Residual impact significance summary – construction and operations phases – reduced abundance of *Cycas pectinata* due to habitat loss and degradation

Value	**Sensitivity of value**			
Cycas pectinata	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium *Cycas pectinata* is listed as Vulnerable on the IUCN Red List and is of international conservation significance	**Medium** The preferred habitat of *Cycas pectinata* is being reduced	**Medium** *Cycas pectinata* can grow on a range of substrates, however, requires medium to tall closed forest on deep soil	**Medium**
Impact	**Magnitude of impact to value**			
Reduced abundance due to habitat loss and degradation - *Cycas pectinata*	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low While there is the possibility that the species occurs in the project footprint, more than 95% of the footprint area is considered to represent suboptimal habitat for the species.	**Low** Localised physical disturbances are unlikely to impact upon the regional populations of the species, instead representing the losses of individual plants	**High** Threats to this species associated with the project may occur during construction or operations	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Medium Uncertainty regarding the distribution of the species within the project area.			

Burmese blackwood occurs in Myanmar, Cambodia, China (Yunnan province), Lao PDR, Thailand, and Vietnam. This medium sized deciduous tree which grows in humid deciduous, evergreen forests as well as open forest, bamboo forest, and dry dipterocarp forest. There is the potential that a number of individual trees of this species are cleared for the project. The residual impact to the Burmese blackwood is considered to be l**ow significance**, based on the **low magnitude** of impact and the **medium sensitivity** of the feature (Table 6.161).

Table 6.161 Residual impact significance summary – construction and operations phases – reduced abundance of Burmese blackwood due to habitat loss and degradation

Value	**Sensitivity of value**			
Burmese blackwood	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium Burmese blackwood is listed as Near Threatened on the IUCN Red List and is of international conservation significance	**High** The population is declining, mainly due to exploitation for timber	**Medium** Burmese blackwood is able to grow in a range of habitats	**Medium**
Impact	**Magnitude of impact to value**			
Reduced abundance due to habitat loss and degradation - Burmese blackwood	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Low spatial extent predicted due to the habitat present with the project footprint.	**Low** Localised physical disturbances are unlikely to impact upon the regional populations of these species, instead representing the losses of individuals	**High** Threats to this species associated with the project may occur during construction or operations, should individuals be present in the project area	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Medium Uncertainty regarding the distribution of the species within the project area.			

Fauna

The biodiversity study anecdotally reported four threatened fauna species including the Chinese pangolin, dhole, Asian black bear and hog badger. These species were historically recorded by hunters in the broader study area including near Tiger Camp. However, there is uncertainty as to the currency of such records. Nonetheless, while the likelihood of occurrence of these species is low, they have been conservatively included for the assessment. After the completion of the biodiversity study, a king cobra was observed within the existing Bawdwin operational area. The king cobra is a threatened species, considered Vulnerable on the IUCN Red List.

Each of these species have wide distributions and broad habitat requirements (Appendix D). As such, there is the possibility that individuals of these species occur in the project footprint, albeit with low likelihood of occurrence. As medium to large sized and mobile mammals, vehicle strikes also have the potential to result in injury or death of individuals. Again, this is assessed to be an unlikely or infrequent occurrence.

The residual impact to Chinese pangolin is considered to be of **moderate significance**, based on the **low magnitude** of impact and the **high sensitivity** of the feature (Table 6.162).

Table 6.162 Residual impact significance summary – construction and operations phases – reduced abundance of Chinese pangolin due to habitat loss and degradation

Value	**Sensitivity of value**			
Chinese pangolin	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Chinese pangolin is listed as Critically Endangered on the IUCN Red List and is of international conservation significance	**High** Chinese pangolin is threatened by hunting and poaching.	**Medium** The Chinese pangolin can be found in a range of habitat	**High**
Impact	**Magnitude of impact to value**			
Reduced abundance due to habitat loss and degradation	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very low The majority of the project footprint is considered to represent suboptimal habitat and the species has a low likelihood of occurring.	**Low** Localised physical disturbances are unlikely to impact upon the regional populations of these species, instead representing the losses of individuals	**High** Threats to this species associated with the project may occur during construction or operations, should individuals be present in the project area	**Low**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High Uncertainty regarding the current presence of the species due to the reliance on interviews with hunters regarding the presence of the species.			

The residual impact to dhole is considered to be of **low significance**, based on the **low magnitude** of impact and the **medium sensitivity** of the feature (Table 6.163).

Table 6.163 Residual impact significance summary – construction and operations phases – reduced abundance of dhole due to habitat loss and degradation

Value	**Sensitivity of value**			
Dhole	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Dhole is listed as Endangered on the IUCN Red List and is of international conservation significance	**Medium** Dhole is threatened by habitat loss and degradation, as well as prey depletion	**High** The Dhole is a habitat generalist and can be found in a range of habitats	**Medium**
Impact	**Magnitude of impact to value**			
Reduced abundance due to habitat loss and degradation	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very low The majority of the project footprint is considered to represent suboptimal habitat and the species has a low likelihood of occurring.	**Low** Localised physical disturbances are unlikely to impact upon the regional populations of these species, instead representing the losses of individuals	**High** Threats to this species associated with the project may occur during construction or operations, should individuals be present in the project area	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	High Uncertainty regarding the current presence of the species due to the reliance on interviews with hunters regarding the presence of the species.			

The residual impact to Asian black bear is considered to be of **low significance**, based on the **low magnitude** of impact and the **medium sensitivity** of the feature (Table 6.164).

Table 6.164 Residual impact significance summary – construction and operations phases – reduced abundance of Asian black bear due to habitat loss and degradation

Value	**Sensitivity of value**			
Asian black bear	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium Asian black bear is listed as Vulnerable on the IUCN Red List and is of international conservation significance	**High** Asian black bear is threatened by habitat loss and hunting.	**Medium** The Asian black bear can be found in a range of habitats	**Medium**
Impact	**Magnitude of impact to value**			
Reduced abundance due to habitat loss and degradation	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very low The majority of the project footprint is considered to represent suboptimal habitat and the species has a low likelihood of occurring.	**Low** Localised physical disturbances are unlikely to impact upon the regional populations of these species, instead representing the losses of individuals	**High** Threats to this species associated with the project may occur during construction or operations, should individuals be present in the project area	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	High Uncertainty regarding the current presence of the species due to the reliance on interviews with hunters regarding the presence of the species.			

The residual impact to hog badger is considered to be of **low significance**, based on the **low magnitude** of impact and the **medium sensitivity** of the feature (Table 6.165).

Table 6.165 Residual impact significance summary – construction and operations phases – reduced abundance of hog badger due to habitat loss and degradation

Value	**Sensitivity of value**			
Hog badger	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium Hog badger is listed as Vulnerable on the IUCN Red List and is of international conservation significance	**Medium** Hog badger has a wide distribution but is threatened by hunting	**Medium** The hog badger can be found in a range of habitats	**Medium**
Impact	**Magnitude of impact to value**			
Reduced abundance due to habitat loss and degradation	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very low The majority of the project footprint is considered to represent suboptimal habitat and the species has a low likelihood of occurring.	**Low** Localised physical disturbances are unlikely to impact upon the regional populations of these species, instead representing the losses of individuals	**High** Threats to this species associated with the project may occur during construction or operations, should individuals be present in the project area	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	High Uncertainty regarding the current presence of the species due to the reliance on interviews with hunters regarding the presence of the species.			

The residual impact to king cobra is considered to be of **low significance**, based on the **low magnitude** of impact and the **medium sensitivity** of the feature (Table 6.166).

Table 6.166 Residual impact significance summary – construction and operations phases – reduced abundance of king cobra due to habitat loss and degradation

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">King cobra</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>Medium
King cobra is listed as Vulnerable on the IUCN Red List and is of international conservation significance</td><td>Medium
King cobra has a wide distribution but is threatened by hunting and habitat loss/degradation</td><td>Medium
The king cobra can be found in a range of habitats, usually forests.</td><td>Medium</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact to value</th></tr>
<tr><td rowspan="6">Reduced abundance due to habitat loss and degradation – king cobra</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Very low
The majority of the project footprint is considered to represent suboptimal habitat and the species has a low likelihood of occurring.</td><td>Low
Localised physical disturbances are unlikely to impact upon the regional populations of these species, instead representing the losses of individuals</td><td>High
Threats to this species associated with the project may occur during construction or operations, should individuals be present in the project area</td><td>Low</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Low</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">Medium
Uncertainty regarding the total population and distribution of the species within the project area.</td></tr>
</table>

Summary of residual impacts

Table 6.167 provides a summary of the residual impacts and their significance. The importance, vulnerability, and resilience of the defined biological value are assessed in Section 5.7.4.

Table 6.167 Summary of assessment of residual biological value impacts

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Habitat loss and degradation due to vegetation clearance and dust deposition	Grassland habitat • Very low sensitivity	Construction, operations and closure	High • High spatial extent • Medium severity • Very high duration	• Revegetation measures (progressive rehabilitation) • Measures to limit physical disturbance and vegetation loss • Implement and maintain erosion and sediment controls.	Low	209.9 ha of modified grassland vegetation will be removed, mostly permanently for the construction of project infrastructure e.g., open pit, TSFs and waste dump. Grassland habitat supports common and generalist species and where temporarily removed can probably be rehabilitated. There is also the potential to rehabilitate the waste dump and TSFs with grassland.	Low • Mapping of this habitat used satellite imagery and field surveys
	Bamboo and shrubland habitat • Low sensitivity	Construction, operations and closure	Medium • Medium spatial extent • Medium severity • Very high duration	• Revegetation measures (progressive rehabilitation) • Measures to limit physical disturbance and vegetation loss • Implement and maintain erosion and sediment controls.	Low	126.6 ha of modified bamboo vegetation will be removed, mostly permanently for the construction of infrastructure. Bamboo habitat does not provide critical habitat to species of conservation significance and where temporarily removed can probably be rehabilitated.	Low • Mapping of this habitat used satellite imagery and field surveys
Habitat loss and degradation due to vegetation clearance, contamination and introduction of invasive species	Sub-tropical mixed hill forest habitat • High sensitivity	Construction, operations and closure	Medium • Low spatial extent • Medium severity • Very high	• Revegetation measures (progressive rehabilitation) • Measures to limit physical disturbance and vegetation loss • Implement and maintain erosion and sediment controls.	High	11.8 ha of ecologically important sub-tropical mixed hill forest will be removed, with either a long term or permanent effect. Sub-tropical mixed hill forest has a higher diversity of flora and fauna compared to bamboo or grassland habitat and supports threatened species.	Low • Mapping of this habitat used satellite imagery and field surveys

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Habitat loss and/or degradation due to vegetation clearance, reduced stream flow and sedimentation	Riparian habitat of Nam Pangyun • Low sensitivity	Construction and operations	Medium • Low spatial extent • Medium severity • Very high duration	• Limit and rehabilitate physical disturbance and vegetation clearance of riparian and aquatic habitat • Implement and maintain erosion and sediment controls. • Implement surface water management measures to reduce degradation of water quality and changes in surface flows	Low	More than 10 watercourse crossings will result in loss of habitat and downstream degradation, and the habitat will also be impacted by sedimentation and reduced stream flow. Riparian habitat along the Nam Pangyun is typically of poor condition, and management measures are expected to mitigate most of the impact.	Medium • Uncertainties relate to surface water impacts and prediction of impacts to water quality and stream flow
	Riparian habitat of Nam La • Medium sensitivity	Construction and operations	Medium • Low spatial extent • Medium severity • Very high duration	• Limit and rehabilitate physical disturbance and vegetation clearance of riparian and aquatic habitat • Implement and maintain erosion and sediment controls. • Implement surface water management measures to reduce degradation of water quality and changes in surface flows	Moderate	There may be some downstream degradation and reduced stream flow during the dry season. Impacts may last longer than the life of the mine due to time taken to rehabilitate cleared vegetation. Riparian habitat along the Nam La is of higher importance and more vulnerable than that of the Nam Pangyun and is typically in better condition.	Medium • Uncertainties relate to surface water impacts and prediction of impacts to water quality and stream flow

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Reduced abundance and/or diversity due to changes to available habitat due to habitat loss and degradation, injury death or displacement from vegetation clearing and earthworks, collision with vehicles and predation by exotic species, and increased disturbance through project-related noise and lighting	Flora and fauna assemblage of grassland habitat • Very low sensitivity	Construction and operations	Medium • Medium spatial extent • Low severity • Very high duration	• Measures to limit and rehabilitate physical disturbance and habitat loss • Traffic measures to prevent collisions • Weed and pathogen prevention measures	Very low	Despite the potential for a large area to be impacted and effects to last beyond the life of the mine, losses of individual plants are not expected to affect regional populations.	Low • Field surveys were conducted • Ecological impacts can be predicted with a degree of confidence given the distribution of the habitat in the region.
	Flora and fauna assemblage of bamboo habitat • Low sensitivity	Construction and operations	Low • Low spatial extent • Low severity • Very high duration	• Measures to limit and rehabilitate physical disturbance and habitat loss • Traffic measures to prevent collisions • Weed and pathogen prevention measures	Low	Despite the potential for effects to last beyond the life of the mine, losses of individual plants are not expected to affect regional populations.	Low • Field surveys were conducted • Ecological impacts can be predicted with a degree of confidence given the distribution of the habitat in the region.
	Flora and fauna assemblage of sub-tropical mixed hill forest • High sensitivity	Construction and operations	Low • Very low spatial extent • Medium severity • High duration	• Measures to limit and rehabilitate physical disturbance and habitat loss • Traffic measures to prevent accidents and spills • Weed and pathogen prevention measures	Moderate	Only a small area may be impacted, however more specialist species are present in this habitat and losses of individual plants may affect the diversity and/or abundance of the population.	Medium • Few survey sites within this habitat
Reduced abundance and/or diversity due to physical disturbance from direct removal or smothering of aquatic and riparian habitat, surface water flow changes	Flora and fauna assemblage of Nam Pangyun aquatic ecosystem • Low sensitivity	Construction, operations and closure	Medium • Medium spatial extent • Low to medium severity • Very high duration	• Implement surface water management measures to reduce degradation of water quality and changes in surface flows • Limit and rehabilitate physical disturbance and habitat loss	Low	The Nam Pangyun has low biological value, supporting tolerant species. While effects are predicted to occur through most of the stream, management measures and consideration of the existing condition limit the magnitude of this impact.	Medium • Uncertainties relate to surface water impacts and prediction of impacts to water quality and stream flow

Impact	**Value and sensitivity**	**Impact phase**	**Impact magnitude**	**Key management measure(s)**	**Impact significance**	**Justification for impact significance**	**Uncertainty**
and reduced water quality							
Reduced abundance and/or diversity due to physical disturbance of aquatic habitat from sedimentation and surface water flow changes	Flora and fauna assemblage of Nam La aquatic ecosystem • Medium sensitivity	Construction, operations and closure	Medium • Low spatial extent • Medium severity • High duration	• Implement surface water management measures to reduce degradation of water quality and changes in surface flows • Limit and rehabilitate physical disturbance and habitat loss	Moderate	Higher ecological importance than the Nam Pangyun aquatic ecosystem, supporting several plant, fish and macroinvertebrate species. Impacts will be mainly during construction however will extend post-closure due to water abstraction during operations and post-closure TSF drainage.	Medium • Uncertainties relate to surface water impacts and prediction of impacts to water quality and stream flow
Reduced abundance and/or diversity due to physical disturbance from sediment-rich poor-quality discharge from the Nam Pangyun	Flora and fauna assemblage of Myitnge River aquatic ecosystem • Medium sensitivity	Construction, operations and closure	Low • Low spatial extent • Low severity • Very high duration	• Implement surface water management measures to reduce degradation of water quality and changes in surface flows • Limit and rehabilitate physical disturbance and habitat loss	Low	Impacts to the aquatic ecosystem are likely to be localised to the confluence with the Nam Pangyun. The Myitnge River aquatic ecosystem is regionally important; however impacts will be managed by the implementation of measures to limit contaminants entering the Nam Pangyun which would then be discharged to the Myitnge River.	Medium • Uncertainties relate to surface water impacts and prediction of impacts to water quality and stream flow
Reduced abundance due to habitat loss and degradation	*Cycas pectinata* • Medium sensitivity	Construction and operations	Low • Low spatial extent • Low severity • High duration	• Limit and rehabilitate physical disturbance and habitat loss • Weed and pathogen prevention measures	Low	Unlikely to occur in the project area, as the habitats are largely suboptimal. Any losses will probably be of individual plants and not likely to affect the regional population.	Medium • Uncertainty regarding distribution
Reduced abundance due to habitat loss and degradation	Burmese blackwood • Medium sensitivity	Construction and operations	Low • Low spatial extent • Low severity • High duration	• Limit and rehabilitate physical disturbance and habitat loss • Weed and pathogen prevention measures	Low	May occur in the project area, within the bamboo habitat. Any losses are likely to be of individual plants and not likely to affect the regional population. The species will be included in the revegetation program to alleviate the impact on the population.	Medium • Uncertainty regarding distribution
Reduced abundance due to habitat loss and degradation	Chinese pangolin • High sensitivity	Construction and operations	Low • Very low spatial extent • Low severity	• Implement fauna management and traffic measures to minimise impacts caused by the project and	Moderate	The majority of the project footprint is suboptimal habitat for this species, and they are unlikely to occur. Any losses are likely to be of individuals and not likely to affect the regional population.	High • Uncertainty regarding current presence • Historic presence reported

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
			• High duration	project-related traffic • Limit and rehabilitate physical disturbance and habitat loss			during interviews with hunters
	Dhole • Medium sensitivity	Construction and operations	Low • Very low spatial extent • Low severity • High duration	• Implement fauna management and traffic measures to minimise impacts caused by the project and project-related traffic • Limit and rehabilitate physical disturbance and habitat loss	Low	The majority of the project footprint is suboptimal habitat for this species, and they are unlikely to occur. Any losses are likely to be of individuals and not likely to affect the regional population.	High • Uncertainty regarding current presence • Historic presence reported during interviews with hunters
	Asian black bear • Medium sensitivity	Construction and operations	Low • Very low spatial extent • Low severity • High duration	• Implement fauna management and traffic measures to minimise impacts caused by the project and project-related traffic • Limit and rehabilitate physical disturbance and habitat loss	Low	The majority of the project footprint is suboptimal habitat for this species, and they are unlikely to occur. Any losses are likely to be of individuals and not likely to affect the regional population.	High • Uncertainty regarding current presence • Historic presence reported during interviews with hunters
	Hog badger • Medium sensitivity	Construction and operations	Low • Very low spatial extent • Low severity • High duration	• Implement fauna management and traffic measures to minimise impacts caused by the project and project-related traffic • Limit and rehabilitate physical disturbance and habitat loss	Low	The majority of the project footprint is suboptimal habitat for this species, and they are unlikely to occur. Any losses are likely to be of individuals and not likely to affect the regional population.	High • Uncertainty regarding current presence • Historic presence reported during interviews with hunters

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
	King cobra • Medium sensitivity	Construction and operations	Low • Very low spatial extent • Low severity • High duration	• Implement fauna management and traffic measures to minimise impacts caused by the project and project-related traffic • Limit and rehabilitate physical disturbance and habitat loss	Low	The majority of the project footprint is suboptimal habitat for this species, and they are unlikely to occur. Any losses are likely to be of individuals and not likely to affect the regional population.	Medium • Uncertainty regarding the total population and distribution of the species within the project area.

6.8.5 Monitoring

The Environmental Management Plan for the Bawdwin Project will provide for regular environmental monitoring and inspections to be completed for all project phases (construction, operation and closure). Monitoring will include:

- Internal audits to confirm that the Bawdwin Project's environmental management measures, including site-specific mitigation measures, is being implemented successfully and management measures are effective in minimising impacts to the environment.
- Routine inspections of the Bawdwin license area to confirm the environment is being managed in accordance with the site-specific management measures agreed with local communities.
- Monitoring of revegetation success in terms of percentage cover, survival, recruitment.

6.8.6 Uncertainties and further work

This section outlines the key uncertainties associated with the impact assessment and outlines recommended further work to address uncertainties. The uncertainties and further work are outlined in Table 6.168.

Table 6.168 Uncertainties and further work in respect of biological impacts

Uncertainty	Further work	Purpose	Assumptions
Limitations in the baseline survey data due to security-related constraints in access to certain areas such as the proposed locations of TSFs and Nam La water harvesting dam.	Conduct pre-clearance surveys for any areas of intact vegetation (e.g., TSF sites).	Obtain baseline survey data and information regarding existing vegetation at TSF sites	Likelihood of occurrence was assessed based on scientific literature and extrapolation of survey results from nearby areas
Potential impacts to water quality and water quantity in the Nam Pangyun and Nam La catchments during construction, operations and post-closure	See Section 6.4 for further work regarding surface water quality and quantity.	To allow for quantitative predictions of the severity and extent of water quality and quantity impacts to downstream users.	Assumptions have been made about the degree of flow reduction expected due to project activities
Mine closure and rehabilitation plan is at conceptual level only and the ability to successfully rehabilitate the project area is uncertain	Develop a closure and rehabilitation plan and strategies including rehabilitation trials	Select the optimal species mix for revegetation, methods of creating suitable rehabilitation medium(s), refinement of cover designs for the TSFs and waste dump, and post closure water strategy	Design and management measures, including rehabilitation measures, are assumed to be effective in mitigating impacts

6.9 Cultural heritage impact assessment

6.9.1 Approach to impact assessment

This section assesses the project impacts to the cultural heritage values identified in Section 5.8.

Section 5.8.5 described the levels of importance, vulnerability and resilience associated with each of the cultural heritage values in the study area. This approach is in line with Burra Charter (Australia ICOMOS Burra Charter, 2013) and Myanmar EIA guidelines.

The impact assessment approach adopted in this section is a ‘significance assessment’ (for further detail see Section 6.1). A significance assessment of cultural heritage impacts involves:

- Identifying the nature of the impact to a cultural heritage value (e.g., physical disturbance, damage or destruction resulting in loss of cultural value to people).
- Determining the magnitude of the impact through an assessment of the spatial extent, severity and duration of the impact.
- Assessing the significance of the residual impact (i.e., with assumed successful implementation of avoidance and management measures). The significance (very low, low, moderate, high or major) of the impact to a cultural heritage value is determined by considering the importance, vulnerability and resilience of the cultural heritage value (as assessed in Section 5.8) and the predicted magnitude of impact to the value.

Context for impact assessment

The Bawdwin mine has a long history with mining dating back to the 15th century when Chinese miners extracted silver from surface and near surface deposits in the Nam Pangyun valley and ER valley. In the early 1900s, underground mining of the lead, zinc and silver resource commenced by British owners under the management of Herbert Hoover, prior to his tenure as the 31st President of the United States. Industrial ore extraction and lead production began in the early 1900s. A narrow gauge railway was completed in 1909 , followed by the Tiger Tunnel in 1918, which allowed efficient access to the massive lead-zinc-silver China Lode orebody, with transport of ore to Namtu for concentration, smelting and refining.

The historical underground operation was based mostly on the China Lode, with vertical access through the 522-m-deep Marmion Shaft. A 2.7-km-long tunnel (named Tiger Tunnel) intersects the underground mine workings at Level 6 and was the main access to the orebody. An underground electric tramway enabled ore transport through the tunnel to the Wallah Gorge railway terminal where it was unloaded and stored in ore bins before transport to Namtu for processing.

Much of the cultural heritage value of Bawdwin relates to the historical mining operations, in addition to sites of importance to current residents which include religious sites including monasteries and pagodas. Sites of mining heritage include examples of mining, mineral extraction and technological advancements spanning six centuries. Items of cultural heritage include the remnants of Chinese era occupation, mining and smelting including such ramparted encampments and smelting furnaces, as well as colonial mine buildings and infrastructure such as the Marmion Shaft and winder house, the railway lines and stations and Tiger Tunnel.

The site has experienced constant change with advancements in mining methods and occupation. Much of the physical evidence of Chinese era mining and mineral processing was lost during development and operation of the 20th century mine. WMM now proposes to redevelop the existing Bawdwin mine into a large-scale modern mining operation. This would see the mining legacy of the Bawdwin deposits continued but will necessitate demolition or removal of some of the existing infrastructure and construction of new infrastructure at Bawdwin to support mining and processing activities. This will fundamentally alter the existing historical mining context, but provides an opportunity to document, research and conserve aspects of the past operations.

6.9.2 Potential sources of impact

The project has the potential to impact known and as-yet unknown cultural heritage features and their associated cultural heritage values.

Potential impacts to cultural heritage features include:

- Direct loss (i.e., destruction) of, or disturbance to, the feature.
- Physical modification of the landscape surrounding the feature and the context of the feature.
- Restriction of access to the heritage feature.

These impacts have the potential to impact associated cultural heritage values in the following ways:

- Loss of connection between people and their places (or features) of cultural value.
- Loss of information and physical records that could allow research and understanding of historic activities and cultural practices at Bawdwin.
- Loss of heritage tourism potential, which has not been comprehensively realised to date, other than sporadic ventures.

The potential impacts to cultural heritage features and their associated values are described below.

As a result of six centuries of continuous occupation and intensive mining/industrial exploitation, the Bawdwin area represents a living, dynamic and complex cultural heritage landscape comprising rich layers and high level of disturbance. As the study area includes hundreds of known (and potentially thousands of unknown) individual features of cultural heritage value, it is not feasible to individually describe and assess impacts to each one. This impact assessment therefore assesses impacts to key cultural heritage structures, buildings, sites and artefacts as well as for defined areas or 'precincts', which have a higher collective heritage value than their components individually. This approach also allows for the fact that in many cases, the heritage value of a site, place or feature relies on a broader context, such as its setting in the landscape or its proximity to other important sites.

Twenty-nine distinct cultural heritage features are known to occur within the project footprint as shown on Figure 6.25. Potential impacts to known cultural heritage sites as defined in Section 5.8 (see figures 5.3 to 5.9) are provided in Table 6.169.

Table 6.169 Potential impacts to known cultural heritage sites

Name	Type	Location	Potential Impact
Hillfort and ridge defence system	A network of Chinese-era hillforts, defences and occupied ridges	Surrounding Bawdwin	Partial loss, landscape modification, restricted access
Scattered artefact fragments	Chinese-era artefacts and evidence of occupation	Bawdwin	Partial loss, disturbance
Occupation terraces	Chinese-era artefacts and evidence of occupation	North of the open pit	Partial loss
Chinese furnace	Chinese-era mining and smelting evidence	Steep hillside opposite the existing open pit	Complete loss
Graveyard 1	Graveyard	Drill track above the Police Station	Complete loss
Graveyard 2	Graveyard	Below Hillfort 1	Disturbance, landscape modification, restricted access
Graveyard 3	Graveyard	Below Hillfort 2	Disturbance, landscape modification, restricted access
Graveyard 4	Graveyard	Meingtha Ridge	Disturbance, landscape modification, restricted access
Graveyard 5	Graveyard	Sand Plant Ridge	Complete loss
Graveyard 6	Graveyard	Very end of Sand Plant Ridge	Disturbance, landscape modification, restricted access
Graveyard 7	Graveyard	Bawdwin, side valley	Disturbance, landscape modification, restricted access
Graveyard 8	Graveyard	Behind Catholic Church	Disturbance, landscape modification, restricted access
Graveyard 9	Graveyard	Hillfort 7	Disturbance, landscape modification, restricted access
Graveyard 10	Graveyard	Hillfort 8 (near new cellphone tower)	Disturbance, landscape modification, restricted access
Graveyard 11	Graveyard	Hillfort 9	Disturbance, landscape modification, restricted access
Graveyard 12	Graveyard	Tiger Camp	Disturbance, landscape modification, restricted access
Graveyard 13	Graveyard	Lower Bawdwin	Disturbance, landscape modification, restricted access
Graveyard 14	Graveyard	Lower Bawdwin	Disturbance, landscape modification, restricted access
Graveyard 15	Graveyard	Upper Bawdwin	Disturbance, landscape modification, restricted access

Name	Type	Location	Potential Impact
Graveyard 16	Graveyard	Upper Bawdwin	Disturbance, landscape modification, restricted access
Graveyard 17	Graveyard	Below Hillfort 3 (Mt Battle)	Disturbance, landscape modification, restricted access
Graveyard 18	Graveyard	Hillfort 20	Disturbance, landscape modification, restricted access
Graveyard 19	Graveyard	Above Goldhole Valley	Complete loss
Graveyard 20	Graveyard	Above open pit (slopes of Mt Lakeland)	Complete loss, disturbance, landscape modification
Graveyard 21	Graveyard	Below Tiger Camp (downstream from spiral)	Disturbance, landscape modification, restricted access
Marmion shaft and winding house complex	Colonial-period mining heritage infrastructure	Bawdwin	Disturbance, landscape modification
Independence monument	Monument	Bawdwin	Disturbance, landscape modification, restricted access
Central Bawdwin Precinct (compressor house, mine office, post office, company store, the Bawdwin railway station and adjacent railway line, Mine Superintendent's and staff bungalows, Dead Chinaman Tunnel, Bawdwin timber yard)	Colonial-period mining heritage infrastructure	Bawdwin	Partial loss, landscape modification, restricted access
Tiger Camp precinct (Tiger Tunnel portal, electric railway, railway yards, electric substation, office, clubhouse, stone store, police station, wagon tippler, ore bins, and Tiger Camp railyards)	Colonial-period mining heritage infrastructure	Tiger Camp	Partial loss, landscape modification, restricted access
Railway (between Bawdwin and Namtu, and between Namtu and Namyao)	Colonial-period mining heritage infrastructure	Bawdwin, Tiger Camp, Namtu	Partial loss
Unknown ruin (temple/shrine)	Religious site (Temple/shrine)[a]	Aung Chan Tha, Bawdwin	Disturbance, landscape modification, restricted access
Aye Say Di Buddhist Temple	Religious Site (Buddhist temple)	Thiri Mingala, Bawdwin	Complete loss
Dha Mi Kha Ya Ma Buddhist Temple/Monastery	Religious site (Buddhist temple/monastery)	Yadanar Myay, Bawdwin	Disturbance, landscape modification, restricted access
Zi Nat Man Aung Temple	Religious site (Buddhist temple)	Pyi Daw Ayi, Bawdwin	Disturbance, landscape modification, restricted access
'Light of Dhama'	Religious site (Buddhist chapel)	Aung The Pye (Gurka Hill), Bawdwin	Disturbance, landscape modification, restricted access

Name	Type	Location	Potential Impact
Dha Pu Nya Karyi	Religious site (Buddhist chapel)	Aung The Pye (Gurka Hill), Bawdwin	Complete loss
Thiri Mingala Ward Library and Buddhist Chapel	Religious site (Buddhist chapel)	Thiri Mingala, Bawdwin	Partial loss, landscape modification, restricted access
Chinese Temple	Religious site (Chinese temple)	Ydanar Myay, Bawdwin	Disturbance, landscape modification, restricted access
Bawdwin Mosque	Religious site (Muslim mosque)	Pyi Daw Ayi, Bawdwin	Disturbance, landscape modification, restricted access
Shree Krishna	Religious site (Indian temple)	Aung The Pye (Gurka Hill), Bawdwin	Disturbance, landscape modification, restricted access
Maha Karli	Religious site (Indian temple)	Aung The Pye (Gurka Hill), Bawdwin	Disturbance, landscape modification, restricted access
Sikh Temple	Religious site (Sikh temple)	Yadanar Myay, Bawdwin	Complete loss
Catholic Church	Religious site (Christian church)	Pyi Daw Aye, Bawdwin	Disturbance, landscape modification, restricted access
Union Baptist Church of Bawdwin	Religious site (Christian church)	Mingalar Kway, Bawdwin	Disturbance, landscape modification, restricted access
Aung Chandra Temple	Religious site (Buddhist temple)	Tiger Camp	Disturbance, landscape modification, restricted access
Aung Mingala Temple	Religious site (Buddhist temple)	Top of Wallah Gorge settlement, Tiger Camp	Complete loss
Wee Motee Reitha	Religious site (Buddhist chapel)	Lower Wallah Gorge, Tiger Camp	Disturbance, landscape modification, restricted access
Aung Mingala Chapel	Religious site (Buddhist chapel)	Tiger Camp	Complete loss
Union Baptist Church	Religious site (Christian church)	Tiger Camp	Disturbance, landscape modification, restricted access
Remaining stone buildings in the Chinese Bazaar area (Bawdwin upper village)	Bawdwin village building	Bawdwin, adjacent to concentrator plant	Complete loss
Stone stores	Tiger Camp village buildings	Tiger Camp	Complete loss
Goldhole Valley area (stonework revetments)	Bawdwin village buildings	Goldhole valley	Complete loss
Areas and structures that are of pre-World War II construction	Bawdwin village buildings	Bawdwin	Partial loss, landscape modification, restricted access

a The vast majority of religious sites are in current or recent use. The status of use of each site will be confirmed during further community consultation.

Direct loss and disturbance

The project has the potential to result in direct loss of cultural heritage features within the project footprint. The ‘loss’ of a feature means the feature is completely destroyed or is completely covered by a project element (e.g., building or stockpile).

The project may also result in disturbance of cultural heritage features. ‘Disturbance’ means that the feature and/or its immediate physical location is not ‘lost’ but modified from its original (i.e., pre-project) condition and this includes physical alteration of, damage to, or relocation of, the feature.

Direct loss and/or disturbance of cultural heritage features can occur due to vegetation clearance, topsoil stripping, subsoil excavation, open pit mining and quarrying. Placement of project buildings and infrastructure on top of cultural heritage features can also result in the loss of cultural heritage features.

Some cultural heritage features (Marmion shaft and winding house and Namtu to Bawdwin railway) will also be decommissioned and removed or relocated to allow for project development.

In addition, some areas have a high likelihood of containing sub-surface cultural heritage features of high value, which may be either inadvertently lost or disturbed during earthworks and mining. Graves may be encountered anywhere in the Nam Pangyun valley around Bawdwin and the hillsides. Populations of the early Chinese mining community ranged from 1,000 to 20,000 (Appendix H), so graves at Bawdwin are likely to be numerous. The area including the existing Bawdwin communities is highly likely to contain sub-surface archaeological evidence of earlier Chinese occupation – particularly at either side of the open pit, around the Mine Office and Post Office areas and upstream to the Goldhole Valley. For example, two furnaces that pre-date the colonial period have been discovered so far during project activities and this indicates that more could possibly be situated beneath the surface.

Modification of surrounding landscape

Modification of the landscape surrounding, or adjacent to, a feature has the potential to impact associated value of that feature if it relies on the context of the existing landscape for its inherent value. Modification of the surrounding landscape due to the project may reduce aesthetic, spiritual and social qualities of some heritage features. This could occur if the heritage feature is associated with a high level of connection to the landscape (e.g., the nature of the feature is tied to its position in the landscape or it has had long term prominent visibility to local communities and reminds them of historic events); aesthetic value (e.g., picturesque viewsheds, position in the topography, proximity to natural features); or spiritual value (e.g., intangible connections to the surrounding landscape.

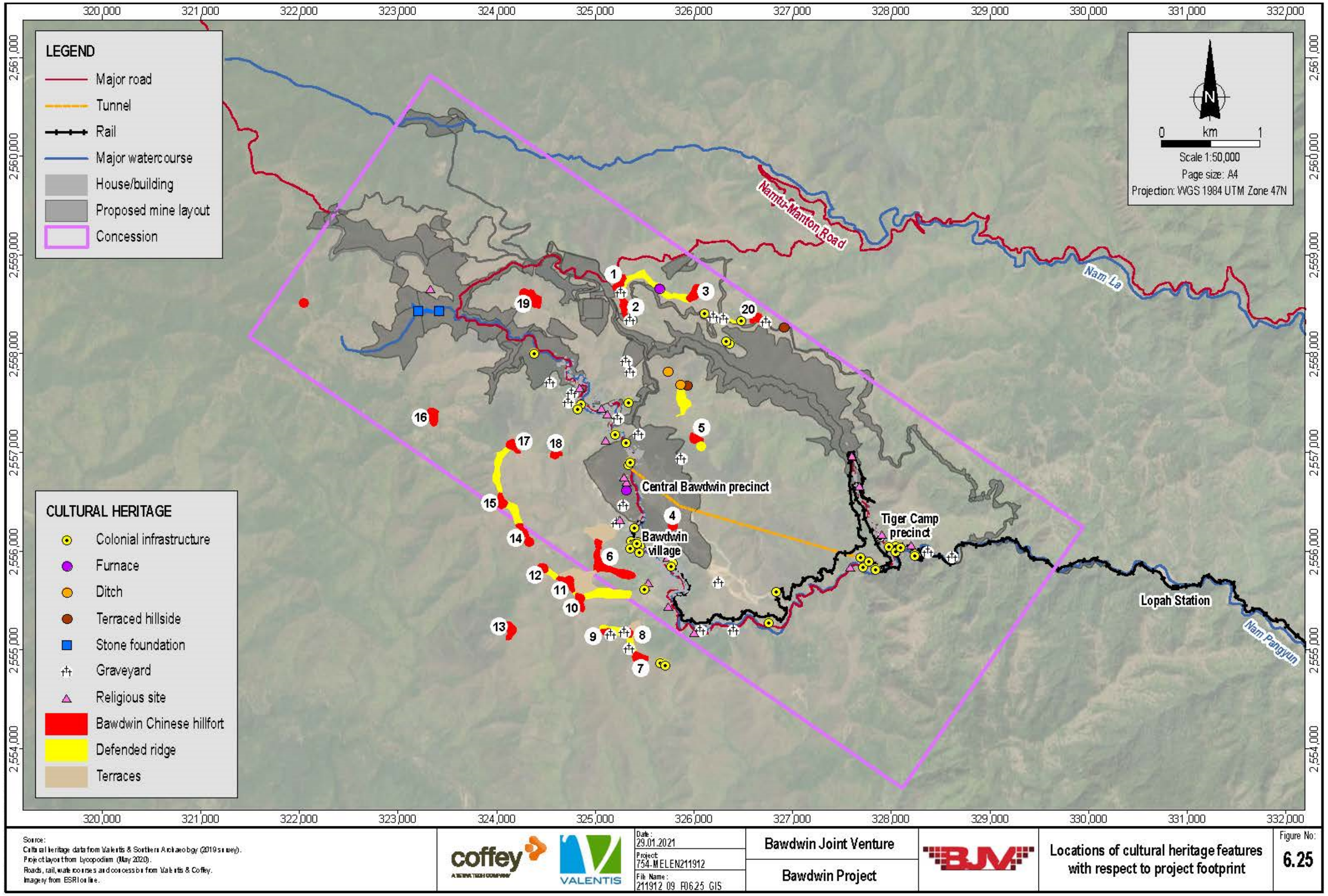


Figure 6.25 Locations of cultural heritage features with respect to Project footprint

Significant modification of the landscape will occur due to development of the following:

- Tailings storage facilities (TSFs) and embankments.
- Waste rock dump (WRD).
- Expansion of the open pit.
- Haul roads.
- ROM pad.
- Power station.
- Processing plant.
- Mine services area.
- Visible air emissions from the processing plant, vehicles, equipment and dust.
- Access road.
- Dams and water reservoirs.

Three-dimensional examples of the changes in landscape due to construction of infrastructure are shown in figures 6.26 and 6.27.

Restriction of access to sites

Development of the project will result in control of access around mining activities and facilities. In addition, some existing roads, paths and access may be altered or removed. As a result, access to cultural heritage features during the construction and operation of the project by local communities will be either very difficult or not possible. A consequence of this could be a reduced or severed connection between local communities and the cultural heritage features they value. The severing of connection with sites of cultural heritage significance can also lead to site deterioration if they are no longer in use or receiving maintenance and repair.

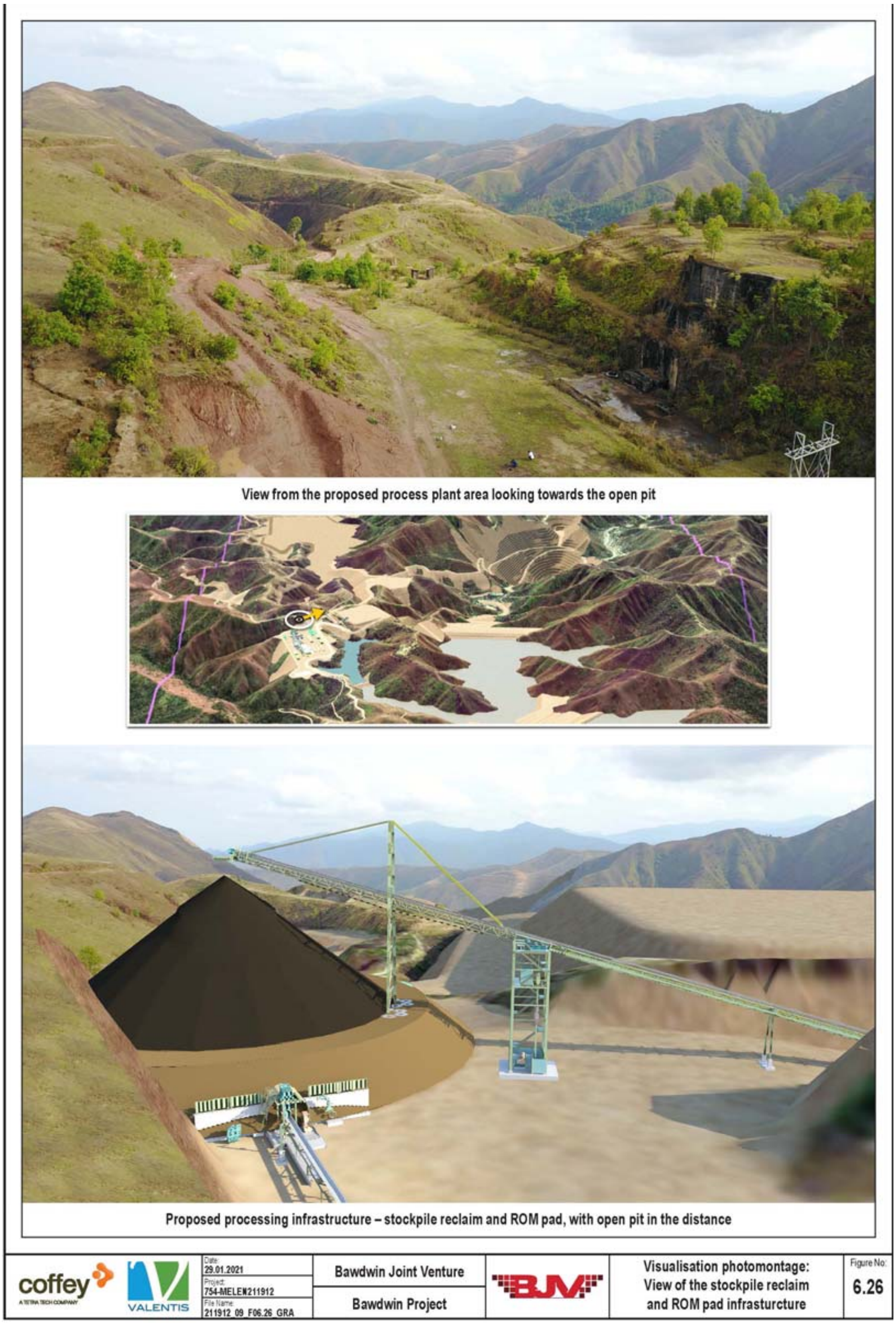


Figure 6.26 Visualisation photomontage: View of the stockpile reclaim and ROM pad infrastructure

Figure 6.27 Visualisation photomontage: View at Upper Bawdwin Village of the proposed TSF-C embankment

Summary of sources of potential impact

Table 6.170 provides a summary of potential impacts to cultural heritage at different phases of the project.

Table 6.170 Summary of potential impacts to cultural heritage during the project life

Potential impacts	Construction	Operation	Closure
Direct loss (i.e. destruction) of, or disturbance to the feature due to vegetation clearance, topsoil stripping, subsoil excavation, earthworks, open pit mining and quarrying.	X	X	X
Direct loss (i.e. destruction) of, or disturbance to the feature due to placement of project building and infrastructure on top of features.	X	X	X
Reduced value of the feature due to physical modification of the landscape surrounding the feature due of project activities and development.	X	X	X
Restriction of access to the cultural heritage feature	X	X	Uncertain

X = occurring in this phase

6.9.3 Proposed mitigation and management measures

Potential impacts to cultural heritage will be managed through development and implementation of the Bawdwin Project Cultural Heritage Management Plan (CHMP). The Bawdwin Project CHMP will provide for the protection and management of cultural heritage within, and in the immediate vicinity of, the project area, and will contain a range of management measures pertaining to project planning and design, site clearance work, inductions and training, ground disturbing works, site-specific management measures for known sites, relocation and preservation of features and response to chance finds.

The CHMP will address requirements of Myanmar legislation and regulations as well as other international standards and conventions. The applicable Myanmar legislation includes The Protection and Preservation of Ancient Monuments Law (2015) and The Protection and Preservation of Antique Objects Law (2015). Under these pieces of legislation an ‘ancient monument’ means building sites, lived, made, used and built by human beings where fossils/remains are more than 100 years old; and an ‘antique object’ means an object which was used by human beings, including fossils, that are over 100 years old. Section 5.8.5 explains how each of the cultural heritage features at Bawdwin relate to these criteria, and how these have informed the inherent sensitivity of each feature.

Myanmar is a ‘State Party’ to the UNESCO World Heritage Convention Concerning the Protection of the World Cultural and Natural Heritage. As a State Party, Myanmar has a duty to ensure the identification, protection, conservation, presentation and transmission to future generations of the country’s cultural heritage. As a State Party, Myanmar is obligated to endeavour, in so far as possible, to (UNESCO, 1972):

- Adopt a general policy which aims to give the cultural and natural heritage a function in the life of the community and to integrate the protection of that heritage into comprehensive planning programmes;
- Set up within its territories, where such services do not exist, one or more services for the protection, conservation and presentation of the cultural and natural heritage with an appropriate staff and possessing the means to discharge their functions;
- Develop scientific and technical studies and research and to work out such operating methods as will make the State capable of counteracting the dangers that threaten its cultural or natural heritage;
- Take the appropriate legal, scientific, technical, administrative and financial measures necessary for the identification, protection, conservation, presentation and rehabilitation of this heritage; and

- Foster the establishment or development of national or regional centres for training in the protection, conservation and presentation of the cultural and natural heritage and to encourage scientific research in this field.

Key requirements of the Protection and Preservation of Ancient Monuments Law include:

- If a person finds an ancient monument, which has no owner or custodian, they must promptly inform the relevant Ward or Village-Tract Administrative Office.
- Any person proposing to do any of the following must obtain permission from the Department of Archaeology and National Museum of the Ministry of Religious Affairs and Culture (MORAC) or its delegate:
  - Repair and maintain the whole or a part of an ancient monument
  - Plaster, modify, whitewash or paint the ancient monument
  - Construct, extend or fence Buddhist ordination hall, monastery, public rest-house, covered passage, gateway courtyard, planet staff, flagstaff, lake, statues, God statues, religious buildings and other buildings near an ancient monument.
  - Reconstruct ancient monuments to their original workmanship
  - Survey, dig and research places where an ancient monument is situated.
  - Protect and preserve an ancient monument by forming trustee or organisations.
  - Undertake a range of activities within a specified area of an ancient monument including:
    - Extending towns, wards, villages.
    - Extending or repairing buildings.
    - Connecting underground cables.
    - Developing wells, lakes and ponds.
    - Constructing a building which is not consistent with the terms and conditions stipulated according to the region by the Ministry near and surrounding the ancient monument.

Key requirements of the Protection and Preservation of Antique Objects Law include:

- If a person finds an object known, or reasonably suspected to be, an antique object they must promptly inform the relevant Ward or Village-Tract Administrative Office.
- Any person proposing to do any of the following must obtain permission from the Department of Archaeology and National Museum of the Ministry of Religious Affairs and Culture (MORAC) or its delegate:
  - Excavate or search of an antique object.
  - Transport an antique object to a foreign country for exhibition and/or preservation.
  - Transport an antique object to another location within Myanmar.
  - Take photos or videos of the antique object and use these for commercial purposes.

The objectives of the Bawdwin Project CHMP will include:

- Provide guidance to all WMM employees and contractors regarding appropriate management of known cultural heritage values and response to chance finds.

- Comply with the requirements of with Myanmar legislation and regulations and WMM Cultural Heritage Policy and Cultural Heritage Management Procedure.
- Meet international standards (including IFC Performance Standard 8) and conventions. The IFC Performance Standard measures to be adopted include:
  - Use internationally recognised practices for the protection, field-based study and documentation of cultural heritage.
  - Engage competent and qualified professionals to assist in identification and protection (i.e., including developing site-specific management measures) of cultural heritage.
  - Implement a chance finds procedure and commit to not disturbing any chance find until an assessment is made by competent professionals and actions consistent with PS8 are identified.
  - Consult with affected communities (who have connection to cultural heritage) and Myanmar government in relation and incorporate the views of these stakeholders in cultural heritage management.
  - For cultural heritage sites that will no longer be accessible, provide alternative access to the site where safe and practicable. Where not possible, provide replacement sites at new locations, incorporating community and government feedback into the decision making.
  - Do not move non-replicable cultural heritage (i.e., "cultural heritage which may relate to the social, economic, cultural, environmental, and climatic conditions of past peoples, their evolving ecologies, adaptive strategies, and early forms of environmental management, where the (i) cultural heritage is unique or relatively unique for the period it represents, or (ii) cultural heritage is unique or relatively unique in linking several periods in the same site" unless: [IFC, 2012])
    - There are no technically or financially feasible alternatives to removal;
    - The overall benefits of the project conclusively outweigh the anticipated cultural heritage loss from removal; and
    - Any removal of cultural heritage is conducted using the best available technique.
- Where impacts to items considered critical cultural heritage are unavoidable (e.g., railway, Marmion Shaft and hillforts and defended ridges, which may be designated as critical cultural heritage), use a process of Informed Consultation and Participation (ICP) of the Affected Communities as described in Performance Standard 1 and which uses a good faith negotiation process that results in a documented outcome.
- Avoid impacts to significant cultural heritage and protect and preserve in-situ key cultural heritage features where possible.
- Identify, record and conduct archaeological investigation and analysis, and conservation of artefacts where appropriate, for cultural heritage features that can't be protected or preserved in-situ. Engage competent and qualified professionals to do this following the Myanmar laws outlined above and using internationally recognised practices as outlined in IFC Performance Standard 8 (see above). In line with IFC Performance Standard 8, impacts to cultural heritage features will be mitigated with the informed participation of affected communities.
- Work with local communities, regulators, cultural heritage experts and key stakeholders to manage cultural heritage features, optimise retention of cultural values and connections and compensate for loss of tangible cultural heritage features.

The CHMP will contain standard management measures to be implemented during all project phases (e.g., planning and design, construction, operations and closure). It will also include site specific management measures for identified cultural heritage features that have the potential to be impacted by the project.

The CHMP will be a live document that is updated as further knowledge on cultural heritage items is gained and more detailed engagement with the community and relevant regulatory authorities is progressed. The details of the CHMP will be discussed and agreed with affected communities and relevant regulatory authorities prior to implementation.

Key avoidance and management measures that will be in the CHMP are summarised below.

Further details are provided below.

Avoidance through design

Key cultural heritage features within the study area have been identified by desktop and field surveys. The project design and siting of key infrastructure has considered these key cultural heritage features during the planning phase. Specific areas where WMM has committed to realigning the project during detailed design is where the plant road traverses adjacent to Hillfort 20 and a small, defended ridge about 250 m southwest of Hillfort 20 (see Figure 6.25). Options for realigning these sections of the road will be assessed during detailed design and the final road alignment will avoid impacting the hillfort and defended ridge.

During the feasibility study and preliminary design of the project, WMM directed design contractors that the site infrastructure layout must be designed to avoid direct disturbance to the ring of Chinese hillforts and defended ridges.

Management measures

The Bawdwin mine and associated area is rich in heritage and cultural significance. Much of the cultural heritage significance is directly associated with the former mining and ancillary areas used over the past six centuries. Redevelopment of the Bawdwin mine will result in direct impacts to sites and evidence of earlier mining activities and its associated habitation.

Declaration of historical sites and objects to authorities

All sites that are designated to be an antique object or monument protected by Myanmar law will be reported to the Myanmar authorities (i.e., the Department of Archaeology and National Museum of MORAC or its delegate). Advice will be sought from the authorities on processes for management of such sites and objects, which may include pre-disturbance surveys.

Pre-disturbance documentation of sites

For all key cultural heritage features and landscapes in the project area that will be adversely affected by the project either through direct disturbance or loss or by landscape scale changes, pre-disturbance documentation of the sites is required. This step is important to record the site context of features and to provide information that will then inform the plan for site survey and archaeological investigation and analysis, and conservation of artefacts. This step will be conducted by appropriate qualified archaeologists. As part of the pre-disturbance documentation and research, visual and 3-dimensional recording and archiving of all key cultural heritage landscape features is proposed. This will include:

- Producing high-quality professional video and still recordings of the Bawdwin infrastructure prior to any construction work commencing. This would be conducted in a thematic approach ensuring that the some of the most modest aspects of Bawdwin are recorded as well as more significant aspects such as mine infrastructure, villages, railway and Chinese hillfort system. The video should document the infrastructure and facilities in use where possible (e.g., the train on the railway, the winding house in operation). The current workforce and villagers should be given the opportunity to feature in the video records. The video and still image documentation will be created and presented as part of a systematic study of Bawdwin cultural heritage under the guidance of qualified archaeologists/historians.
- Producing professional 3-dimensional scanning/recording of key buildings and structures that will be disturbed (e.g., winder house, headframe). This will allow virtual models of buildings to be built and faithful reconstructions if they are relocated.

In-situ protection

Cultural heritage features that can be avoided by project development will be protected in situ by the following measures:

- Locations of identified cultural heritage features will be recorded in GIS and restriction zones will be established around the feature. A spatial database with all protected zones georeferenced and labelled and provision of relevant spatial layers will be maintained.
- Restriction zones will be marked in the field using physical barriers where appropriate and clear signage.
- No disturbance will be allowed to occur within restriction zones without necessary approvals and management plans being in place (archaeologist clearance, community and regulatory engagement).
- Access to established no-go zones around cultural heritage features within the Bawdwin license area will be approved by an internal permit process.
- Maintenance and monitoring plans will be developed for key cultural heritage features that remain in situ. This may include the Central Bawdwin Precinct buildings: compressor house, mine office, post office, company store, the Bawdwin railway station and adjacent railway line, Mine Superintendent’s and staff bungalows, Dead Chinaman Tunnel, Bawdwin timber yard.

Provisions for access to culturally significant sites that have been used by affected communities within living memory for long-standing cultural purposes will be facilitated where possible, subject to overriding health, safety, and security considerations.

Pre-disturbance surveys

Pre-disturbance surveys are required for all areas of the site that may be subject to direct disturbance (either full or partial) . These will be conducted by suitably qualified, internationally recognised archaeologist in conjunction with Myanmar archaeologists and with the appropriate government approvals in place. The scope and approach of the pre-disturbance surveys will be elaborated on a case-by-case basis.

The development and construction schedule will allow appropriate time for cultural heritage management measures (including pre-disturbance surveys, excavation planning and excavations) to be implemented ahead of ground disturbing works. The time required for pre-disturbance surveys will depend on field conditions and the size/complexity of the area to be cleared. It is recommended that this work is scheduled to occur a dry season in advance of planned site disturbance the following dry season.

For those sites that have pre-disturbance surveys and there are no identified cultural heritage values disturbance work may progress subject to issue of an internal approval via a land disturbance permit and compliance with the chance find procedure.

For those sites for which pre-disturbance surveys have been completed and there is identified cultural heritage values or features that cannot be avoided by the project development, the following measures for archiving and preserving are proposed:

- Engage a suitably qualified archaeological team (including international experts and Myanmar nationals) to develop necessary work plans and to undertake archaeological investigation, analysis and conservation plans for each site.
- Engage with regulators, community and other relevant stakeholders (e.g., religious leaders) so their input has been taken into consideration with respect to a) cultural heritage importance and b) the preparation of work plans and archaeological investigation, analysis and conservation . The plans will ensure that appropriate consultation occurs with community and landholders regarding the management of cultural heritage sites including obtaining endorsement prior to the disturbance of any sites.
- Establish a procedural requirement to obtain internal approval to conduct and works that will disturb ground that has not previously been disturbed by the project, via a land disturbance permit.
- Minimise other disturbance by restricting vehicle, plant and equipment movement to designated tracks, as far as practicable.

Site specific processes for disturbance and preservation of cultural heritage features

Management measures will vary depending on the nature of the cultural heritage features or values that will be disturbed. It is important that a process of controlled archaeological excavation and detailed research is conducted as part of the process to ensure that the interpretative value of artefacts is captured. Where feasible and in line with community feedback and directives from the Myanmar authorities (i.e., Department of Archaeology and National Museum or its delegate and ME-1), the project will relocate heritage features to a mining museum/historic precinct to allow preservation of artefacts and structures from Bawdwin's mining history.

The project will hand over the operation of the mining museum/historic precinct to the local community (while measures for maintaining the artefacts and structures will be overseen by qualified experts). This may provide ongoing opportunities for employment, economic and social benefits for the community and allow for the preservation of living cultural heritage values (i.e., the foundry skills required to maintain the rail engines). The following measures are proposed as a base case:

- For key mining-related cultural heritage features, detailed work plans for the retrieval, dismantling and storage of the features will be developed, endorsed and overseen by a suitably qualified archaeologist. This may include:
  - Identification and agreement of key mining-related cultural heritage features that will be retrieved, dismantled and stored.
  - Storage of all plant, machinery and artefacts of cultural heritage significance within or around buildings that will be removed for later display or beneficial use.
  - Dismantling of key buildings/structures of significance for later reinstatement off site.

- Establishment of a mining museum/historic precinct to preserve and display artefacts and structures from Bawdwin's mining history. This may include (subject to feedback from consultation with the community and Myanmar authorities (including Department of Archaeology and National Museum or its delegate and ME-1) such key items as the reinstated headframe and winding house from the site, together with selected mine railway infrastructure at Namtu, as well as the mine office, post office, timekeeper's office, company store, rail station building, lower management house and representative examples of workers' houses. It is likely that the museum will be established in Namtu. A site has not been selected to date. WMM has already commenced engagement of ME-1 on this subject.
- Additional preservation of cultural heritage features may possibly include (subject to feedback from the authorities and community):
  - Relocate the tippler from Tiger Camp precinct to the mining museum/historic precinct as a working exhibit.
  - Restore and preserve a working example of the underground electric locomotive, man cars and ore wagons at the mining museum/historic precinct as a working exhibit.
  - Retain the ore bins in situ at the Tiger Camp precinct.
  - Retain the rail spiral near Tiger Camp in situ in its entirety.
  - Retain the rail bed and track running from the Tiger Camp railyard to the mouth of the Tiger Tunnel.
  - Retain and preserve the Tiger Tunnel portal and approach.
- For the portion of railway that will be disturbed, the rail line and associated infrastructure will be dismantled and stored for potential reuse elsewhere. WMM has identified an opportunity to reinstate a portion of railway. This may be able to restore some cultural association with the railway and offer tourism opportunities, particularly when combined with the new mining museum to be established. The railway from Namtu to Namyao has not been maintained for at least a decade and is currently not passable (Petchey, 2020).

- For graves, a process for the inspection, exhumation, archiving and relocation will be established with qualified archaeologists, regulators, the community and appropriate religious leaders. It is expected that those graveyards that have strong cultural ties or active community use with the local community (see Table 5.68 in Section 5.8 for identified graveyards still currently in use) will be re-established/relocated as part of the community resettlement plan. Other graves dating back to the Chinese mining area are likely to have less of a community connection, but high bioarchaeological and historic value. Further engagement and investigation into the appropriate management of these graves is required as soon as feasible to avoid any delays in development of some areas. For graves to be relocated, the process will involve culturally and legally sanctioned exhumation and relocation of individual graves.
- For religious sites, a process for managing the loss of sites will be established with qualified archaeologists, regulators, the community and appropriate religious leaders. Initial stakeholder feedback has indicated that some items are able to be relocated or recreated in the new resettlement villages however for other items e.g., pagodas, it is culturally inappropriate to actively dismantle or move them.
- Artefacts and evidence of Chinese occupation in the Nam Pangyun valley. The initial cultural heritage survey found a range of artefacts and evidence from this period and identified high potential for more artefacts to be present and discovered with further investigation. Sites of artefacts and evidence of Chinese occupation that will be disturbed will require formal archaeological excavation, research, analysis and conservation of artefacts. This work will be conducted by qualified archaeologists with the process and final deposit of artefact collections being agreed with Myanmar authorities (i.e., the Department of Archaeology and National Museum of MORAC or its delegate) as well as affected communities.

Chance find management

A chance find procedure will be developed and implemented, which will outline actions required if previously unknown cultural heritage resources, particularly archaeological resources, are encountered during project construction or operation. It is a process that prevents chance finds from being disturbed until an assessment by a competent specialist is made and actions consistent with the CHMP are implemented.

The chance finds procedure will involve ceasing work in the immediate vicinity of the potential feature, investigation and evaluation of the cultural significance of the feature by a suitably qualified archaeologist and development of site-specific management measures.

Cultural heritage team

It is essential to have cultural heritage personnel with appropriate experience at site to:

- Interpret the CHMP on a day-to-day basis and advise managers and operational personnel on cultural heritage issues and legislative requirements.
- Lead activities related to graves, including liaison with authorities and community leaders and oversight of exhumation/relocation activities.
- Provide rapid response to chance finds, particularly during development and construction. It is anticipated that finds will be frequent, although many will be minor.

The following measures are proposed as a base case:

- Establish a cultural heritage team as part of the SHEC team at Bawdwin, including at least one qualified archaeologist.
- Assign archaeological resources during the construction period, including qualified archaeologists with suitable experience.
- Provide appropriate facilities for storage and initial examination of cultural heritage artefacts

Other measures

The CHMP will also outline procedures to ensure that the workforce including contractors is made aware of the cultural heritage values and the importance of complying with the mitigation and management measures. This will involve a combination of methods such as incorporating requirements into contracts, workforce induction, cultural awareness training, workforce training, education and awareness, compliance audits and monitoring.

Cultural heritage features that are relocated or stored will need appropriate management plans in place to ensure that they have the necessary levels of safeguard and care and maintenance. Sites that are relocated within the Bawdwin concession area will become registered on the GIS and have appropriate no-go zones established around the features.

The closure and rehabilitation of the Bawdwin mine also offers an opportunity to improve on the landscape scale impacts to cultural heritage values in the long-term. Further refinement of closure design should consider how to optimise cultural heritage values.

6.9.4 Residual impact assessment

This section assesses the residual significance of impacts identified in Section 6.9.3 after implementation of the management measures outlined in Section 6.9.4. The residual impact assessment is also based on the project design approach of avoiding impacts to sites/features of cultural heritage. This includes, for example, the plant access road, which will be redesigned during detailed design to avoid the road construction impacting on Hillfort 20 and the small defended ridge 250 m to the southwest (see Figure 6.25). The magnitude of each residual impact is assessed based on the impact’s geographic extent, severity and duration, taking into consideration the existing conditions of the features and their importance, vulnerability and resilience. Table 6.171 presents the criteria used to determine the magnitude of each impact.

Table 6.171 Criteria used to determine the magnitude of impacts to cultural heritage

	Very low	Low	Medium	High	Very high
Spatial extent	Impact affects a very small area and/or a very low portion of the heritage value of type of feature (<10%).	Impact affects a localised area and/or a low portion of the heritage value or type of feature (e.g., 10 to 40%).	Impact affects a moderate portion of the heritage value or type of feature (e.g., 40 to 70%).	Impact affects a high portion of the heritage value or type of feature (e.g., >70%).	Impact affects all remaining value(s) associated with the feature or features.
Severity	Insignificant disturbance to the feature. Extent of change in the context of existing changes due to historic mining is very low and sites are likely to retain nearly all of their value. Community access to the feature will continue.	Minor disturbance to the feature. Extent of change in the context of existing changes due to historic mining is low and sites are likely to retain most of their value. Community access to the feature will continue but tightly controlled.	Significant disturbance to the feature and/or relocation of a feature. Extent of change in the context of existing changes due to historic mining is moderate and the inherent value of the system will be partially lost. Community access to the feature will be limited and alternative access may be required.	Very significant disturbance to the feature and/or relocation. Extent of landscape change in the context of existing changes due to historic mining is severe and the inherent value of the system will be lost. Community access to the feature will be lost.	Severe disturbance or loss of feature. Extent of landscape change in the context of existing changes due to historic mining is very severe and the high inherent value of the system will be lost Community access to the feature will be lost.
Duration	Impact is very short in duration (i.e., days)	Impact is short term (i.e., months or less)	Impact is medium term (1 to 2 years).	Impact is long term (3 to 15 years).	Impact is greater than 15 years or permanent.

Direct loss and disturbance

Notwithstanding avoidance and management measures in place, heritage features are predicted to be directly lost due to ground clearance and excavation; positioning of buildings, stockpiles, dumps and infrastructure; and decommissioning activities to make way for new project infrastructure.

Features that will be directly lost inside the project footprint include:

- Evidence of Chinese-era mining and smelting from within the open pit footprint and in Goldhole Valley.
- Removal of the remaining Chinese Bazaar buildings.
- Four graveyards from within the open pit footprint and areas that will be excavated.
- Religious sites within the open pit, tailings storage embankment and Wallah Gorge waste rock dump footprints.
- Colonial era infrastructure, including the Namtu to Bawdwin railway, the Independence Monument, the settling pond and dam diversion.

Features that will be directly disturbed within and around the project footprint include:

- Colonial era infrastructure, including the decommission and removal of Marmion Shaft and winding house.

- Chinese-era mining and smelting evidence – in the cases where earthworks or mining inadvertently damages or modifies such feature or it is relocated by the project.
- Some components of the hillforts and defended ridges. While only one hillfort will be removed from the open pit area, the hillfort and defended ridges are treated as a collective system so the loss of one hillfort is considered to be partial loss or disturbance of the overall feature. The loss of the hillfort (Hillfort 4; see Figure 6.25) from within the open pit area is assessed in the context of this hillfort being already extensively damaged from historical mining activities and natural degradation.
- Artefacts and evidence of Chinese occupation in the Nam Pangyun valley – in the cases where earthworks or mining inadvertently damages or modifies such a feature or it is relocated by the project.
- Graves and/or graveyards – in the cases where earthworks or mining inadvertently damages or modifies such feature or it is relocated by the project.

The residual significance of these impacts is assessed below.

Mining and smelting evidence from the Chinese era

One of the two known Chinese-era furnaces (known as Bawdwin furnace) will be lost from within the open pit footprint (see Figure 6.25). Additional furnaces may possibly lie under the surface and may also be lost from within the footprint.

While there may be more furnaces that are not impacted (see Section 5.8.4), the loss of any individual furnace will represent a significant portion of furnaces of that type and age in a regional, national and international context. Due to the design of these furnaces being cut into the steep hillsides, it is unlikely such a feature can be successfully archaeologically investigated, analysed and preserved.

Surface and underground mine workings from the Chinese era will also be lost as the open pit expands during mining. Much of the original Chinese surface mine workings (i.e., from the Chinaman Lode area) has already been destroyed during the Colonial-era and modern mining periods. However, the numerous workings that survive in the peripheral areas around the current open pit will be lost as the open pit expands. Mine workings from Goldhole Valley will also be lost. The final pit lake (see Chapter 4) will inundate the entire pit area and any remnants of the Chinese-era underground workings.

Two types of direct loss and disturbance to the Chinese era mine workings (surface and underground workings) and smelting evidence (furnaces) have been identified: the loss of known sites; and the loss of unknown sites (i.e., those that have not yet been identified). The residual impact of loss of known Chinese era mining and smelting evidence during the operations phase will be of **major significance**, based on the **high magnitude** of impact and the **high sensitivity** of these features (Table 6.172).

Table 6.172 Residual impact significance summary – operations phase – loss of known sites of mining (underground workings) and smelting from the Chinese era due to earthworks and mining

Value	**Sensitivity of value**			
Chinese era mining and smelting evidence (underground workings)	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High These sites have high potential archaeological and technological research value, particularly as little is known about the early minerals exchange network throughout southeast Asia and the mining methods at the centre of it. Such features provide important archaeological and technological evidence of early mining activity and also aid in the overall interpretation of the Chinese occupation at Bawdwin. The collective evidence of mining and smelting during Chinese occupation was assessed as having high historic, scientific (archaeological) and technological importance. While the known mining and smelting evidence of from the Chinese era have been assigned a high importance, this rating is also conservatively applied to as-yet unencountered Chinese mining and smelting evidence. However, further assessment would be needed to confirm the actual importance of such features once discovered. Low likelihood of being classified as critical heritage under IFC Performance Standard 8.	**High** Two furnaces that are of possible Chinese original have been located to date (on the hillside adjacent to the open pit and on the hills more than 1.5 km north of the open pit), but more may exist. These sites are vulnerable to project disturbance as they are typically located on valley slopes and any direct disturbance or alteration to the slopes will cause damage. Ancient Chinese underground workings are highly vulnerable to project disturbance as these are concentrated mostly around the current open pit and mineral resource.	**Low** Damage to or loss of ancient furnaces or mine workings cannot be reversed. It is unlikely that if significantly damaged that any heritage value associated with these features would be retained.	**High**
Impact	**Magnitude of impact**			
Loss of known sites of mining (underground workings) and smelting from the Chinese era due to earthworks and mining	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Impact is likely to be restricted to a localised area but one of the two known smelting furnaces will be lost, representing half of the known features.	**High** The loss of these features would represent a significant proportion of similar examples regionally, nationally and internationally.	**Very high** Loss will be permanent as such features are unsalvageable.	**High**
	Residual impact significance			**Major**
	Assessment of uncertainty			
	Low It is known that these items will be within the mining footprint and will be lost permanently.			

The residual impact of disturbance to Chinese era smelting evidence (furnaces) during the operations phase will be of **high significance** based on the **medium magnitude** of impact and the **high sensitivity** of this feature (Table 6.173).

Table 6.173 Residual impact significance summary – operations phase – disturbance to currently unknown Chinese era smelting evidence (furnaces) due to earthworks and mining

Value	**Sensitivity of value**			
Currently unknown Chinese era smelting evidence (furnaces)	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Such features provide important archaeological and technological evidence of early mining activity but also aid in the overall interpretation of the Chinese occupation at Bawdwin	**High** Only two Chinese era furnaces have been identified	**Low** Damage to the features would be irreversible and it is unlikely heritage value would remain	**High**
Impact	**Magnitude of impact**			
Disturbance to currently unknown Chinese era smelting evidence (furnaces) due to earthworks and mining	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Impact is likely to be restricted to project footprint	**Medium** Medium intensity impact with sites damaged but not lost. Extent of change in the context of existing changes due to historic mining is moderate and the inherent value of the system will be partially lost.	**Very high** Any damage to such features will be permanent.	**Medium**
	Residual impact significance			**High**
	Assessment of uncertainty			
	Medium The field survey was limited to surface observations only from a single site visit. There is uncertainty in the location and number of possible subsurface heritage features and artefacts, which cannot be confirmed until excavation works are conducted. It is assumed that some Chinese era smelting evidence (furnaces) will be disturbed based on the proximity of the pit to historic Chinese mining practices.			

Bawdwin Village buildings

- The buildings of key cultural heritage significance include the remaining stone buildings in the Chinese Bazaar area and the remains of a Chinese-era bridge (stone foundations) in the Goldhole Valley area. The Chinese Bazaar was a group of buildings from the British colonial era located in the northern part of the mine pit footprint. These buildings and structures were constructed for the Chinese workforce at Bawdwin during the colonial period.

The impact of loss of the remaining Chinese bridge foundation in the construction phase will be of **major significance**, based on the **very high magnitude** of impact and the **high sensitivity** of the features (Table 6.174).

Table 6.174 Residual impact significance summary – construction phase – direct loss of old Chinese bridge foundation due to earthworks and mining

Value	**Sensitivity of value**			
Chinese bridge foundation	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High This feature has high historical and scientific (archaeological)	**High** This is the last known feature of its type in this setting, and its removal would	**Low** This feature would lose most of its heritage value if dismantled and	**High**

Value	Sensitivity of value			
	significance as it is evidence of the early Chinese community in Bawdwin. The bridge foundation is a rare remaining feature of the ancient Chinese occupation from the early settlements at Bawdwin	constitute a complete loss of the bridge foundation from the mining setting	removed, even if portions of it were preserved in museums	
Impact	**Magnitude of impact**			
Direct loss of old Chinese bridge foundation due to earthworks and mining	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very high Last known Chinese bridge foundation in Bawdwin village will be lost.	**High** High intensity impact as structure will be completely dismantled and removed.	**Very high** The remains of the bridge will be removed, so the feature and associated heritage values will be permanently lost.	**Very high**
	Residual impact significance			**Major**
	Assessment of uncertainty			
	Low It is known that the bridge will be lost during project construction.			

The residual impact of loss of the remaining Chinese Bazaar buildings during the construction phase will be of **major significance**, based on the **very high magnitude** of impact and the **medium sensitivity** of the features (Table 6.175).

Table 6.175 Residual impact significance summary – construction phase – direct loss of Chinese bazaar buildings due to earthworks and mining

Value	**Sensitivity of value**			
Chinese bazaar buildings	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium They have medium historical and scientific significance as remaining evidence of the early colonial-period Chinese community at Bawdwin	**Medium** This feature comprises a group of buildings in Nam Pangyun valley close to existing mining operations. As a group of buildings, it has medium vulnerability to impact given some overall heritage value of the area will be retained due to the remaining unimpacted buildings.	**Medium** The Bawdwin village buildings (including Chinese Bazaar buildings) are a collection of buildings, which provides some resilience to localised changes affecting the area as a whole	**Medium**
Impact	**Magnitude of impact**			
Direct loss of Bawdwin village buildings (Chinese bazaar buildings) due to earthworks and mining	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very high All remaining Chinese Bazaar buildings will be lost.	**High** High intensity impact as the buildings and structures will be completely dismantled and removed. Aspects of these buildings will be kept available for inclusion in museums but most of the cultural heritage value will be lost given most of the heritage value is due to the buildings being complete and part of a group of historic buildings in a mining setting.	**Very high** The buildings will be removed, so the features and associated heritage values will be permanently lost.	**Very high**
	Residual impact significance			**Major**
	Assessment of uncertainty			
	Low It is known which buildings will be removed during construction.			

Graveyards

The level of significance pertaining to graveyards (or individual graves) is highly subjective and may be greater for particular groups such as the families of buried relatives, while for others the site may be valued for its general archaeological and historical importance.

Given the long running occupation by mining communities at Bawdwin and recent accidental discoveries of graves and human remains around Bawdwin, it is likely that undiscovered graveyards and individual graves are widespread in Nam Pangyun valley, including in those areas to be excavated or mined.

The permanent loss of graves or graveyards will occur if currently unknown graveyards are inadvertently destroyed during earthworks and mining. Known graves or graveyards will be exhumed and relocated by qualified archaeologists under a cultural heritage management plan and as such will not be lost but disturbed.

The residual impact to currently unknown graveyards in the construction and operations phases will be of **high significance**, based on the **medium magnitude** of impact and the **high sensitivity** of this feature (Table 6.176).

Table 6.176 Residual impact significance summary – construction and operations phases – loss of currently unknown graveyards due to earthworks and mining

Value	**Sensitivity of value**

Graveyards	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Modern graveyards probably have social and spiritual value to existing communities, whilst older graveyards probably have bioarchaeological and historical value	**High** Graveyards are highly vulnerable to disturbance, particularly the graveyards that are not known or clearly marked as these are more likely to be accidentally encountered or damaged.	**Low to medium** Damage to, or loss of, graveyards cannot be reversed and if relocated the original heritage value may be lost or reduced. Many of the graveyards are located in prominent positions in the landscape and have little resilience to being relocated without losing some aesthetic (and potentially spiritual) value, but would probably retain their social, and potentially archaeological, value with appropriate measures put in place.	**High**
Impact	**Magnitude of impact**			
Loss of currently unknown graveyards due to earthworks and mining	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium The impact is predicted to be localised to within the project footprint, but could impact a moderate portion of the overall number of graves (potentially thousands more grave sites are likely to exist) being impacted; although there is uncertainty due to fact that the complete distribution of these features is not known.	**Medium** Graves contain human remains and can provide significant bioarchaeological information about the early populations at Bawdwin (e.g., ethnicities, health, quality of life, working conditions, cultural practices, customs), and additionally, community access to these sites will be lost. With management measures implemented to relocate graves, the disturbance to graveyards will be of medium severity.	**Very high** Any damage to or loss of graveyards will be irreversible	**Medium**
	Residual impact significance			**High**
	Assessment of uncertainty			
	Medium The field survey was limited to surface observations only from a single site visit. There is uncertainty in the location and number of possible graveyards and associated artefacts, which cannot be confirmed until excavation works are conducted. It is assumed that numerous previously undiscovered graveyards will be disturbed during mining, given the long running occupation at the site and the widespread graveyards around the valley. Also, the level of sensitivity pertaining to graveyards (or individual graves) is highly subjective; although for the purposes of the impact assessment, sensitivity has been assumed to be high for all graveyards given they contain or are associated with human remains.			

Four known graveyards occur with the project footprint (see Figure 6.25):

- A grave of unknown ethnicity at the southern edge of the open pit.
- A number of Chinese graves on a summit in the northern section of the open pit.
- Several Chinese stacked rock graves on a spur in the northeastern margin of the open pit

- A Chinese graveyard located on the crest of a ridge just beyond the site of the old sand plant. Consists of approximately 12 visible stone mounds.

These graveyards will be exhumed and relocated prior to mining. As a result, some of the cultural heritage value of the graves can be preserved. It is not clear what connection the current community has with the four known graveyards that will be disturbed; however, given their likely age (historic Chinese period) and state of disrepair, it is unlikely the graveyards are highly valued by the local community.

The residual impact to four known graveyards in the construction and operations phases will be of **high significance**, based on the **medium magnitude** of impact and the **high sensitivity** of this feature (Table 6.177).

Table 6.177 Residual impact significance summary – construction and operations phases – disturbance to known graveyards due to earthworks and mining

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Graveyards</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>High
Modern graveyards probably have social and spiritual value to existing communities, whilst older graveyards probably have bioarchaeological and historical value</td><td>High
Graveyards are highly vulnerable to disturbance because human remains should always be treated with dignity and respect and this cannot be always achieved if accidentally encountered or damaged</td><td>Low to medium
Damage to or loss of graveyards cannot be reversed and if relocated the original heritage value may be lost</td><td>High</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact</th></tr>
<tr><td rowspan="6">Disturbance to known graveyards due to earthworks and mining</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Very low
A very small portion (4 of 21 known graveyards) is likely to be affected.</td><td>Medium
Although management measures will be implemented to ensure known graveyards will be exhumed and relocated prior to mining, the value is diminished once taken from their original and prominent positions in the landscape. Community access to these sites will also be lost.</td><td>Very high
Damage to or loss of graveyards cannot be reversed and if relocated the original heritage value may be reduced.</td><td>Medium</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>High</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">Low
It is known that the graveyards will be removed, so there is low uncertainty on this impact significance rating. The level of significance pertaining to graveyards (or individual graves) is highly subjective; although for the purposes of the impact assessment, sensitivity has been assumed to be high for all graveyards given they contain or are associated with human remains.</td></tr>
</table>

Religious sites

Two religious sites (Aye Say Di Buddhist Temple and Sikh Temple) will be removed from within the open pit footprint, two sites (Dha Pu Nya Karyi Buddhist Chapel and Thiri Mingalar Buddhist Chapel) will be removed from within the tailings storage embankment footprint and two sites (Aung Mingalar Buddhist Temple and Aung Mingalar Buddhist Chapel) are within the waste rock dump footprint. Aye Say Di Buddhist Temple was the first Buddhist temple to be established at Bawdwin in the modern era and is one of the three main Buddhist temples at Bawdwin. The Sikh temple no longer has an active congregation and is now used as a private house. Dha Pu Nya Karyi Buddhist Chapel was constructed in 1974 and serves the local community as a chapel and Buddhist school. In Wallah Valley, Aung Mingalar Buddhist Temple was built in the 1980s and Aung Mingalar Buddhist Chapel was built in about 1970. Thiri Mingalar Buddhist chapel has a small library downstairs and was built by the community in 2014.

While the loss of these particular sites will be permanent, the project will consult with the community to ensure alternative facilities are available or the sites are relocated/rebuilt at the resettlement sites. Apart from their prominent elevated positions in the remote, mountainous landscape, there is nothing particularly unique about the buildings themselves in a Myanmar or southeast Asian context. The impact will not represent a significant loss (regionally and nationally) in the context of other similar religious sites. The impact is considered to be of medium magnitude for the Aye Say Di Buddhist Temple, Dha Pu Nya Karyi Buddhist Chapel, Aung Mingalar Chapel, Aung Mingalar Temple and Thiri Mingalar Buddhist Chapel and low magnitude for the Sikh Temple, given the latter is not currently used for its original purpose as a place of worship. It is noted that the magnitude and significance of impact will vary between community members depending on their use of these sites and spiritual connection to these sites.

The residual impact of loss of religious sites during the construction phase will be of **low (for Sikh temple) to moderate (all other sites) significance**, based on the **low (for Sikh temple) to medium (all other sites) magnitude of impact** and the **medium sensitivity** of the features (Table 6.178).

Table 6.178 Residual impact significance summary – construction phase – loss of religious sites (currently used and currently unused) for religious purposes due to being decommissioned and removed from project footprint

Value	**Sensitivity of value**			
Bawdwin and Tiger Camp religious sites	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium to high Many of the religious site at Bawdwin and Tiger Camp areas are still in use and further consultation with communities is required to better understand the significance of these sites to them. The religious sites are assessed to have high social and spiritual significance, medium to high aesthetic and historic significance, and low scientific or technological significance and have been given an overall ranking of medium to high importance.	**Low to medium** Many of the religious sites are located on prominent locations on hillsides and are susceptible to loss of aesthetic value.	**Medium to high** Most sites are likely to retain their heritage value after some degree of change (i.e., replacing components of, or upgrading of, the buildings). If relocated they are likely to lose aesthetic (and potential spiritual) value but would probably retain their social value with appropriate measures put in place.	**Medium**
Impact	**Magnitude of impact**			
Loss of religious sites (currently used and currently unused) for religious purposes (Aye Say Di Buddhists Temple, Dha Pu Nya Karyi Buddhist Chapel, Aung Mingalar Chapel, Aung Mingalar Temple, Thiri Mingalar Buddhist Chapel and the Sikh Temple) due to being decommissioned and removed from project footprint	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium A moderate portion (six of the nineteen religious sites) identified in the baseline study will be lost.	**Very low (Sikh temple)** Temple no longer has an active congregation and is now used as a private house, so loss of cultural heritage value expected to be very low **Medium (all other sites)** With the availability of alternative or new religious sites that accommodate the interests of the local community, it is likely that some values (to the community) will continue to be realised.	**Very high** The loss of these religious sites and any associated value will be permanent.	**Low (for Sikh Temple)** **Medium (all other sites)**
	Residual impact significance			**Low (Sikh temple)** **Moderate (all other sites)**
	Assessment of uncertainty			
	Medium It is known which sites will be permanently removed. However, the importance each site to the community should be further investigated. A sensitivity rating of medium has been assumed but this may vary between members of the community and for each site.			

Colonial-period infrastructure

Marmion shaft and winding house

The Marmion shaft and winding house lie within the proposed footprint of the expanded open pit and will have to be documented, surveyed, dismantled and removed. The distinctive steel headframe, the winding house, winding equipment and engines will be relocated to a mining museum, possibly together with associated infrastructure in the shaft yard; therefore, some cultural heritage value will be retained. The mining museum may provide employment, economic and social benefits to the local communities and allow for preservation of living cultural heritage. Qualified cultural heritage experts will advise on which parts of the Marmion shaft and winding house should be displayed in the museum. The project will result in the loss of the majority of a rare and highly sensitive feature from its natural setting.

The residual impact to the Marmion shaft and winding house during the construction phase will be of **major significance**, based on the **very high magnitude** of impact and the **medium to high sensitivity** of the features (Table 6.179). Notwithstanding the assessed significance of the impact, reinstatement of the Marmion shaft and winding house at a purpose-built museum will, to a certain degree, preserve this as an example of colonial mining infrastructure.

Table 6.179 Residual impact significance summary – construction phase – disturbance of Marmion shaft and winding house due to being decommissioned and removed from project footprint

Value	**Sensitivity of value**			
Marmion shaft and winding house	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The Marmion shaft and winding house is a rare example of a complete British 20th-century winding plant located in its original context in the remote Myanmar mountains that is largely in its original condition. This site was assessed as having high aesthetic, historic, scientific (archaeological) and technological importance and has a high likelihood of being classified as critical heritage under IFC Performance Standard 8.	**Medium** Heritage value is vulnerable to degradation, loss or replacement of the building, equipment or their elements and also loss of the functional integrity of the winding house. Given that the Marmion shaft and winding house are complete features that are almost entirely in their original condition, their value is vulnerable to change.	**Medium** Would probably still retain some of its heritage value if relocated and refurbished however, key to its current value is its current functionality and surrounding context in the Bawdwin mining landscape and with other key mining heritage features.	**Medium to high**
Impact	**Magnitude of impact**			
Disturbance of Marmion shaft and winding house due to being decommissioned and removed from project footprint	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very high This is a single feature and the impact will affect the entirety of the value associated with it.	**High** This is a rare example of a complete and functioning British 20th-century winding plant in its original condition. The removal of this feature from the site is considered a significant loss in the regional and international context of mining infrastructure. The feature will be dismantled and reassembled (but not functionally) in a museum.	**Very high** Remove of the feature from site and loss of functionality will be permanent.	**Very high**
	Residual impact significance			**Major**
	Assessment of uncertainty			
	Low It is known that this feature will be disassembled, relocated and reassembled. There is an assumption that the feature will be adequately managed in a museum by third parties once handed over by the project.			

Namtu to Bawdwin railway

The Namtu to Bawdwin railway will be dismantled and removed to make way for the project access road between Namtu and Tiger Camp. The rail sheds, workshops, station master's house and some of the railyard sidings can be retained. However, the rail line and associated infrastructure will be stored for potential re-use elsewhere. WMM will examine the feasibility of using the retained rail line and associated infrastructure for a new/reinstated section of railway that may be able to provide future tourism opportunities, which may bring economic and social benefits to local communities.

The residual impact to the Namtu to Bawdwin railway during the construction phase will be of **major significance**, based on the **very high magnitude** of impact and the **medium sensitivity** of the features (Table 6.180). Notwithstanding the assessed significance of the impact, preserving elements of the existing rail, railyards and working steam and diesel railway engines in combination with a purpose-built museum to document the history of the Bawdwin mine will, to a certain degree, conserve this as an example of colonial mining infrastructure.

Table 6.180 Residual impact significance summary – construction phase – loss of Namtu to Bawdwin railway due to being decommissioned and removed from project footprint

Value	**Sensitivity of value**			
Namtu to Bawdwin railway	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The railway is a prominent feature of the Pangyun Valley and an important example of early twentieth century British engineering in a mountainous location. Its significance comes from its engineering, unique setting and that it is still largely intact (apart from some sections that need repair) and a complete system. Similar railways around the world are recognised by UNESCO as world heritage sites and as such it is expected that the railway would be of high international importance and potential future heritage tourism potential. The railway also has importance to the local community as it is key representation of the link between the Bawdwin mine and the Namtu communities over the last 100 years. The Namtu to Bawdwin railway was assessed as having high aesthetic, historic, scientific (archaeological) and technological importance. It is highly likely to be classified as critical heritage under IFC Performance Standard 8.	**Medium** The railway has some inherent vulnerability because it is heavily reliant on its location and setting for its cultural heritage value and these two aspects cannot be changed. Therefore, changes to the setting (particularly visual aesthetics) within the Nam Pangyun valley could detract from the heritage value of the railway itself. The condition and integrity of the railway is also vulnerable to change and deterioration if not maintained and this would detract from its aesthetic, historic and technological significance. While wooden and metal structures have been, and will continue to be, exposed to weathering and degradation (i.e., corrosion, rotting, erosion of adjacent ground, etc.), ongoing natural degradation of these is not expected to materially influence the vulnerability of their heritage value over the project timescale.	**Medium** As fixed infrastructure, the railway has limited resilience to change, particularly considering its location and the importance of this setting to its value., which provides access to the Nam Pangyun and Tiger Camp. The age of the railway also makes it susceptible to further degradation and deterioration. Preservation of the rail infrastructure or sections of the rail would provide some resilience to maintaining the heritage value of the site.	**Medium**
Impact	**Magnitude of impact**			
	Spatial extent	***Severity***	***Duration***	***Magnitude***

Value	Sensitivity of value			
Loss of Namtu to Bawdwin railway due to being decommissioned and removed from project footprint	**High** The entire section of rail between Namtu and Tiger Camp will be removed, representing a loss of all of the operational portion of the feature.	**Very high** The railway will no longer be a (largely) complete system, which provides most of its heritage value. Although not in its original setting, the reuse of the rail line would allow some cultural heritage and tourism value to be retained. As there are few examples like it in the world, this feature has the potential for international heritage recognition, and loss of would be considered a significant loss in the regional and international contexts. The loss of the railway has a high potential to also result in the loss of heritage tourism potential.	**Very high** The railway between Namtu and Tiger Camp will be removed, so the feature and its associated heritage values will be permanently lost.	**Very high**
	Residual impact significance			**Major**
	Assessment of uncertainty			
	Low It is known that this feature will be disassembled and relocated. Although any potential reuse of the rail line to reinstate other degraded sections is still to be confirmed. There is an assumption that representative components of the feature will be adequately managed in a museum by third parties once handed over by the project.			

Independence Monument

The Stone Pillar of Independence is located in the grounds of No.1 Primary School in Yadanar Myae ward, north of the Chinese Bazaar buildings and existing mine pit. The monument is located in the footprint of the proposed haul road to the TSF. It is assumed that this feature will be able to be translocated to a new area being largely intact (i.e., with probable damage at the base of the feature when removing it). WMM will consult authorities and village leaders to determine whether they wish the monument to be relocated.

The residual impact of loss of the independence monument during the construction phase will be of **low significance**, based on the **low magnitude** of impact and the **low sensitivity** of the feature (Table 6.181).

Table 6.181 Residual impact significance summary – construction phase – disturbance of independence monument due to being decommissioned and removed from project footprint

Value	**Sensitivity of value**			
Independence monument	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium This feature represents an important moment in Myanmar's history but probably has medium archaeological, social and cultural value given its degraded condition and its low prominence in the overall landscape	**Low** This feature is already degraded (weathered, discoloured, weeds growing at the base)	**High** This feature can probably be relocated and retain its heritage value	**Low**
Impact	**Magnitude of impact**			
Disturbance of independence monument due to being decommissioned and removed from project footprint	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very high This is a single feature and the impact will affect the entirety of the value associated with it.	**Low** The monument can probably be preserved and potentially put in a more prominent location, in consultation with the local community.	**Low** The heritage value of this feature will only be lost during the time that it is being relocated.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Low It is known that this feature will be removed and relocated.			

Chinese hillforts and defended ridges

Nearly all of the Chinese hillforts and defended ridges system has been avoided by the direct project footprint. However, one hillfort (Hillfort 4) will be removed from within the open pit footprint and parts of the defended ridges associated with hillforts 1, 4 and 20 will be disturbed (see Figure 6.25). This represents the loss of only a small portion of the overall hillfort and defended ridges system and is therefore considered 'disturbance' to this overall heritage feature. Hillfort 4 has been extensively modified by previous mining activity, with approximately three quarters of the fort being removed from mining and construction of a drill pad.

The residual impact of disturbance to the hillfort and defended ridges system during the operations phase will be of **moderate significance**, based on the **low magnitude** of impact and the **high sensitivity** of the features overall (medium for Hillfort 4 only) (Table 6.182).

Table 6.182 Residual impact significance summary – operations phase – disturbance to the hillfort and defended ridges system due to mining

Value	**Sensitivity of value**			
Chinese hillfort and defended ridges system	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The hillforts served as a collective defence (and probably administrative) system for the mine. The remnants of the hillforts are largely intact which is unusual for features older than 500 years in a monsoon climate. The hillforts and defended ridges are unlike any features found elsewhere in Myanmar. These features have high aesthetic, historic, scientific (archaeological) and technological importance and are highly likely to be classified as critical heritage under IFC Performance Standard 8.	**High** These features are located in prominent positions of the landscape and are highly vulnerable to changes to both the feature and surrounding landscape. Hillfort 4, however, is considered to have **medium** vulnerability as it is already highly damaged.	**Medium** The hillfort and defended ridges system would be able to withstand some localised changes to the surrounding landscape, but cultural heritage values would be difficult to re-establish if damaged. Some of the hillforts, e.g., Hillfort 4 and the hills at Hillfort 1, have been extensively modified from their original condition by twentieth century mining activities, and have some resilience to further disturbance.	**High** **Medium for Hillfort 4**
Impact	**Magnitude of impact**			
Disturbance to the hillfort and defended ridges system due to mining	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Although only a small area is lost, it is part of an already fragmented/damaged feature (with some hillforts being removed completely during historic mining, drilling and road construction activities) with its remaining elements being rare in regional and international contexts.	**Low** The hillfort to be removed (after start of year 3 of mining) is already extensively damaged with only a small portion of it remaining. Investigation of the area for artefacts and archaeological evidence is required as per mitigation and management measures prior to disturbance. With the loss of this hillfort the overall heritage values of the hillfort and defended ridges system will largely be preserved.	**Very high** The impact will be permanent.	**Low**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	Medium The magnitude and significance ratings for Hillfort 4 have medium uncertainty. This hillfort was in proximity to the Chinese-era gossan quarry, and as it would have been at the top of the slope, looking down over the quarry, it may have played an important role in the oversight and defence of that quarry and employed numerous personnel. As this site may have had a concentration of many personnel over a long period, there could be a high potential for artefacts in this area. Site investigation of this hillfort will be conducted prior to its clearance to investigate the presence of sensitive cultural heritage features and to allow development of appropriate management measures. Until those investigations are conducted, there is moderate uncertainty with the impact rating.			

Artefacts and evidence of Chinese occupation in Nam Pangyun valley

Given the long history of mining and occupation at Bawdwin, it is likely that a variety of artefacts and evidence exists buried under the landscape in the valley. The archaeological value of evidence of Chinese occupation relates to allowing for an understanding of the Chinese occupation and the historic operation of the mine and hillfort system. Some artefacts and evidence could date back to the very first mining activity at Bawdwin in the fifteenth century.

The baseline survey investigated and observed surficial material only. The survey identified numerous small and fragmented artefacts including ceramics, coins, tools and waste slag from earlier Chinese occupation as well as some stone revetment along watercourses, stone foundations on a bridge, and stone terraces which may be of pre-Colonial Chinese origin. Smaller artefacts such as ceramics, fragments and tools are expected to be widespread throughout the valley and deeply buried. Additional, larger features such as buildings or parts of buildings are likely to be present deep below the surface. Archaeological excavations would be needed to further investigate the locations and sensitivities of buried artefacts and evidence of Chinese occupation.

Material in the valley has already been subjected to substantial impact by subsequent mining phases and occupation with direct disturbance, placement of waste as fill, mining and placement of buildings. Documents from the early 20th century detail the range of Chinese-era features that remained at Bawdwin prior to construction of the colonial-era mine. At higher elevations along the hillsides there are known and potentially unknown remains of Chinese terraces in a less modified form but these too are likely to have experienced extensive degradation over the centuries.

The project will result in the direct removal of stone revetments, which may possibly be of pre-Colonial Chinese origin (although archaeological investigation would be required to confirm this) in the eastern part of the tailings storage embankment (Figure 6.25). Other known larger heritage features such as terraced hillsides will be avoided by the project footprint.

It is expected that earthworks and mining will result in destruction of buried (and as-yet unknown) artefacts and evidence of earlier occupation. Due to the nature of mining it is likely that in most cases encountering features under the surface will result in their complete destruction (i.e., loss). There will also probably be cases where chance discoveries are made and those features are potentially archaeologically investigated, analysed, and conserved for scientific research.

The residual impact of loss of smaller, widespread artefacts and evidence of Chinese occupation during the construction and operations phases will be of **high significance**, based on the **medium magnitude** of impact and the **high sensitivity** of the features (Table 6.183).

Table 6.183 Residual impact significance summary – construction and operations phases – loss of smaller, widespread artefacts and evidence of Chinese occupation due to earthworks and mining

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Smaller, widespread artefacts and evidence of Chinese occupation</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>High
These features allow for an understanding of the Chinese occupation and the historic operation of the mine and hillfort system, and have high historic, archaeological and technological importance. While the known artefacts and evidence of Chinese occupation have been assigned a high importance, this rating is also conservatively applied to as yet unencountered artefacts and evidence. Since it is likely that archaeological evidence from the initial Chinese occupation and earlier periods (especially if from the Bronze Age) would have high historic, archaeological and technological importance. However, further assessment would be needed to confirm the actual importance of currently unknown features once discovered.</td><td>High
These features are vulnerable to being disturbed or destroyed due to the widespread location of features and likely presence of unknown features. Artefacts and other evidence generally hold higher significance if they can remain intact (including when in situ or when excavated) and their heritage context is understood.</td><td>Medium
The artefacts and evidence of Chinese occupation are expected to be widespread throughout the Nam Pangyun valley but concentrated in the valley floors. This material has already been subjected to substantial impact by historic mining and occupation with direct disturbance, placement of waste, mining and placement of buildings. Identification of features and artefact material may allow for its relocation, conservation and use in scientific research. The success of regaining the value of the features will be dependent on appropriate archaeological recording, analysis and reporting.</td><td>High</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact</th></tr>
<tr><td rowspan="6">Loss of smaller, widespread artefacts and evidence of Chinese occupation due to earthworks and mining</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Medium
The project area will affect a moderate portion of the area where Chinese artefacts and evidence of previous settlement is likely to occur (i.e., in the valley, around Bawdwin and near the open pit).</td><td>Medium
These fragments are expected to be widespread in the valley and loss of portion of these artefacts and evidence due to the project footprint is considered to be of moderate severity.</td><td>Very high
The impact will be permanent.</td><td>Medium</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>High</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">Medium
The field survey was limited to surface observations only from a single site visit. There is uncertainty in the location and number of possible subsurface heritage features and artefacts, which cannot be confirmed until excavation works are conducted. It is assumed that some evidence of Chinese occupation will be disturbed based on the proximity of the pit to historic Chinese mining practices and residences.</td></tr>
</table>

The impact of disturbance of smaller, widespread artefacts and evidence of Chinese occupation during the construction and operations phases will be of **moderate significance**, based on the **low magnitude** of impact and the **high sensitivity** of the features (Table 6.184).

Table 6.184 Residual impact significance summary – construction and operations phases – disturbance of smaller, widespread artefacts and evidence of Chinese occupation due to earthworks and mining

Value	Sensitivity of value			
Smaller, widespread artefacts and evidence of Chinese occupation	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High These features allow for an understanding of the Chinese occupation and the historic operation of the mine and hillfort system, and have high historic, scientific (archaeological) and technological importance. While the known artefacts and evidence of Chinese occupation have been assigned a high importance, this rating is also conservatively applied to as yet unencountered artefacts and evidence. Since it is likely that archaeological evidence from the initial Chinese occupation and earlier periods (especially if from the Bronze Age) would have high historic, archaeological and technological importance. However, further assessment would be needed to confirm the actual importance of currently unknown features once discovered.	**High** These features are vulnerable to being disturbed or destroyed due to the widespread location of features and likely presence of unknown features. Artefacts and other evidence generally hold higher significance if they can remain intact (including when in situ or when excavated) and their heritage context is understood.	**Medium** The artefacts and evidence of Chinese occupation are expected to be widespread throughout the Nam Pangyun valley but concentrated in the valley floors. This material has already been subjected to substantial impact by historic mining and occupation with direct disturbance, placement of waste, mining and placement of buildings. Identification of features and artefact material may allow for its relocation, conservation and use in scientific research. The success of regaining the value of the features will be dependent on appropriate archaeological recording, analysis and reporting.	**High**

Impact	Magnitude of impact			
Disturbance of smaller, widespread artefacts and evidence of Chinese occupation due to earthworks and mining	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium The project area will disturb a moderate portion of the area where Chinese artefacts and evidence of previous settlement is likely to occur (i.e., in the valley, around Bawdwin and near the open pit).	**Low** These fragments are expected to be widespread in the valley and disturbance of portion of these artefacts and evidence due to the project development is considered to be of low severity. **Low** Additionally, where features are able to be translocated and preserved, it is considered that in those cases such opportunities may provide for positive outcomes in a cultural heritage context and allow some of the associated value of the features to be retained.	**High** Disturbance of sites may be able to be remediated in some cases, but in other cases it may be permanent damage.	**Low**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	Medium The field survey was limited to surface observations only from a single site visit. There is uncertainty in the location and number of possible subsurface heritage features and artefacts, which cannot be confirmed until excavation works are conducted. It is assumed that some evidence of Chinese occupation will be disturbed based on the proximity of the pit to historic Chinese mining practices and residences.			

The residual impact of loss of larger/rarer artefacts (rather than smaller and less significant artefacts) and evidence of Chinese occupation during the construction and operations phases will be of **major significance**, based on the **high magnitude** of impact and the **high sensitivity** of the features (Table 6.185).

Table 6.185 Residual impact significance summary – construction and operations phases – loss of larger/rarer artefacts and evidence of Chinese occupation due to earthworks and mining

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Larger/rarer artefacts and evidence of Chinese occupation</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>High
These features allow for an understanding of the Chinese occupation and the historic operation of the mine and hillfort system, and have high historic, scientific (archaeological) and technological importance.
While the known artefacts and evidence of Chinese occupation have been assigned a high importance, this rating is also conservatively applied to as yet unencountered artefacts and evidence. Since it is likely that archaeological evidence from the initial Chinese occupation and earlier periods (especially if from the Bronze Age) would have high historic, archaeological and technological importance. However, further assessment would be needed to confirm the actual importance of currently unknown features once discovered.</td><td>High
These features are vulnerable to being disturbed or destroyed due to the widespread location of features and likely presence of unknown features. Artefacts and other evidence generally hold higher significance if they can remain intact (including when in situ or when excavated) and their heritage context is understood.</td><td>Medium
The artefacts and evidence of Chinese occupation are expected to be widespread throughout the Nam Pangyun valley but concentrated in the valley floors. This material has already been subjected to substantial impact by historic mining and occupation with direct disturbance, placement of waste, mining and placement of buildings. Identification of features and artefact material may allow for its relocation, conservation and use in scientific research. The success of regaining the value of the features will be dependent on appropriate archaeological recording, analysis and reporting.</td><td>High</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact</th></tr>
<tr><td rowspan="6">Loss of larger/rarer artefacts and evidence of Chinese occupation due to earthworks and mining</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Medium
The project area will affect a moderate portion of the area where Chinese artefacts and evidence of previous settlement is likely to occur (i.e., in the valley, around Bawdwin and near the open pit).</td><td>High
These features would be completely destroyed.</td><td>Very high
The impact will be permanent.</td><td>High</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Major</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">Medium
The field survey was limited to surface observations only from a single site visit. There is uncertainty in the location and number of possible subsurface heritage features and artefacts, which cannot be confirmed until excavation works are conducted. It is assumed that some evidence of Chinese occupation will be disturbed based on the proximity of the pit to historic Chinese mining practices and residences.</td></tr>
</table>

The residual impact of disturbance of larger/rarer artefacts and evidence of Chinese occupation during the construction and operations phases will be of **high significance**, based on the **medium magnitude** of impact and the **high sensitivity** of the features (Table 6.186).

Table 6.186 Residual impact significance summary – construction and operations phases – disturbance of larger/rarer artefacts and evidence of Chinese occupation due to earthworks and mining

Value	Sensitivity of value			
Larger/rarer artefacts and evidence of Chinese occupation	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High These features allow for an understanding of the Chinese occupation and the historic operation of the mine and hillfort system, and have high historic, scientific (archaeological) and technological importance. While the known artefacts and evidence of Chinese occupation have been assigned a high importance, this rating is also conservatively applied to as yet unencountered artefacts and evidence. Since it is likely that archaeological evidence from the initial Chinese occupation and earlier periods (especially if from the Bronze Age) would have high historic, archaeological and technological importance. However, further assessment would be needed to confirm the actual importance of currently unknown features once discovered.	**High** These features are vulnerable to being disturbed or destroyed due to the widespread location of features and likely presence of unknown features. Artefacts and other evidence generally hold higher significance if they can remain intact (including when in situ or when excavated) and their heritage context is understood.	**Medium** The artefacts and evidence of Chinese occupation are expected to be widespread throughout the Nam Pangyun valley but concentrated in the valley floors. This material has already been subjected to substantial impact by historic mining and occupation with direct disturbance, placement of waste, mining and placement of buildings. Identification of features and artefact material may allow for its relocation, conservation and use in scientific research. The success of regaining the value of the features will be dependent on appropriate archaeological recording, analysis and reporting.	**High**
Impact	**Magnitude of impact**			
Disturbance of larger/rarer artefacts and evidence of Chinese occupation due to earthworks and mining	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium The project area will affect a moderate portion of the area where Chinese artefacts and evidence of previous settlement is likely to occur (i.e., in the valley, around Bawdwin and near the open pit).	**Medium** Where features are able to be translocated and preserved, it is considered that in those cases such opportunities may provide for positive outcomes in a cultural heritage context and allow some of the associated value of the features to be retained.	**Very high** The impact will be permanent.	**Medium**
	Residual impact significance			**High**
	Assessment of uncertainty			
	Medium The field survey was limited to surface observations only from a single site visit. There is uncertainty in the location and number of possible subsurface heritage features and artefacts, which cannot be confirmed until excavation works are conducted. It is assumed that some evidence of Chinese occupation will be disturbed based on the proximity of the pit to historic Chinese mining practices and residences.			

Modification of surrounding landscape

Notwithstanding avoidance and management measures in place, the following heritage features are predicted to have their aesthetic, spiritual and social qualities diminished due to nearby landscape modifications (i.e., rather than being directly disturbed) via construction of buildings, embankments, dumps and infrastructure; and air and dust emissions:

- Chinese hillforts and defended ridges (treated as a collective system – see section 6.9.2).
- Religious sites at Bawdwin (two sites)
- Graveyards in the central study area between the open pit and tailings storage embankment, adjacent to the southern boundary of the open pit, near the mine services area and adjacent to the northern plant road and process plant.
- Central Bawdwin precinct
- Bawdwin village buildings
- Tiger Camp precinct
- Tiger Camp village buildings

These impacts are assessed below.

Chinese hillforts and defended ridges

Chinese hillforts and defended ridges are elevated fortified structures in the topography such that they overlook the valley and surrounds. Their landform and position in the landscape are major contributors to their inherent value as an historic defence system. While largely avoided by the project footprint, project components will modify the landscape around the hillforts and defended ridges, particularly in the central and north portions of the study area (see Figure 6.25). In these areas, the hillforts and defended ridges will be surrounded by the process plant, power station (and emissions plume), haul roads, open pit and Wallah Gorge waste dump – all of which will be significant changes to the landscape. The remainder of the hillforts and defended ridges system to the south and west is unlikely to be impacted given its greater distance from the project.

The residual impact of modification of the landscape surrounding the hillfort during the construction and operations phases and defended ridges system will be of **high significance**, based on the **high magnitude** of impact and the **medium sensitivity** of the features (Table 6.187).

Table 6.187 Residual impact significance summary – construction and operations phases - reduced heritage values due to modification of landscape Chinese hillforts and defended ridges

Value	**Sensitivity of value**			
Chinese hillforts and defended ridges	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High These features are unique to Bawdwin, have high aesthetic, historic, scientific (archaeological) and technological importance and are highly likely to be classified as critical heritage under IFC Performance Standard 8	**Medium** These features are located in prominent positions of the landscape and are vulnerable to changes to both the feature and surrounding landscape	**Medium** These features would be able to withstand some localised changes to the surrounding landscape, but cultural heritage values would be difficult to re-establish if damaged	**Medium**
Impact	**Magnitude of impact**			
Reduced heritage values due to modification of landscape surrounding Chinese hillforts and defended ridges	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	High Extensive landscape change as approximately 1 to 2 km of the hillforts and defended ridge system (approximately one-third of the total system) will experience significant surrounding landscape change (even in the context of existing mining-related landscape changes), representing impact of a major proportion of the feature.	**High** Changes to the surrounding landscape will be significant and is expected to reduce the level of prominence of the hillforts and defended ridges in the central and north study area. The viewsheds from the hillforts and defended ridges themselves will also be adversely affected.	**High to very high** the impact will be long term in the case of buildings (i.e., until they are decommissioned) but the changes in topography (i.e., open pit and tailings storage facility and waste rock dumps) will be permanent.	**High**
	Residual impact significance			**High**
	Assessment of uncertainty			
	Low Three-dimensional visualisation of the predicted changes to landscape demonstrates that changes to surrounding landform will be significant and the hillforts are likely to lose some of their prominence in the landscape.			

Bawdwin religious sites

Two temples (Dha Mi Kha Ya Ma Buddhist temple and Chinese temple) will experience extensive change to their surrounding landscape. These religious sites will be surrounded by the open pit to the south, haul roads to the east and tailings storage embankment to the northwest. This could diminish aesthetic, spiritual or social value of these sites. These will be long term impacts for buildings and permanent for landform modifications. Of the three religious sites, the Dha Mi Kha Ya Ma Buddhist temple is on a hilltop and probably has the highest associated aesthetic value. While the Chinese temple is located on a prominent spur it is not currently used by the community.

The residual impact of modification of the landscape surrounding religious sites in Bawdwin and Tiger Camp during the construction and operations phases will be of **low significance**, based on the **low magnitude** of impact and the **medium sensitivity** of the features (Table 6.188).

Table 6.188 Residual impact significance summary – construction and operations phases – reduced heritage values due to modification of landscape surrounding Bawdwin and Tiger Camp religious sites

Value	Sensitivity of value			
Bawdwin and Tiger Camp religious sites	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium to high Religious sites are valuable to communities and have high social and spiritual significance	**Low to medium** The sites are susceptible to loss of aesthetic value	**Medium to high** Most or all of their value would probably remain if changed or relocated	**Medium**
Impact	**Magnitude of impact**			
Reduced heritage values due to modification of landscape surrounding Bawdwin religious sites	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very low Extensive landscape change, however only two of the nineteen identified religious sites in Bawdwin and Tiger Camp will be impacted, representing impacts to less than 10% of religious sites.	**Low** It is likely that the sites will still retain some (or possibly most) of their aesthetic, spiritual or social value, particularly in the context of existing mining and industrial operations in the broader area. Communities from the area will be resettled during project operations and will be provided with alternative religious places.	**High to very high** The impact will be long term in the cases of buildings (i.e., until they are decommissioned) but the changes in topography (i.e., open pit and tailings storage facility and waste rock dumps) will be permanent.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Low Three-dimensional visualisation of the predicted changes to landscape demonstrate that changes to surrounding landform will be significant. However, it is unlikely the impact magnitude and significance would be greater than low, given the location of the sites within and around an existing mining landscape.			

Graveyards

The landscape will be significantly modified around existing known graveyards as follows:

- Area between the open pit and tailings storage embankment (central study area):
  - Burmese graveyard located in a small side gully off the main Nam Pangyun valley. This graveyard is still in use.
  - Chinese cemetery on a vegetated ridge. The graveyard is overgrown and not in use.
  - Chinese, Christian and Myanmar graves located on a ridge. These vary from small piles of stones and small headstones to larger cement tombs. The graveyard appears recent and is probably still in use.
- Adjacent to the southern boundary of the open pit:
  - Chinese graves located on the crest of Meingtha Ridge and marked by stone mounds.
  - Graves of unknown ethnicity located on the hillside beside the Catholic Church.
- Near the mine services area:
  - Chinese graves comprising two distinctive stone mounds beside two large earth mounds, with more graves scattered down the ridgeline.
- Adjacent to the northern plant road and process plant:
  - Chinese graveyard comprising a number of stone-ringed mounds and piles of displaced stone, which mark the graves.
  - Chinese graveyard located on a crest of a ridge with a range of grave types, including simple mound as well as more elaborate graves with headstones. There is evidence of artisanal mining in and around the graves.
  - Chinese graveyard located on the ridgeline to the southeast of Mt Battle. The graveyard consists of a number of stone mounds on the crest of the descending ridge.
  - Chinese graveyard located on the ridge to the east of Hillfort 20. Graves are marked by stone outlines and low stone mounds.

As these sites are generally located on prominent ridges and crests, they are expected to have high aesthetic and spiritual value and are vulnerable to changes in the surrounding landscape.

The residual impact of modification of the landscape surrounding graveyards during the construction and operations phases will be of **high significance**, based on the **medium magnitude** of impact and the **high sensitivity** of this feature (Table 6.189).

Table 6.189 Residual impact significance summary – construction and operations phases – reduced heritage values due to modification of landscape surrounding graveyards

Value	**Sensitivity of value**			
Graveyards	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Modern graveyards probably have social and spiritual value to existing communities, whilst older graveyards probably have bioarchaeological and historical value	**High** Graveyards are highly vulnerable to disturbance because human remains should always be treated with dignity and respect and this cannot be always achieved if accidentally encountered or damaged	**Low to medium** Damage to or loss of graveyards cannot be reversed and if relocated the original heritage value may be lost	**High**
Impact	**Magnitude of impact**			
Reduced heritage values due to modification of landscape surrounding graveyards	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Extensive landscape change impacting around half of the known graveyards with 10 of the 21 known graveyards will be impacted by landscape modification, representing half of the known graveyards.	**Medium** Due to the context of existing changes to the landscape and viewsheds due to historic mining and associated activities. As these graveyards would have all been established after mining of the nearby landscape had commenced, a level of surrounding landscape modification would have been experienced (and expected) by those that originally constructed them and those that visit those graveyards to this day.	**High to very high** The changes to the surrounding landscape will be in some cases long term (i.e., buildings and plant emissions) and for other cases permanent (tailings storage embankments, haul roads and open pit).	**Medium**
	Residual impact significance			**High**
	Assessment of uncertainty			
	Medium Three-dimensional visualisation of the predicted changes to landscape demonstrate that changes to surrounding landform will be significant. There is some uncertainty as to how alterations to surrounding landscape would detract from cultural heritage value of some graveyards given many were located in prominent positions based on views over the valley, although with an existing degree of visual impact from long running mining at Bawdwin.			

Central Bawdwin precinct

The central Bawdwin precinct contains a group of key structures (e.g., mine office, clubhouse, Dead Chinaman Tunnel, Bawdwin timberyard, compressor house) relating to historic mine operation and key buildings of importance to the wider community (e.g., post office, company store, railway station). This has been a key area of social importance throughout Bawdwin's history, from the early Chinese, through to the Colonial period, to the current day.

The southern portion of the open pit mine footprint will be within 100 to 200 m of the central Bawdwin precinct to the north and east (see Figure 6.25). In this area, the visual landscape will change with the extension of the open pit and the change is considered significant as the open pit will essentially cut off the top of the ridgeline adjacent to the precinct.

The residual impact of modification of the landscape surrounding the central Bawdwin precinct during the construction and operations phases will be of **moderate significance**, based on the **medium magnitude** of impact and the **medium sensitivity** of the features (Table 6.190).

Table 6.190 Impact significance summary - Reduced heritage values due to modification of landscape surrounding Central Bawdwin precinct

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Central Bawdwin precinct</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>High
The precinct contains key structures of importance to historic mine operations and the modern wider community, and was assessed as having high historic, scientific (archaeological), technological and social importance This precinct contains key structures relating to historic mine operation and key buildings of importance to the wider community. This precinct has been a key area of social importance throughout Bawdwin's history, from the early Chinese, through to the Colonial period, to the current day. While the significance of each building or structure within this precinct may vary in its specific values and attributes, it is important to recognise the heritage value of this area as a whole.
This precinct was assessed as having high historic, scientific (archaeological), technological and social importance.</td><td>Medium
This precinct has some vulnerability to loss of heritage value as it is in a fixed location and setting that cannot be moved. This is relevant to both changes to the visual setting (i.e., if additional buildings are to be constructed nearby in the future), or if they may be impacted directly to make way for more modern infrastructure for development of the project.
While wooden and metal buildings and structures have been, and will continue to be, exposed to weathering and degradation (i.e., corrosion, rotting, erosion of adjacent ground, etc.), ongoing natural degradation of these is not expected to materially influence the vulnerability of their heritage value over the project timescale.</td><td>Medium
The area would be able to withstand some localised changes in terms of additional buildings and changes to the landscape without materially affecting the aesthetic, historic and social appeal of the area as a whole</td><td>Medium</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact</th></tr>
<tr><td rowspan="6">Reduced heritage values due to modification of landscape surrounding Central Bawdwin precinct</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>High
Extensive landscape change (most of the viewshed surrounding the precinct will change).</td><td>Medium
Given that the precinct, its buildings and their values are associated with the mining context, it is unlikely that increased visibility of a nearby open pit mining operation would significantly reduce the historic and social values of the area as a whole but may materially reduce aesthetic value.</td><td>Very high
Changes to the landscape will be permanent.</td><td>Medium</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Moderate</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">Low
Three-dimensional visualisation of the predicted changes to landscape demonstrate that changes to surrounding landform will be significant. However, it is unlikely the impact significance would be greater than moderate, given the location of the sites within and around an existing mining landscape.</td></tr>
</table>

Tiger Camp precinct

This precinct contains a group of key industrial structures and buildings associated with historic mine operation (e.g., Tiger Tunnel and electric railway, railway yards, tippler and ore bins). It is an important industrial archaeological area that has also historically been an important workplace.

The residual impact of modification of the landscape surrounding the Tiger Camp precinct during the construction and operations phases will be of **low significance**, based on the **low magnitude** of impact and the **medium sensitivity** of the features (Table 6.191).

Table 6.191 Residual impact significance summary – construction and operations phases – reduced heritage values due to modification of landscape surrounding Tiger Camp precinct

Value	Sensitivity of value			
Tiger Camp precinct	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High This precinct contains a group of key industrial structures and buildings associated with historic mine operation (e.g., Tiger Tunnel and electric railway, railway yards, tippler and ore bins). It is an important industrial archaeological precinct, containing evidence for the development of the mine and the use of electric motive power. Overall the precinct was assessed to have high historic and technological significance. The precinct is not likely to be classified as critical heritage under IFC Performance Standard 8.	**Medium** This precinct has some vulnerability to loss of heritage value as it is in a fixed location and setting that cannot be moved. This is relevant to both changes to the visual setting (i.e., if additional buildings are to be constructed nearby in the future), or if they may be impacted directly to make way for more modern infrastructure for development of the project. While wooden and metal buildings and structures have been, and will continue to be, exposed to weathering and degradation (i.e., corrosion, rotting, erosion of adjacent ground, etc.), ongoing natural degradation of these is not expected to materially influence the vulnerability of their heritage value over the project timescale.	**Medium** The area would be able to withstand some localised changes in terms of additional buildings and changes to the landscape without materially affecting the aesthetic, historic and social appeal of the area as a whole.	**Medium**
Impact	**Magnitude of impact**			
Reduced heritage values due to modification of landscape surrounding Tiger Camp precinct	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Minor landscape change as the only key change to the surrounding area will be due to construction of the explosives facility adjacent and to the west of the precinct, and are not in the immediate vicinity of key buildings and structures (only a small portion of the viewshed will be affected).	**Low** The degree of landscape change will be minor with the area able to withstand localised changes without losing the values associated with the key industrial structures and buildings as a collective. The impact is not expected to materially reduce the aesthetic or social heritage value of the Tiger Camp precinct.	**High** Changes to the landscape will be long term.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			

	Low Three-dimensional visualisation of the predicted changes to landscape demonstrate that changes to surrounding landform will be of low severity in this location. It is unlikely the impact significance would be greater than low, given the location of the sites within and around an existing mining landscape.

Tiger Camp buildings

The residual impact of modification of the landscape surrounding Tiger Camp buildings during the construction and operations phases will be of **low significance**, based on the **low magnitude** of impact and the **medium sensitivity** of the features (Table 6.192).

Table 6.192 Residual impact significance summary – construction and operations phases – reduced heritage values due to modification of landscape surrounding Tiger Camp buildings

Value	**Sensitivity of value**			
Tiger Camp buildings	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium The buildings include the stone stores which have medium historical significance as they are an example of the development of permanent community resources in early Bawdwin	**Medium** While these buildings are located away from proposed project activities, they're susceptible to loss of aesthetic value to changes nearby	**Medium** Most or all of the heritage value would remain after change, provided the key characteristics (i.e., key buildings and any important contents) were not lost or materially altered	**Medium**
Impact	**Magnitude of impact**			
Reduced heritage values due to modification of landscape surrounding Tiger Camp buildings	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Minor landscape change as the only key change to the surrounding area will be due to construction of the explosives facility adjacent and to the west of the precinct, and are not in the immediate vicinity of key buildings and structures (only a small portion of the viewshed will be affected).	**Low** The degree of landscape change will be minor with the area able to withstand localised changes without losing the values associated with the key industrial structures and buildings as a collective. The impact is not expected to materially reduce the aesthetic or social heritage value of the Tiger Camp precinct.	**High** Changes to the landscape will be long term.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Low Three-dimensional visualisation of the predicted changes to landscape demonstrate that changes to surrounding landform will be of low severity in this location. It is unlikely the impact significance would be greater than low, given the location of the sites within and around an existing mining landscape.			

Restriction of access to sites

To manage health, safety and security, heritage features that are likely to have access restricted are those closest to and surrounded by project infrastructure and activities. These instances are described, and impacts assessed, below.

This assessment addresses restricted access for the local community only. It is considered that over the timescale of the project, the site will not be a key heritage tourism location or area of archaeological or heritage study for outside visitors but rather those opportunities may be realised at some stage in the future after mining operations cease. Therefore, this impact assessment does not address the impact of restricted access to outside (i.e., visitors from within Myanmar and from overseas) visitors.

Chinese hillforts and defended ridges

Access to sections of the Chinese hillforts and defended ridges along the northern plant haul road and processing plant site will be restricted. Access to the other southern and western parts of the system will remain as is.

The residual impact of restriction of access to the hillfort and defended ridges system during the construction and operations phases will be of **low significance**, based on the **low magnitude** of impact and the **medium sensitivity** of the features (Table 6.193).

Table 6.193 Residual impact significance summary – construction and operations phases – restricted access to Chinese hillforts and defended ridges

Value	**Sensitivity of value**			
Chinese hillforts and defended ridges	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High These features are unique to Bawdwin, have high aesthetic, historic, scientific (archaeological) and technological importance and are highly likely to be classified as critical heritage under IFC Performance Standard 8	**High** These features are located in prominent positions of the landscape and are highly vulnerable to changes to both the feature and surrounding landscape. Hillfort 4, however, is considered to have **medium** vulnerability as it is already highly damaged.	**Medium** These features would be able to withstand some localised changes to the surrounding landscape, but cultural heritage values would be difficult to re-establish if damaged	**Medium**
Impact	**Magnitude of impact**			
Restricted access to Chinese hillforts and defended ridges	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	High Access largely prevented with the development of the project.	**Very low** The degree to which the local community currently accesses the site is not clear but the value of this feature is most likely based on its visual presence in the landscape rather than from being accessed. Loss of access is unlikely to significantly affect the associated value of the Chinese hillforts and defended ridges system.	**High** Access around this area will be restricted in the long term during both construction and operations.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Low Although the degree to which the local community currently accesses (and values) the hillforts and defended ridges is not clear, loss of access is unlikely to significantly affect the associated value of the Chinese hillforts and defended ridges system and the impact is unlikely to be greater than low significance.			

Bawdwin religious sites

Access will be restricted to Bawdwin religious sites, which will be surrounded by the Bawdwin open pit and tailings storage embankment, haul road and mine services area. Local communities still use the majority of these sites and as such they have important spiritual and social values. Access to these sites will be tightly controlled to manage safety around the mining activities but this is consistent with previous practices throughout operation of the mine in the modern era and as such would be expected or anticipated by the local community.

It is not clear, for each religious site, whether the community will want to return during or after project construction and operations. This will need to be determined by community consultation and development of site-specific management approaches with religious leaders.

Subject to community feedback and health and safety considerations, the project may provide intermittent community access to religious sites for certain events and maintenance activities or, if required, carry out maintenance of buildings on behalf of the community. In addition, the project will commit to providing alternative religious sites outside the project area if deemed appropriate during community consultation.

As the requirements of the community and specific management approaches for each of the religious sites will not be confirmed until after further stakeholder engagement (with religious leaders, affected community and relevant Myanmar authorities), this impact is associated with a moderate degree of uncertainty.

The residual impact of restriction of access to religious sites in Bawdwin and Tiger Camp during the construction and operations phases will be of **moderate significance**, based on the **medium magnitude** of impact and the **medium sensitivity** of the features (Table 6.194).

Table 6.194 Residual impact significance summary – construction and operations phases – restricted access to Bawdwin religious site

Value	**Sensitivity of value**			
Bawdwin and Tiger Camp religious sites	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium to high Religious sites are valuable to communities and have high social and spiritual significance	**Low to medium** The sites are susceptible to restricted access given their locations amongst project activities	**Medium to high** Most or all of their value would probably remain if changed or relocated	**Medium**
Impact	**Magnitude of impact**			
Restricted access to Bawdwin religious sites	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	High Access will be restricted to all religious sites in Bawdwin.	**Very low** While access will largely be restricted to the present religious sites, there will be support for alternative religious services, either new or relocated. The project will consult with the community to determine arrangements to allow continuation of religious practices by the community. Depending on community feedback, the project may provide intermittent access to existing sites (subject to health and safety risks) for certain events and maintenance activities or carry out maintenance on behalf of the community if required. Overall, with this range of management approaches, loss of cultural heritage value of existing religious sites is predicted to be very low.	**High** This impact has the potential to be long term (i.e., during construction and operations)	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	Medium The requirements of the community and specific management approaches for each of the religious sites will not be confirmed until after further community consultation (and with Myanmar authorities). It is currently not confirmed whether the community would prefer to return to existing religious sites or be more content with alternative sites provided. The uncertainty is limited however, given that the project has a range of approaches to manage this impact to suit the requirements of the community and Myanmar authorities. Further, community consultation to date has not indicated the loss of access to existing religious sites as being a concern of local people.			

Central Bawdwin precinct

Access will be restricted to and within the Central Bawdwin precinct, which will be adjacent to open pit mining operations. This area is unlikely to have high heritage importance to the local community given that most of the key features of cultural heritage value will probably be relocated to a mining museum (subject to confirmation with Myanmar authorities ((i.e., the Department of Archaeology and National Museum of MORAC or its delegate and ME-1) and community). It is anticipated that features that will remain in situ will include the compressor house and Bawdwin timber yard. . The project will avoid direct disturbance of these features. Depending on feedback from Myanmar authorities and the community the project will allow periodic maintenance to be carried out (subject to safe access) or WMM will conduct the maintenance on behalf of the community, if required. Access will be tightly controlled given this is central part of the project area; however, the community is unlikely to have high cultural heritage connection to the sites remaining in situ. However, this and the requirement for community access will be confirmed during community consultation, and as such there is a moderate level of uncertainty with the assessment of this impact.

The residual impact of restriction of access to the central Bawdwin precinct during the construction and operations phases will be of **low significance**, based on the **low magnitude** of impact and the **medium sensitivity** of the features (Table 6.195).

Table 6.195 Residual impact significance summary – construction and operations phases – restricted public access to and within the Central Bawdwin precinct

Value	**Sensitivity of value**			
Central Bawdwin precinct	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The precinct contains key structures of importance to historic mine operations and the modern wider community, and was assessed as having high historic, scientific (archaeological), technological and social importance. However, for this particular impact, the area is deemed to be of **medium importance** once the key features of cultural heritage significance (e.g., mine office, post office, timekeeper's office, company store, rail station, lower management house and specimens of workers' houses) are relocated to a mining museum and sites of lower cultural heritage value (compressor house and timber yard) remain in situ	**Medium** The precinct has some vulnerability to loss of heritage value as it is in a fixed location and setting that cannot be moved	**Medium** The area would be able to withstand some localised changes in terms of additional buildings and changes to the landscape without materially affecting the aesthetic, historic and social appeal of the area as a whole	**Medium**
Impact	**Magnitude of impact**			
Restricted public access to and within the Central Bawdwin precinct	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Very limited access to the Central Bawdwin precinct, although features of highest value will be accessible in a mining museum/precinct (subject to directives from Myanmar authorities and the community).	**Very low** Access will be restricted to the most apparent historically important area in the context of previous mining activities, however operation of the mine and employment opportunities are likely to take precedence over the restriction of access. Also, access restriction is consistent with previous practices throughout operation of the mine in the modern era and as such would be expected or anticipated by the local community. Access to the key features of cultural heritage value will be maintained in the form of a mining/museum, which will also aid in preserving these items from degradation. It is unlikely that the community will have high cultural heritage connection to the sites remaining in situ and any restricted access would be very low severity in the context of the range of management approaches outlined.	**High** This impact has the potential to be long term (i.e., during construction and operations)	**Low**
	Residual impact significance			**Low**

	Assessment of uncertainty
	Medium The requirements of the community and specific management approaches for each of the sites will not be confirmed until after further community consultation (and with Myanmar authorities). It is currently not confirmed whether the community would prefer to return to features to remain in situ for cultural heritage connection or maintenance of the features. The uncertainty is limited however, given that the project has a range of approaches to manage this impact to suit the requirements of the community and Myanmar authorities.

Bawdwin village buildings

After the Bawdwin lower village community is resettled there will be no community access to and around Bawdwin village area. The Bawdwin village buildings will be surrounded by the Bawdwin open pit and tailings storage embankment, haul road and mine services area. The Bawdwin village buildings comprise mostly old housing from the Colonial period which are in variable condition. These buildings and structures range in historical cultural heritage value from low (post- second world war buildings) to medium (pre- second world war buildings). Some of these buildings may be used by the project for accommodation (where deemed suitable) during the early stages of project construction. The buildings will be assessed for cultural heritage value before being removed. Old buildings from the Chinese bazaar and the Chinese-era stone revetment have higher cultural heritage value but it is unlikely that the community will have strong connection to these features that would be disrupted once the community is resettled elsewhere. If identified during community consultation and engagement with Myanmar authorities (i.e., the Department of Archaeology and National Museum of MORAC or its delegate), that certain buildings are preferred to be maintained or relocated, or alternative buildings provided elsewhere, this will be addressed on a case-by-case basis and in consultation with the Myanmar authorities.

The residual impact of restriction of access to Bawdwin village buildings during the construction and operations phases will be of **low significance**, based on the **low magnitude** of impact and the **medium sensitivity** of the features (Table 6.196).

Table 6.196 Residual impact significance summary – construction and operations phases – restriction of access to and around Bawdwin village buildings

Value	**Sensitivity of value**			
Bawdwin village buildings	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium The buildings of key cultural heritage significance include the remaining stone buildings in the Chinese Bazaar area and the remains of ancient Chinese bridges in the Goldhole Valley area. These buildings have medium historical and scientific significance as remaining evidence of the early colonial-period Chinese community at Bawdwin.	**Medium** The Bawdwin village buildings are vulnerable to loss of aesthetic value from landscape changes in proximity to these sites and vulnerable to direct disturbance as they are in a fixed location close to existing mining operations. While wooden and metal buildings and structures have been, and will continue to be, exposed to weathering and degradation this does not materially influence the vulnerability of their heritage value over the project timescale.	**Medium** The area would be able to withstand some localised changes in terms of additional buildings and changes to the landscape without materially affecting the aesthetic, historic and social appeal of the area as a whole	**Medium**
Impact	**Magnitude of impact**			
Restriction of access to and around Bawdwin village buildings	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Very limited access to and within the village buildings, although depending on the approach to managing the impact, buildings and structures may be relocated or alternatives provided, resulting in impact to only some of these features.	**Very low** Access restriction is consistent with previous practices throughout operation of the mine in the modern era and as such would be expected or anticipated by the local community. In addition, some people who currently reside in the area will be resettled to safer areas with access to other services and resources. Access to the key features of cultural heritage value will be maintained in the form of a mining/museum, which will also aid in preserving these items from degradation. It is unlikely that the community will have high cultural heritage connection to the sites remaining in situ and any restricted access would be very low severity in the context of the range of management approaches outlined.	**High** This impact has the potential to be long term (i.e., during construction and operations). Some buildings will be removed permanently.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Medium The requirements of the community and specific management approaches for each of the sites will not be confirmed until after further community consultation (and with Myanmar authorities). It is currently not confirmed whether the community would prefer to return to features to remain in situ for cultural heritage connection or maintenance of the features. The uncertainty is limited however, given that the project has a range of approaches to manage this impact to suit the requirements of the community and Myanmar authorities.			

Tiger Camp precinct

This precinct contains a group of key industrial structures and buildings associated with historic mine operation (e.g., Tiger Tunnel and electric railway, railway yards, tippler and ore bins). It is an important industrial archaeological area that has also historically been an important workplace. The key features of cultural heritage value (or in some cases, examples of) will be either relocated to a mining museum/precinct (i.e., tippler, electric locomotive, man cars, ore wagons – some of which potentially as functioning exhibits) or protected in situ (i.e., ore bins, electric rail bed and track, Tiger Tunnel portal and approach). Active maintenance may be carried out by the project or facilitated access to the community subject to safety considerations and feedback from the community and Myanmar authorities (i.e., the Department of Archaeology and National Museum of MORAC or its delegate) on the preferred management approaches.

Given that community access to the key features of higher cultural heritage value will be maintained, although in a new location (mining museum) and some limited access may be facilitated, the residual impact of restriction of access to the central Tiger Camp precinct during the construction and operations phases will be of **low significance**, based on the **low magnitude** of impact and the **medium sensitivity** of the features (Table 6.197).

Table 6.197 Residual impact significance summary – construction and operations phases – restricted public access to and within the Central Tiger Camp precinct

Value	**Sensitivity of value**			
Central Tiger Camp precinct	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The precinct contains key structures of importance to historic mine operations and is an important industrial archaeological area, with high historic and technological significance	**Medium** The precinct has some vulnerability to loss of heritage value as it is in a fixed location and setting that cannot be moved	**Medium** The area would be able to withstand some localised changes in terms of additional buildings and changes to the landscape without materially affecting the aesthetic, historic and social appeal of the area as a whole	**Medium**
Impact	**Magnitude of impact**			
Restricted public access to and within the Central Tiger Camp precinct	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Very limited access at all religious sites in the Tiger Camp precinct. Although depending on the approach to managing the impact, buildings and structures may be relocated or alternatives provided, resulting in impact to only some of these features.	**Very low** Access restriction is consistent with previous practices throughout operation of the mine in the modern era and as such would be expected or anticipated by the local community. In addition, some people who currently reside in the area will be resettled to safer areas with access to other services and resources. Access to the key features of cultural heritage value will be maintained in the form of a mining/museum, which will also aid in preserving these items from degradation. It is unlikely that the community will have high cultural heritage connection to the sites remaining in situ and any restricted access would be very low severity in the context of the range of management approaches outlined.	**High** This impact has the potential to be long term (i.e., during construction and operations). Some buildings will be removed permanently.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Medium The requirements of the community and specific management approaches for each of the sites will not be confirmed until after further community consultation (and with Myanmar authorities). It is currently not confirmed whether the community would prefer to return to features to remain in situ for cultural heritage connection or maintenance of the features. The uncertainty is limited however, given that the project has a range of approaches to manage this impact to suit the requirements of the community and Myanmar authorities.			

Tiger Camp village buildings

Access will be restricted to and around Tiger Camp village, since the new access road between Namtu and Tiger Camp will not be for public use. The Tiger Camp village buildings comprise mostly old housing from the Colonial period which are in variable condition and the buildings and structures range from low (post-war buildings) to medium (pre-war buildings) historical cultural heritage value. Many of these will be used by the project for accommodation (where deemed suitable) and may be removed prior to operations to avoid squatting. The buildings will be assessed for cultural heritage value before being removed. It is unlikely that the community will have strong connection to these buildings that would be disrupted once the community is resettled elsewhere. If identified during community consultation and engagement with the Myanmar authorities, that certain buildings are preferred to be maintained or relocated, or alternative buildings provided elsewhere, this will be addressed on a case by case basis and in consultation with the Myanmar authorities (i.e., the Department of Archaeology and National Museum of MORAC or its delegate and ME-1).

The residual impact of restriction of access to Tiger Camp village buildings will be of **low significance**, based on the **low magnitude** of impact and the **medium sensitivity** of the features (Table 6.198).

Table 6.198 Residual impact significance summary – construction and operations phases – restriction of access to and around Tiger Camp village buildings

Value	**Sensitivity of value**			
Tiger Camp village buildings	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium The buildings include the stone stores which have medium historical significance as they are an example of the development of permanent community resources in early Bawdwin. The buildings are unlikely to be considered critical heritage under IFC Performance Standard 8.	**Medium** The sites are vulnerable to some loss of aesthetic value from landscape changes or if other buildings are constructed in proximity to these sites. They are also vulnerable to direct disturbance as they are in a fixed location. While wooden and metal buildings and structures have been, and will continue to be, exposed to weathering and degradation (i.e., corrosion, rotting, erosion of adjacent ground, etc.), ongoing natural degradation of these is not expected to materially influence the vulnerability of their heritage value over the project timescale.	**Medium** The precinct would probably still retain most or all of its heritage value after change, provided the key characteristics (i.e., key buildings and any important contents) were not lost or materially altered. As this feature is a collection on buildings, it does provide some resilience to localised changes.	**Medium**
Impact	**Magnitude of impact**			
Restriction of access to and around Tiger Camp village buildings	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Very limited access to and within the Tiger Camp village buildings. Although depending on the approach to managing the impact, buildings and structures may be relocated or alternatives provided, resulting in impact to only some of these features.	**Very low** Replacement buildings will be provided at the resettlement location. Existing buildings are likely to have low value to communities that are being resettled to newer and safer housing. It is unlikely that the community will have high cultural heritage connection to the sites remaining in situ and any restricted access would be very low severity in the context of the range of management approaches outlined.	**High** This impact has the potential to be long term (i.e., during construction and operations). Some buildings will be removed permanently.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Medium The requirements of the community and specific management approaches for each of the sites will not be confirmed until after further community consultation (and with Myanmar authorities). It is currently not confirmed whether the community would prefer to return to features to remain in situ for cultural heritage connection or maintenance of the features. The uncertainty is limited however, given that the project has a range of approaches to manage this impact to suit the requirements of the community and Myanmar authorities.			

Summary of residual impacts

As described above, much of the cultural heritage at Bawdwin relates to the continued mining presence over the last six centuries. The development of the project will continue this mining operation into modern times, but as a consequence there will be loss of some of the existing (historical) infrastructure. This will fundamentally alter the current historical mining context, but provides an opportunity to document, research and conserve aspects of the past operations. Proposed measures are aimed to minimising impacts to known cultural heritage sites, and where avoidance is not possible putting in measures to comprehensively document and preserve key items to highlight and display the history of the Bawdwin mine into the future.

Table 6.199 provides a summary of the residual impacts and their significance.

Table 6.199 Summary of assessment of residual cultural heritage impacts

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Direct loss due to earthworks and mining	Chinese era mining and smelting evidence (known sites of mining (underground workings) and smelting) • High sensitivity	Construction and operations	High magnitude • Medium spatial extent • High severity • Very high duration	• Avoidance through design, where practicable • Declare historical sites and objects to authorities • Record and document historical sites and objects • Ground disturbance permit process • Pre-disturbance surveys • Archaeological excavation, research, analysis and conservation of artefacts • In situ protection (i.e., no go zones) • Chance finds procedure	Major	Permanent loss of rare and highly sensitive cultural heritage features.	Low • It is known that these items will be within the mining footprint and will be lost permanently
Disturbance due to earthworks and mining	Currently unknown but expected Chinese era smelting evidence (furnaces) • High sensitivity	Construction and operations	Medium magnitude • Medium spatial extent • Medium severity • Very high duration	• Avoidance through design, where practicable • Declare historical sites and objects to authorities • Record and document historical sites and objects • Ground disturbance permit process • Pre-disturbance surveys • Archaeological excavation, research, analysis and conservation of artefacts • In situ protection (i.e., no go zones) • Chance finds procedure	High	Permanent damage to rare and sensitive cultural heritage features. May result in partial loss of inherent value.	Medium • Field survey limited to surface observations from a single site visit • Uncertainty in the location and number of subsurface features and artefacts

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Direct loss due to earthworks and mining	Chinese stone bridge foundation • High sensitivity	Construction and operations	Very high magnitude • Very high spatial extent • High severity • Very high duration	• Avoidance through design, where practicable • Declare historical sites and objects to authorities • Record and document historical sites and objects • Ground disturbance permit process • Pre-disturbance surveys • Archaeological excavation, research, analysis and conservation of artefacts • In situ protection (i.e., no go zones) • Chance finds procedure	Major	Permanent loss of the last known Chinese Bridge foundation in Bawdwin, a feature of key cultural heritage significance which provides evidence of the early Chinese community at Bawdwin.	Low • It is known that the bridge will be lost during project construction
	Chinese bazaar buildings • Medium sensitivity	Construction and operations	Very high magnitude • Very high spatial extent • High severity • Very high duration	• Avoidance through design, where practicable • Declare historical sites and objects to authorities • Record and document historical sites and objects • Ground disturbance permit process • Pre-disturbance surveys • In situ protection (i.e., no go zones) • Archaeological excavation, research, analysis and conservation of artefacts • Chance finds procedure	Major	Permanent loss of buildings of key cultural heritage significance which are evidence of the early colonial-period Chinese community at Bawdwin. However aspects of these buildings will be kept available for inclusion in museums. Some cultural heritage value will be lost as its value is associated with the buildings being complete and part of a group of historic buildings in a mining setting.	Low • It is known which buildings will be removed during construction

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Direct loss due to earthworks and mining	Graveyards (currently unknown) • High sensitivity	Construction and operations	Medium magnitude • Medium spatial extent • Medium severity • Very high duration	• Avoidance through design, where practicable • Declare historical sites and objects to authorities • Record and document historical sites and objects • Ground disturbance permit process • Pre-disturbance surveys • In situ protection (i.e., no go zones) • Chance finds procedure • Implement a process for the inspection, exhumation and archiving of graves with input from qualified archaeologists, regulators, the community and appropriate religious leaders. • For graveyards still in use, re-establish/relocate them as part of the community resettlement plan. • Conduct further engagement and investigation of graves from the Chinese mining era. For graves to be relocated, the process will involve culturally and legally sanctioned exhumation and relocation of individual graves.	High	Permanent loss of currently unknown graveyards that include human remains (highly sensitive features). This impact will be localised to the project footprint and management measures to relocate graves will be implemented.	Medium • Field survey limited to surface observations from a single site visit • Uncertainty in the location and number of graveyards • Sensitivity is highly subjective for individual graves

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Disturbance due to earthworks and mining	Graveyards (known) • High sensitivity	Construction and operations	Medium magnitude • Very low spatial extent • Medium severity • Very high duration	• Avoidance through design, where practicable • Declare historical sites and objects to authorities • Record and document historical sites and objects • Ground disturbance permit process • Pre-disturbance surveys • Chance finds procedure • In situ protection (i.e., no go zones) • Implement a process for the inspection, exhumation and archiving of graves with input from qualified archaeologists, regulators, the community and appropriate religious leaders. • For graveyards still in use, re-establish/relocate them as part of the community resettlement plan. • Conduct further engagement and investigation of graves from the Chinese mining era. For graves to be relocated, the process will involve culturally and legally sanctioned exhumation and relocation of individual graves.	High	Permanent disturbance of four graveyards that include human remains (highly sensitive features). Damage or loss will be permanent and despite relocation of the graveyards, cultural heritage value may be lost.	Low • It is known that the graveyards will be removed • Sensitivity is highly subjective for individual graves

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Loss due to being decommissioned and removed from project footprint	Religious sites (currently used and currently unused) for religious purposes (Aye Say Di Buddhists Temple, Dha Pu Nya Karyi Buddhist Chapel, Aung Mingalar Chapel, Aung Mingalar Temple, Thiri Mingalar Buddhist Chapel and the Sikh Temple) • Medium sensitivity	Construction	Low magnitude (Sikh Temple) • Medium spatial extent • Very low severity • Very high duration Medium magnitude (all other temples) • Medium spatial extent • Medium severity • Very high duration	• Consult with qualified archaeologists, regulators, the community and appropriate religious leaders to develop a process for managing the loss of religious sites • Where feasible, and in line with stakeholder feedback, provide alternative religious sites for the community	Low (Sikh Temple) Moderate (the Aye Say Di Bhuddist Temple and Dha Pu Nya Karyi Bhuddist Chapel)	Permanent loss of features. However, project will provide alternative access to religious sites. With the availability of alternative or new religious sites that accommodate the interests of the local community, it is likely that some values (to the community) will be retained. The impact for the Sikh Temple is lower given it does not have a congregation currently.	Medium • It is known which sites will be permanently removed • Importance to communities requires further investigation • Sensitivity may vary between community members and each site
	Colonial-period infrastructure – Marmion shaft and winding house • Medium to high sensitivity	Construction	Very high magnitude • Very high spatial extent • High severity • Very high duration	• Relocate Marmion shaft headframe and winding house to a mining museum/precinct, subject to feedback from community and regulators	Major	Permanent removal of a unique heritage feature that is likely to be classified as Critical Heritage under IFC guidelines and which has potential for international heritage recognition. The feature will be dismantled and reassembled in a museum (although not functioning).	Low • It is known that this feature will be disassembled and relocated • Assumed that the feature will be adequately managed in a museum by third parties once handed over by the project.
	Namtu to Bawdwin railway • Medium sensitivity	Construction	Very high magnitude • High spatial extent • Very high severity	• Where feasible, retain sections of the original railway • Reinstate or create sections of railway elsewhere (subject to	Major	Permanent loss of a unique heritage feature that is likely to be classified as Critical Heritage under IFC guidelines and which has potential for international heritage recognition. The railway between Namtu and Tiger Camp will be	Low • It is known that this feature will be disassembled and relocated

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
			• Very high duration	community and regulator feedback) • Preserve railway infrastructure in the mining museum/precinct		removed and some associated value will be lost. However some cultural heritage tourism value may be retained if reused.	• Potential reuse to be confirmed • Assumed that representative components of the feature will be adequately managed in a museum by third parties once handed over by the project.
	Independence monument • Low sensitivity	Construction	Low magnitude • Very high spatial extent • Low severity • Low duration	• Monument to be translocated in consultation with local community	Low	The monument can be relocated while retaining most of its heritage value.	Low • It is known that this feature will be removed and relocated.
Disturbance due to mining	Hillfort and defended ridges system • High sensitivity (Hillfort 4 medium)	Operations	Low magnitude • Low spatial extent • Low severity • Very high duration	• Avoidance through design, where practicable • Declare historical sites and objects to authorities • Record and document historical sites and objects • Ground disturbance permit process • Pre-disturbance surveys • Archaeological excavation, research, analysis and conservation of artefacts • In situ protection (i.e., no go zones) • Chance finds procedure	Moderate	Hillfort 4 will be lost, however this is only a small portion of the overall hillforts and defended ridge system. The remaining elements of the system still able to provide the inherent value of the overall feature.	Medium (Hillfort 4) • High potential for artefacts due to location • Site investigation required to investigate features and develop appropriate management measures
Loss due to earthwo	Smaller, widespread artefacts	Construction and operations	Medium magnitude • Medium	• Avoidance through design, where practicable	High	Significance of impact will depend on the feature affected (particularly its level of rarity and	Medium • Field survey limited to

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
rks and mining	and evidence of Chinese occupation • High sensitivity		spatial extent • Medium severity • Very high duration	• Declare historical sites and objects to authorities • Record and document historical sites and objects • Ground disturbance permit process • Pre-disturbance surveys • Archaeological excavation, research, analysis and conservation of artefacts • In situ protection (i.e., no go zones) • Chance finds procedure		distribution). Smaller, widespread artefacts include fragments of ceramics which are expected to be widespread in the valley and not particularly unique from that time period.	surface observations from a single site visit • Uncertainty in the location and number of subsurface features and artefacts • Some loss assumed based on pit location relative to historic mining activities
Disturbance due to earthworks and mining	Smaller, widespread artefacts and evidence of Chinese occupation • High sensitivity	Construction and operations	Low magnitude • Medium spatial extent • Low severity • High duration	• Avoidance through design, where practicable • Declare historical sites and objects to authorities • Record and document historical sites and objects • Ground disturbance permit process • Pre-disturbance surveys • Archaeological excavation, research, analysis and conservation of artefacts • In situ protection (i.e., no go zones) • Chance finds procedure	Moderate	As above, significance of impact will depend on the feature affected. Impacts are lower as the features are disturbed as opposed to lost, and in some cases they may be able to be exhumed and preserved and some heritage value retained.	Medium • Field survey limited to surface observations from a single site visit • Uncertainty in the location and number of subsurface features and artefacts • Some disturbance assumed based on pit location relative to historic mining activities
Loss due to earthworks and mining	Larger/rarer artefacts and evidence of Chinese occupation	Construction and operations	High magnitude • Medium spatial extent • High severity	• Avoidance through design, where practicable • Declare historical sites and objects to authorities • Record and document	Major	Significance of impact will depend on the feature affected (particularly its level of rarity and distribution). Larger features such as buildings (e.g., houses) are expected to be rarer than small artefacts and may be completely destroyed when encountered.	Medium • Field survey limited to surface observations from a single site visit

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
	• High sensitivity		• Very high duration	historical sites and objects • Ground disturbance permit process • Pre-disturbance surveys • Archaeological excavation, research, analysis and conservation of artefacts • In situ protection (i.e., no go zones) for significant heritage areas that will not be disturbed by the project • Chance finds procedure			• Uncertainty in the location and number of subsurface features and artefacts • Some loss assumed based on pit location relative to historic mining activities
Disturbance due to earthworks and mining	Larger/rarer artefacts and evidence of Chinese occupation • High sensitivity	Construction and operations	Medium magnitude • Medium spatial extent • Medium severity • Very high duration	• Avoidance through design, where practicable • Declare historical sites and objects to authorities • Record and document historical sites and objects • Ground disturbance permit process • Pre-disturbance surveys • Archaeological excavation, research, analysis and conservation of artefacts • In situ protection (i.e., no go zones) • Chance finds procedure	High	As above, significance of impact will depend on the feature affected. Impacts are lower as the features are disturbed as opposed to lost, and in some cases they may be able to be exhumed and preserved and some heritage value retained.	Medium • Field survey limited to surface observations from a single site visit • Uncertainty in the location and number of subsurface features and artefacts • Some loss assumed based on pit location relative to historic mining activities
Reduced heritage values due to modification of surrounding landscape	Chinese hillforts and defended ridges • Medium sensitivity	Construction and operations	High magnitude • High spatial extent • High severity • High to very high	• Avoidance through design, where practicable • Declare historical sites and objects to authorities • Record and document historical sites and objects	High	Approximately 1 to 2 km of the hillforts and defended ridge system (approximately one-third of the total system) will experience significant surrounding landscape change (even in the context of existing mining-related landscape changes), and this represents long term impact to a major proportion of the feature.	Low • Significance supported by three-dimensional visualisation of changes

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
			duration	• Carefully rehabilitate project disturbance, where possible, to blend with surrounding landforms		The viewsheds from the ridges will also be impacted.	
	Bawdwin religious sites • Medium sensitivity	Construction and operations	Low magnitude • Very low spatial extent • Low severity • High to very high duration	• Avoidance through design, where practicable • Declare historical sites and objects to authorities • Record and document historical sites and objects	Low	While the impact is long term to permanent, it is likely that the sites will still retain some (or possibly most) of their aesthetic, spiritual or social value, particularly in the context of existing mining and industrial operations in the broader area.	Low • Significance supported by three-dimensional visualisation of changes
	Graveyards (10 known graveyards) • High sensitivity	Construction and operations	Medium magnitude • Medium spatial extent • Medium severity • High to very high duration	• Avoidance through design, where practicable • Declare historical sites and objects to authorities • Record and document historical sites and objects	High	As these sites are generally located on prominent ridges and crests, they are expected to have high aesthetic and spiritual value and are vulnerable to changes in the surrounding landscape. While the changes to the surrounding landscape will be in some cases long term (i.e., buildings and plant emissions) and for other cases permanent (tailings storage embankments, haul roads and open pit), it is considered that the severity will be medium in the context of existing changes to the landscape and viewsheds due to historic mining and associated activities.	Medium • Significance supported by three-dimensional visualisation of changes • Uncertain how alterations to surrounding landscape would detract from cultural heritage value of some graveyards given their location and existing visual impact
	Central Bawdwin precinct • Medium sensitivity	Construction and operations	Medium magnitude • High spatial extent • Medium severity • Very high duration	• Avoidance through design, where practicable • Declare historical sites and objects to authorities • Record and document historical sites and objects	Moderate	The visual landscape will change with the extension of the open pit and the change is considered significant as the open pit will essentially cut off the top of the ridgeline adjacent to the precinct. However, given that the precinct, its buildings and their values are associated with the mining context, it is unlikely that increased visibility of a nearby open	Low • Significance supported by three-dimensional visualisation of changes

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
						pit mining operation would significantly reduce the aesthetic, historic and social values of the area.	
	Tiger Camp precinct • Medium sensitivity	Construction and operations	Low magnitude • Low spatial extent • Low severity • High duration	• Avoidance through design, where practicable • Declare historical sites and objects to authorities • Record and document historical sites and objects	Low	The degree of landscape change will be minor with the area able to withstand localised changes without losing the values associated with the key industrial structures and buildings as a collective. This impact is not expected to materially reduce the heritage value of the Tiger Camp precinct.	Low • Significance supported by three-dimensional visualisation of changes
	Tiger Camp buildings • Medium sensitivity	Construction and operations	Low magnitude • Low spatial extent • Low severity • High duration	• Avoidance through design, where practicable • Declare historical sites and objects to authorities • Record and document historical sites and objects	Low	The degree of landscape change will be minor with the area able to withstand localised changes without losing the values associated with the key industrial structures and buildings as a collective. This impact is not expected to materially reduce the heritage value of the Tiger Camp buildings.	Low • Significance supported by three-dimensional visualisation of changes
Restricted access	Chinese hillforts and defended ridges • Medium sensitivity	Construction and operations	Low magnitude • High spatial extent • Very low severity • High duration	• Subject to overriding health, safety, and security considerations provide community access to culturally significant sites	Low	While access around this area will be restricted in the long term during both construction and operations, loss of access is unlikely to significantly affect associated value of the Chinese hillforts and defended ridges system, as most of its value comes from its visual presence in the landscape rather than from ability to access the feature.	Low • Loss of access is unlikely to significantly affect value
	Bawdwin religious sites • Medium sensitivity	Construction and operations	Medium magnitude • High spatial extent • Very low severity • High duration	• Subject to overriding health, safety, and security considerations provide community access to culturally significant sites • For cultural heritage sites that will no longer be accessible, provide alternative access to the site where safe and practicable. Where not possible,	Moderate	Access to these sites will be tightly controlled to manage safety around the mining activities (long term potential inconvenience) but this is consistent with previous practices throughout operation of the mine in the modern era and as such would be expected or anticipated by the local community. Furthermore, the project will provide alternative access to religious sites in cases where they cannot be accessed by the community.	Medium • Further community consultation required

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
				provide replacement sites at new locations, incorporating community and government feedback into the decision making. • Subject to community feedback and health and safety considerations, provide intermittent community access to religious sites for certain events and maintenance activities or, if required, carry out maintenance of buildings on behalf of the community.			
	Central Bawdwin precinct • Medium sensitivity	Construction and operations	Low magnitude • Medium spatial extent • Very low severity • High duration	• Key features of cultural heritage value will probably be relocated to a mining museum • Avoid direct disturbance of remaining features, where practicable • Subject to overriding health, safety, and security considerations provide community access to culturally significant sites	Low	It is unlikely that the community will have high cultural heritage connection to the sites remaining in situ. Operation of the mine and employment opportunities are likely to take precedence over the restriction of access to features of heritage value. Also, access restriction is consistent with previous practices throughout operation of the mine in the modern era and as such would be expected or anticipated by the local community. Once the mining operations cease, access to the features will be returned.	Medium • Further community consultation required
	Bawdwin village buildings • Medium sensitivity	Construction and operations	Low magnitude • Medium spatial extent • Very low severity	• Key features of cultural heritage value will probably be relocated to a mining museum • Avoid direct disturbance of remaining features, where practicable	Low	It is unlikely that the community will have high cultural heritage connection to the sites remaining in situ. Operation of the mine and employment opportunities are likely to take precedence over the restriction of access to features of heritage value. Also, access restriction is	Medium • Further community consultation required

Impact	Value and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
			• High duration	• Subject to overriding health, safety, and security considerations provide community access to culturally significant sites		consistent with previous practices throughout operation of the mine in the modern era and as such would be expected or anticipated by the local community. Buildings or structures may be relocated, or alternatives provided, and once the mining operations cease, access to the features will be returned.	
	Tiger Camp precinct • Medium sensitivity	Construction and operations	Low magnitude • Medium spatial extent • Very low severity • High duration	• Key features of cultural heritage value will probably be relocated to a mining museum • Avoid direct disturbance of remaining features, where practicable • Subject to overriding health, safety, and security considerations provide community access to culturally significant sites	Low	It is unlikely that the community will have high cultural heritage connection to the sites remaining in situ. Operation of the mine and employment opportunities are likely to take precedence over the restriction of access to features of heritage value. Also, access restriction is consistent with previous practices throughout operation of the mine in the modern era and as such would be expected or anticipated by the local community. Buildings or structures may be relocated, or alternatives provided, and once the mining operations cease, access to the features will be returned.	Medium • Further community consultation required
	Tiger Camp village buildings • Medium sensitivity	Construction and operations	Low magnitude • Medium spatial extent • Very low severity • High duration	• Key features of cultural heritage value will probably be relocated to a mining museum • Avoid direct disturbance of remaining features, where practicable • Subject to overriding health, safety, and security considerations provide community access to culturally significant sites	Low	Restriction of access to the area is likely to result in the loss of connection between the community and the area. However, operation of the mine and employment opportunities are likely to take precedence over the restriction of access to features of heritage value. Also, access restriction is consistent with previous practices throughout operation of the mine in the modern era and as such would be expected or anticipated by the local community. Buildings or structures may be relocated, or alternatives provided, and once the mining operations cease, access to the features will be returned. Some people who currently reside in the area will be resettled to safer areas with access to other services and resources.	Medium • Further community consultation required

6.9.5 Monitoring

The Bawdwin Project CHMP will provide for regular cultural heritage monitoring and inspection to be completed for all project phases (construction, operation and closure), with particular focus on ground disturbing activities (e.g., earthworks, excavation, mining) and confirmation of protection measures. Monitoring will include:

- Internal audits to confirm that the Bawdwin Project CHMP, including site-specific and standard management measures and chance finds procedure, is being successfully implemented and management measures are effective in minimising impacts to cultural heritage.
- Routine inspections of known cultural heritage features within the Bawdwin license area to confirm they are being managed in accordance with the site-specific management measures agreed with local communities and landholders.
- Ongoing liaison with local communities and other relevant stakeholders regarding cultural heritage issues, including receipt of complaints or concerns through the grievance procedure.

6.9.6 Uncertainties and further work

The key uncertainties and further work required to address these uncertainties are outlined in Table 6.200.

Table 6.200 Uncertainties and further work in respect of cultural heritage impacts

Uncertainty	Further work	Purpose	Assumptions
The field survey was limited to surface observations only from a single site visit. It is highly likely that further information on cultural heritage features in the study area would be found by conducting detailed visual surveys and archaeological excavation surveys combined with consultation with local communities.	Pre-disturbance visual recording of sites and pre-disturbance surveys as outlined in Section 6.9.3. Pre-disturbance surveys in predicted disturbance areas as outlined in Section 6.9.3. Conduct broader consultation with relevant archaeological experts, affected communities and religious leaders, international experts and relevant Myanmar authorities (i.e., the Department of Archaeology and National Museum of MORAC or its delegate) regarding cultural heritage management.	To determine the locations, extent and nature of archaeological artefacts and features that may be impacted. To aid in developing site/feature specific management measures that incorporate input from the community.	For impacts to currently unknown features, the assessments were based on interpolation from locations of known features recorded during the visual survey and known historic occupation and land uses at Bawdwin and surrounds.
There is high uncertainty in the location of possible subsurface heritage features and artefacts, which cannot be confirmed until excavation works are conducted.	Pre-disturbance visual recording of sites above ground and pre-disturbance surveys as outlined in Section 6.9.3. Pre-disturbance surveys in predicted disturbance areas as outlined in Section 6.9.3.	To better understand the locations of subsurface features of cultural heritage significance and aid in development of appropriate management measures.	The approximate extent and locations of subsurface features were interpreted from observations of landform, surface expressions or features, and knowledge of past activities and events during the baseline survey.
In many cases, the exact age of the cultural heritage feature cannot be confirmed but only interpreted from available evidence.	Conduct broader consultation with relevant archaeological experts, affected communities and religious leaders, international experts and relevant Myanmar authorities (i.e., the Department of Archaeology and National Museum of MORAC or its	To better understand the cultural heritage value of features.	In such cases, best estimates have been made of the associated time periods by a professional cultural heritage archaeologist, Dr Peter Petchey.

Uncertainty	Further work	Purpose	Assumptions
	delegate) regarding age of features		
Uncertainty surrounding specific management measures that will be adopted for cultural heritage features	Pre-disturbance visual recording of sites above ground and pre-disturbance surveys as outlined in Section 6.9.3. Pre-disturbance surveys in predicted disturbance areas as outlined in Section 6.9.3. Conduct broader consultation with relevant archaeological experts, affected communities and religious leaders, international experts and relevant Myanmar authorities (i.e., the Department of Archaeology and National Museum of MORAC or its delegate) regarding cultural heritage management. Develop a CHMP with site/feature specific measures.	To ensure that management measures are being implemented as required and are successful (Section 6.9.5).	The assessment of significance of residual impacts assumes that avoidance and management measures are successfully implemented. There is an assumption that selected features or representative components of the feature will be adequately managed in a museum by third parties once handed over by the project.
The cultural heritage field survey relied on opportunistic consultation with local people during the field survey. As a result, the significance and sensitivities of cultural heritage values do not factor in the specific views of the local community or the broader scientific community for each cultural heritage feature.	Consult applicable communities, religious leaders, Myanmar authorities (i.e., the Department of Archaeology and National Museum of MORAC or its delegate) and local administrators. Management measures will be discussed and agreed with affected communities and relevant stakeholders and regulators prior to implementation. Declare identified existing cultural heritage findings to the Department of Archaeology and National Museum of MORAC in line with The Protection and Preservation of Ancient Monuments Law (2015) and The Protection and Preservation of Antique Objects Law (2015).	To confirm the sensitivity of all potentially disturbed cultural heritage features and to assist in developing appropriate site/feature specific management measures.	The assessment of significance and importance is based on the professional judgement of the archaeologist, Dr Peter Petchey, who conducted the baseline survey. The assessment of impact magnitude is based on the professional judgement of Coffey's environmental and social impact assessment consultants, with input from Dr Peter Petchey.

Uncertainty	Further work	Purpose	Assumptions
The magnitude and significance ratings for Hillfort 4 have medium uncertainty as this site may have had a concentration of many personnel over a long period, there could be a high potential for artefacts in this area.	Site investigation of this hillfort prior to its disturbance.	To investigate the presence of sensitive cultural heritage features and to allow development of appropriate management measures	Medium impact magnitude and moderate impact significance has been assumed given the hillfort has been extensively damaged from historic mining activities and natural degradation. However, medium uncertainty has been acknowledged until the site is surveyed for potential cultural heritage artefacts.
It is currently not confirmed whether the community would prefer to return to existing features, features to remain in situ for cultural heritage connection or maintenance of the features or be more content with alternative sites provided (religious sites only). The degree to which the local community currently accesses (and values) some features (i.e. the hillforts and defended ridges) is not clear.	The requirements of the community and specific management approaches for each of the religious sites and other sites which will have access restricted will be confirmed after further community consultation (and with Myanmar authorities).	To better understand the severity and duration of impact due to restricted access to cultural heritage sites and features and confirm appropriate management measures.	Assumptions regarding the requirements have been made considering the project has a range of approaches to manage this impact to suit the requirements of the community and Myanmar authorities.

6.10 Social impact assessment

6.10.1 Approach to impact assessment

This section assesses the project impacts to the social values identified in Section 5.9.

The social impact assessment method used in this section is a ‘significance assessment’. This approach assesses the potential significance of impacts by considering the sensitivity of social aspects to change, and the magnitude of change that they are predicted to experience as a result of project-related activities.

The assessment of potential impacts is based on specialist judgement and technical assessment supported by field data and scientific literature. Particular emphasis has been placed on ensuring that the impact assessment describes the rationale, justification and any limitations and uncertainties of the assessment.

Further details on the significance assessment method is described in Section 6.1.

Context for impact assessment

The project is located in Namtu township in Kyaukme District. Namtu township comprises 24 village tracts including Bawdwin (also known as Baw Twin) and Namtu Town. The Bawdwin village tract borders Hu Hsar village tract to the west, Hin Poke village tract to the northwest, Kyu Hsawt village tract to the northeast, Namtu Town to the east, and Hko Mo village tract to the southeast.

The Bawdwin village tract consists of Bawdwin upper and lower villages (made up of nine wards) and Tiger Camp and surrounding farms and scattered houses. The Bawdwin and Tiger Camp villages were established to accommodate Bawdwin mine workers. Surrounding the Bawdwin concession area, there are several dozen villages lying within the Hu Hsar, Hin Poke, Kyu Hsawt, Man Pun, Man Pat 2, Hko Mo, Tun Hsay and Hkay Hkin village tracts, which have a combined population of approximately 9,000 people (excluding the Bawdwin village tract). Several of these villages interact with Bawdwin and Namtu to varying degrees, for example to access schools and for religious purposes. See Figure 6.28 for locations of Bawdwin and villages of interest within the surrounding village tracts.

The Bawdwin upper and lower villages are currently primarily accessed by a gravel road running along the Nam Pangyun stream valley from the Namtu – Manton Road. The area includes former mining and processing infrastructure, some with historical significance, including the Marmion Shaft headframe and winding house, flotation and concentrator plant, mine offices, workshops, power station, railway lines and yards and rail loading facility.

Tiger Camp contains historical mineral handling infrastructure and a small collection of settlements situated around the confluence of the Nam Pangyun and Wallah streams. Infrastructure in the Tiger Camp area was a critical part of the mine's operation during the colonial period and includes the ore tippler, ore bins, railyards, the Tiger Tunnel portal, electric substation, office, clubhouse, stone store and police station.

The Nam Pangyun valley hosts the railway corridor and is a relatively narrow valley at Tiger Camp before broadening into a wider valley at lower elevations towards the junction with the Myitnge River (known locally as the Namtu River). The narrow gauge railway runs from the Bawdwin Mine offices to the Tiger Camp rail loading facilities, via the lower village and Wallah Gorge. From the loading facilities the line runs down the Nam Pangyun valley to the Namtu Railway Station, which is located on the edge of the Myitnge River, on the south-eastern side of Namtu township.

Namtu township is centred on the Myitnge River, which bisects the town. Namtu is a large regional town and hub for several dozen surrounding villages and farms, providing commercial supplies, fuel, schooling, banking, local employment and medical services. Namtu Town contains the Pang Hai Ward and the Tha Ta La Wards, the latter of which means 'mining enterprise'. Tha Ta La Ward is made-up of seven wards. Like the Bawdwin villages, Tha Ta La Ward was originally established to accommodate workers in the Bawdwin-Namtu mineral industry and government officers involved in the mine operations.

Social values and impact zones

Social values are qualities of the social environment that are conducive to individual wellbeing now and into the future, and for which community stakeholders have a high regard. Each social value is characterised by a range of indicators.

The identification of social values held by stakeholders is central to the social impact assessment process. These values are developed by assessing stakeholder interests in relation to social conditions and their indicators. The identification of social values allows consideration of the local aspirations for transformation of the existing environment to better support sustainable livelihoods and avoids a singular focus on preservation of the existing environment which, in a developing country context, is often a lower priority aspiration. It also establishes a basis for dialogue with and between stakeholders with differing interests and strategies for achieving a sustaining social environment. It facilitates an integrative approach to impact assessment where potentially multiple impact pathways combine to affect a single value, in either a positive or negative sense.

Three overarching socio-economic components have been defined for the project. These are:

- Local economies, land use and livelihoods
- Living conditions, social cohesion and security
- Access to health, education, religious and other services

Associated social values within these components have been defined based on the information derived from the social baseline study (Appendix E), engagement with Bawdwin and Tiger Camp communities, engagement with communities in the surrounding village tracts (Chapter 9), and research on social conditions in northern Shan State. Defined social values are described in the following section.

Local economies, land use and livelihoods

Bawdwin and Tiger Camp villages were originally established to accommodate Bawdwin mine workers and those involved in supporting the mine operations. The economy and livelihoods of people in the villages within the Bawdwin concession area remain linked to the mine. There are, however, several areas where small scale farming and grazing has been established within the Bawdwin concession area and some livelihoods are based on or supplemented by small-scale trading and artisanal mining or scavenging of the slag on hillsides and in the Nam Pangyun valley downstream of the mine.

Nearly all community members have a regular income from either a Government paid pension or a monthly salary from WMM for mining activities. Of the respondents from the surveys and focus group interviews in the vicinity of Bawdwin, the majority remain working in the mining sector (56%) or are retired (18%). After WMM took over the mining license in 2009, the workforce has decreased from approximately 2,000 to nearly 900. There are currently 362 WMM employees (WMM) at Bawdwin (including 158 females) and 526 WMM employees at Namtu (including 281) females.

WMM provides housing and accommodation to the majority of its employees under rental agreements. Rental rates differ between persons employed by WMM, and residents not employed by WMM. Local economies in the village tracts adjacent to Bawdwin are based primarily on upland agriculture. Traditionally this has been shifting cultivation where fields are rotated and fallowed to restore productivity with the most important shifting cultivation crop in Myanmar being upland rice and maize (during the monsoon season from May to September), with pumpkin, beans and pulses also being important (Jepsen, et al. 2019). However, there is a transition from shifting cultivation in upland areas to annual commodity cropping. In Shan State, the ethnic minority-populated uplands have become a major maize production area for the China market (e.g., Woods, 2015), and some of the villages in the vicinity of Bawdwin may be engaging in this type of cropping. Crop farming in the Bawdwin concession area is primarily for subsistence, but some agriculture products are sold in local markets and some also sold in Namtu and Lashio. Corn and jengkol (also known as dogfruit), are the primary agricultural products being sold by Bawdwin community members. While agriculture is dominant, it is still vulnerable to climate variability, forcing households to adopt other livelihood strategies such as labour migration for work in manufacturing in Yangon or border townships. In 2011, Namtu Township was assessed by the World Food Program as having 26% of households with severe or moderate food insecurity and 28% of households with a poor or medium level of food access (World Food Program, 2011).

The social values associated with the local economies, land use and livelihoods have been identified as:

- Employment opportunities (including the equality of access to employment opportunities)
- Business sectors providing goods and services
- Sustainable livelihoods (either secure access to productive agricultural land or non-agricultural employment opportunities)

Living conditions, social cohesion and security

Within Bawdwin and Tiger Camp, housing, water and sanitation infrastructure has been deteriorating over time, and combined with high levels of land contamination due to previous mining and processing activities, has resulted in current poor environmental amenity which is of concern to residents.

Housing in the Bawdwin and Tiger Camp villages is generally made of wood or bamboo with tin roofing and most residents have lived in the same dwelling for a number of decades, many for over four decades. The majority of residential houses on the Bawdwin concession area are assets of the WMM and ME-1 defined by the Production Sharing Contract (PSC). Rentals are subsidised for persons employed by WMM, and residents not employed by WMM pay an unsubsidised rate. Unsubsidised rental rates are between 4,000 and 8,000 MMK per month. Housing extensions and new dwellings have been erected by some residents, at their own cost, to allow for family growth.

In addition, there has been unauthorised settlement and construction of houses in small hamlets outside the existing Bawdwin villages.

While residents of Bawdwin and Tiger Camp villages are predominantly of Bamar ethnic origin, there is a high level of cultural respect and harmonious relations with other minority ethnic groups. This is evident both within the villages (where there are religious and cultural facilities for a number of religious denominations, including Buddhist, Christian, Hindu and Islam) and with surrounding ethnic minority villages who access services available within the Bawdwin concession area (e.g., health and education, including sending their children to board within Bawdwin while attending school) despite there being continuing social tension with the presence and activity of ethnic armed organisations (EAOs).

Various non-government armed groups operate in Northern Shan State. Members of both the Ta'ang National Liberation Army, an ally of the Kachin Independence Army, and the Shan State Army live in the villages in tracts adjoining the Bawdwin concession area. Infantry Battalion No. 66 of the Myanmar national army (the Tatmadaw) is also deployed near Bawdwin and Namtu with one base currently located on the northern edge of the Bawdwin concession area. Armed conflict severely disrupts livelihoods, fostering a lack of community trust in the government, the Tatmadaw and EAOs.

A peace process between the EAOs and the Myanmar government and military is ongoing. The most recent Union Peace Conference took place in mid-August 2020 resulting in the signing of the Union Accord III that lays out a framework for the implementation of the National Ceasefire Agreement (SFCG, 2020). However, the Myanmar national army continues to clash with the TNLA from time to time in Northern Shan State. Heavy fighting occurred in Namtu Township in March 2019 between EAOs (MIPS, 2020). In April 2019, the Tatmadaw and TNLA also clashed in Namtu Township near an area highly contested in inter-EAO conflict (MIPS, 2020). While Namtu remains affected by social tensions, a drop in clashes between state security forces and the TNLA occurred between 2018 (25 clashes) and 2019 (15 clashes) (MIPS, 2020). Overall, inter-EAO conflict also decelerated in Namtu between 2018 and 2019 (MIPS, 2020). However, conflict is still present between the TNLA, Shan State Army and Myanmar national army in and around Namtu Township with recent clashes near Man Sam, Namtu, Namhsan and Hispaw some of which resulted in injuries to villagers.

Based on stakeholder consultation and socio-economic baseline surveys, communities are concerned about the lack of job opportunities and economic security, with young people particularly concerned with poor access to quality education being an impediment to improving livelihoods.

The social values associated with living conditions, social cohesion and security have been identified as:

- Adequate living conditions and infrastructure (housing, roads, communications, water, power etc)
- Harmonious social relations (cohesion, wellbeing and identity) and security
- Effective local and regional governance
- Consideration of vulnerable groups
- Environmental amenity (i.e., clean air, water and soils) to support community health and wellbeing

Access to health, education and other services

Currently the Bawdwin communities have access to a range of medical facilities. These include a small government hospital staffed by nurses. The facility lacks a resident doctor, is not well equipped or supplied, lacks essential prescription drugs and is not suited to emergency situations. In Tiger Camp, there is one sub healthcare centre. In addition, there is a company clinic in Bawdwin (operated by WMM), which is available for company employees. The clinic currently has one doctor on roster at any given time and is well-equipped with basic essential medicines and medical devices. A well-equipped ambulance with assigned drivers is available for emergency transportation. Diagnostic facilities are not available in either the Bawdwin public hospital or the WMM clinic and therefore residents must travel to Namtu or Lashio for these or other higher level services.

The Bawdwin and Namtu study areas were found to have a higher proportion of people who had completed some form of higher education compared with the Shan State average. Levels of basic education were 79% for Bawdwin, 76% for Namtu compared to Shan State overall in which 49% of people have basic education. The higher level of education is attributed to the availability of education facilities. In Bawdwin and Tiger Camp there are nine educational facilities ranging from nursery to high school. Results from the household surveys show a small proportion of respondents in Bawdwin and all wards across Namtu have a percentage of the population that is illiterate, with illiteracy rates generally higher for females. It is unclear why this is the case but it may be connected to traditional concepts of gender roles.

In a report on local governance UNDP (2015) Myanmar found that: '*Overall, in Shan State, as in all other Regions and States, people clearly acknowledge the improvements in service delivery, notably for road infrastructure, education, health and, although to a lesser extent, water supply. People mentioned access to safe drinking water as the largest challenge in service delivery and people also asked for enhanced investments in this sector*'. The main development issues identified by UNDP (2015) in Namtu Township, compared to Shan State more broadly are shown in Table 6.201. Poor health was identified as a development issue in Namtu Township at almost double the rate identified in Shan State.

Table 6.201 Main development issues identified in Namtu Township and Shan State

Development issue	Rate identified by Namtu Township residents (%)	Rate identified by Shan State residents (%)
No access to water	25%	25%
No grid electricity	27%	18%
Poor health	23%	12%
Not enough jobs	13%	10%
Poor education	8%	8%
Poor road access to villages/wards	3%	17%

Source of data: UNDP (2015)

Whilst the aforementioned UNDP report dates from 2015, the social baseline study and interviews with leaders of villages in tracts adjoining the Bawdwin concession area confirm the findings of the UNDP report and identify that provision of basic services in the Bawdwin concession area is regarded as highly important, particularly since alternative services in other centres (e.g., Namtu and Lashio) are more difficult, time-consuming and costly to access.

The social values associated with access to health, education and other services have been identified as:

- Access to health services
- Access to schools and training opportunities
- Access to spiritual and religious support venues and services
- Access to commercial services

Defined impact zones

The social baseline assessment was used to characterise which groups of people, in which locations, may be subject to different types of impact. These zones of influence have been termed 'impact zones'. They have been broadly defined through consideration of: community location (including watershed boundaries, and proximity to the project's footprint, lease boundaries and logistics support corridors), and the type of project activity that may occur in proximity to villages in the impact zone. The study area for socio-economic impacts has been categorised into one of five groups. The grouping reflects both the geographic location of the people (and proximity to impacts of mine redevelopment) and also their affiliation with the mine and the concession areas.

The defined socio-economic impact zones are presented in Table 6.202 and shown in Figures 6.28 and 6.29.

Table 6.202 Defined socio-economic impact zones

Impact zones	Description
Impact Zone 1 - Bawdwin communities consisting of upper and lower Bawdwin villages and Tiger Camp (and Nam La village and scattered hamlets and houses within the south and eastern portions of the Bawdwin concession area but outside of the village settlements)	Comprises the mine villages, namely Bawdwin upper village, Bawdwin lower village and Tiger Camp. Current Bawdwin residents are generally 2nd or 3rd generation in-migrants, 80% of whom are of Bamar ethnic origin, who consider Bawdwin as their permanent place of residence, with no access to residential areas elsewhere. A considerable portion (~30%) of the current Bawdwin population has temporarily emigrated elsewhere for the purpose of work and remits income home to families at Bawdwin. Persons in this impact zone includes workers currently employed by WMM, retired workers living in company housing and families of these workers as well as other residents of the villages that do not have official ties to the mine site but support and are dependent on the towns (e.g., monks, teachers, shop owners). The impact zone includes public assets that have been developed to service the community, including monasteries, temples and other places of worship, hospitals and schools, post office, police station etc. In addition to the formal village settlements, there are a number of scattered hamlets and individual houses within the Bawdwin concession area, which are also included in this category, including the Nam La village and associated farms. These residents have constructed homes outside the formal village areas and have developed areas for agricultural activities. This latter group is considered as a sub-group to the overall impact zone.
Impact Zone 2 – Villages in village tracts adjoining the Bawdwin concession area (and the Loi Mi village and associated farms that use land within the Bawdwin concession area)	This zone is defined as the villages in the village tracts adjoining the Bawdwin concession area. These are the villages of interest which lie closest to the project, other than the Bawdwin and Tiger Camp communities. In accordance with the 2020 Myanmar Information Management Unit (MIMU) Place Code list (MIMU, 2020b), these are: • Hu Hsar village tract to the southwest, containing six villages of interest (Haik Taung (Pa), Hu Hsar, Haik Taung (Ka), Long Jar, Yaw Ba Gang and Hu Ngway) • Hin Poke village tract to the northwest¸ containing six villages of interest (Hin Poke, Loi Mi, Nam Ma La, Loi Ping (Kone Kayar), Hsin Li, Nam Hkun). • Kyu Hsawt village tract to the northeast which is sparsely populated (population of less than 1,000) with no listed villages. Combined, this zone contains 12 villages. Note: there is a discrepancy between MIMU (2020b) spatial data and excel database for Loi Mi, Hsin Li and Loi Ping (Kone Kayar) villages, which geographically appear to be located in Baw Twin and Kyu Hsawt village tracts, respectively, whilst are registered within Hin Poke village tract. Some scattered hamlets within and immediately adjacent to the Bawdwin concession area are included in this category, for example, residences adjacent to Loi Mi village in the northwestern corner of the Bawdwin concession area. The Loi Mi village and associated farms also currently use a small portion of the Bawdwin concession area for small-scale agricultural plots for agricultural purposes and may graze livestock in some of the concession area. These villages interact with Bawdwin and Namtu to varying degrees, to access schools, markets, medical and other services and for religious purposes.
Impact Zone 3 – Namtu Town	This zone covers the urban areas of Namtu Town and is defined as Namtu (Urban) village tract, which covers the majority of Namtu (Urban) and Hko Mo village tract that covers the south eastern portion of the town and immediately adjacent areas to the south. Namtu Town is a large regional town and hub for several dozen surrounding villages and farm tracts, providing commercial supplies, fuel, schooling, banking, local employment and medical services. Namtu Town contains the Pang Hai Ward and the Tha Ta La Wards, which means 'mining enterprise'. Based on census data the main employment group is ‘own account worker’, followed by household worker, students, private employees, retired/elderly, and government employees.

Impact zones	Description
Impact Zone 4 - Nam Pangyun valley	There are a number of permanent residences outside the Bawdwin concession area along the riverbanks of the Nam Pangyun, where inhabitants have small agricultural plots, some permanent and some seasonal. The valley between Tiger Camp and the Myitnge River junction is also periodically used by artisanal miners who fossick for the lead-zinc slag which was discarded during the historical smelting in the Chinese period of occupation and has washed into the Nam Pangyun. The number of miners varies by the time of the year (more in the dry season and depending on the regional security climate) and ranges from a few hundred to a few thousand. Most accommodate themselves in self-constructed timber, bamboo and tarpaulin shelters within the riverbed and on the riverbanks.
Impact Zone 5 – Namtu to Lashio road	This zone includes villages along the road between Namtu and the intersection with National Highway 3 (Oriental highway) near Lashio. This corridor will be the main supply and export route for the project. This area includes two towns of roughly 3,000 people (Man Sam and Ei Naing), and numerous smaller villages. Man Sam and Ei Naing have medical clinics and limited shops. The lower elevation lands are farmed with relatively broad-acre plantation crops such as corn and bananas, with some rubber plantations. Rice fields occupy higher level locations which are closer to water sources.
Impact Zone 6 - Lashio	Lashio is the largest town in northern Shan State, with a population of more than 130,000 people, about 200 kilometres (120 mi) northeast of Mandalay. As a regional city it is the regional business centre and has a range of services such as the Lashio General Hospital, three universities and a broad range of services available.

In addition to the local and regional social impact zones defined in Table 6.202, a number of socio-economic impacts will affect the Shan State and Myanmar more broadly.

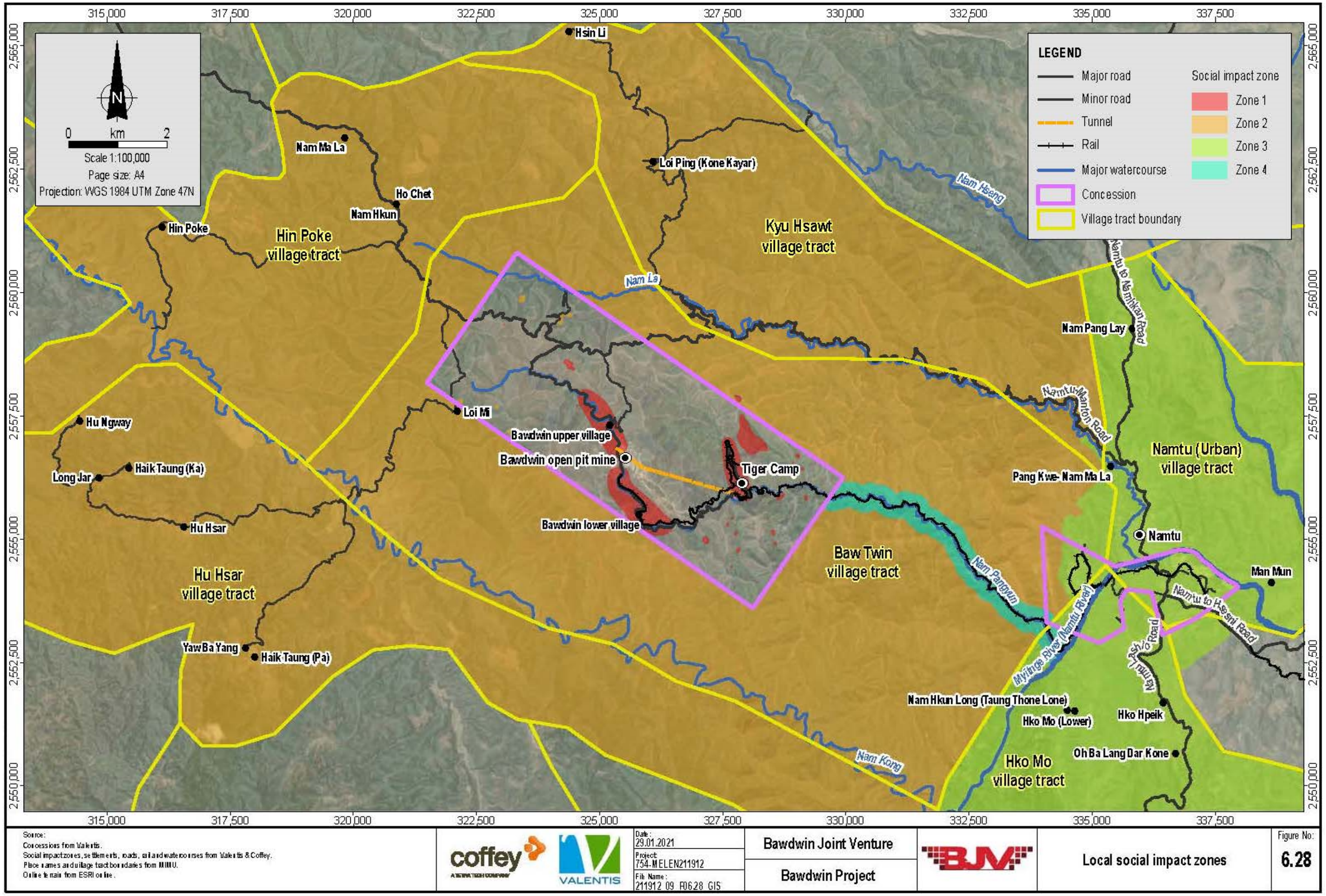


Figure 6.28 Local social impact zones

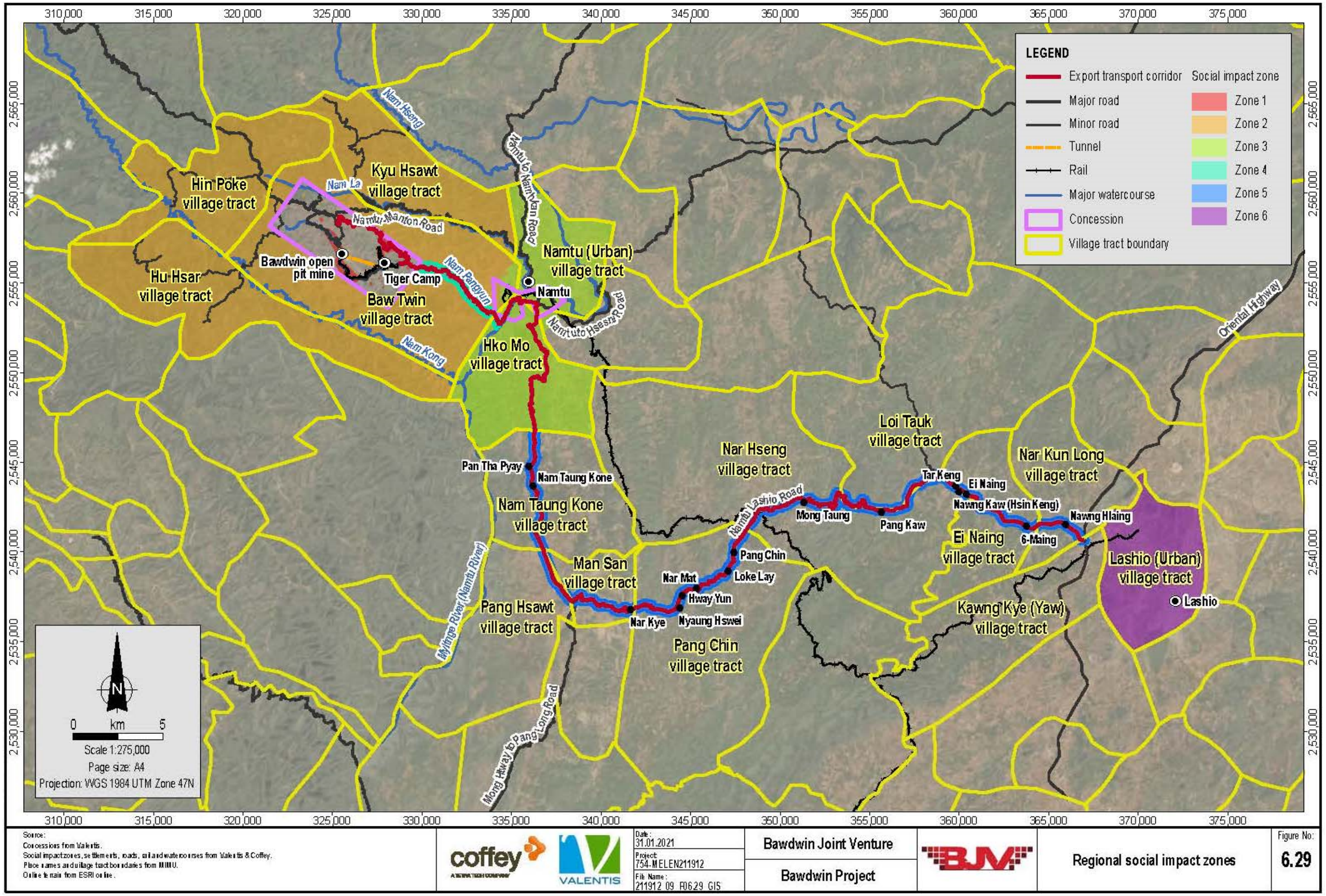


Figure 6.29 Regional social impact zone

6.10.2 Sources of potential impact

The project has the potential to impact a range of social and socio-economic aspects at differing spatial scales. In order to predict direct and indirect socio-economic impacts caused by project, it is critical to understand the key sources of potential impact or drivers of change. Direct cause and effect relationships in for socio-economic impacts can be influenced by a range of factors independent of the project such as (but not limited to) Union, State and district level government policies and regulations; the existing socio-economic environment; regional security and stability; and transport linkages that enable to import and export supply of goods. Furthermore, the magnitude of predicted impacts will depend on the implementation of avoidance and management measures outlined in this EIA. Therefore, it is acknowledged that there is a degree of uncertainty associated predicted impacts.

Sources of potential impacts are essentially the causes or triggers that result in changes or effects to social and socio-economic aspects, both positive and negative. Based on experiences of resource developments in Myanmar and around the world in similar socio-economic contexts, sources of potential impact that will occur as a result of the project include:

- Physical disturbance and displacement of settlements.
- Increased infrastructure use (accelerating deterioration) as well as any infrastructure improvements and upgrades.
- Project workforce sourcing, accommodation and management.
- Supply of goods and supporting services for the project.
- Project emissions and discharges.
- Altered road traffic composition (increased proportion of heavy vehicles, traffic levels by time-of-day etc).
- In-migration.

Physical disturbance and displacement

The proposed project with its large open pit, new mineral processing plant and mine waste storage facilities has a substantially larger footprint than the historical Bawdwin mining operation. The total footprint area is approximately 470 ha. The new footprint comprises:

- An expanded open pit of 98.2 ha (from approximately 21.9 ha).
- Tailings storage facilities including embankments, diversion dam and closure spillways, covering 149 ha in the north-western corner of the Bawdwin concession area.
- A waste rock dump and sediment dams within the Wallah Valley, covering 107 ha.
- New access roads to project components from Namtu, covering 44 ha.
- New water dams and reservoirs in the northern parts of the Bawdwin concession area, covering 24 ha.

Large footprint projects, by definition, have a need for land and this may impact existing land users. This can displace people and/or impact on their livelihoods. The physical fragmentation of the landscape and restrictions on access that occur from the construction and operation of a project can also cause disruption to daily living and to people’s livelihoods (Vanclay, 2017). In addition, large development projects may exacerbate existing levels of conflict. Research has identified that there are often low levels of community satisfaction with the peace process between the EAOs and the Myanmar government and military, and concern over the relationship between the peace process and large development projects (SFCG, 2020).

The Bawdwin project is a brownfield development and will occur within the existing Bawdwin concession area and supporting infrastructure easements. In this respect, the project will not materially alter the intended use of the land within the Bawdwin concession area.

While the project will be located within the existing Bawdwin concession area and associated easements, it has the potential to result in the loss of land for agricultural or other land uses. In addition, the development will restrict the existing informal use land within the Bawdwin concession area (e.g., for free roaming cattle grazing, scavenging for slag on the hillsides, artisanal mining along the rail corridor in the Nam Pangyun valley). Continuation of these informal land uses in proximity to an active and large-scale mining operation such as the Bawdwin project poses significant health and safety risks to the Bawdwin communities. The activities will therefore be restricted to minimise risk.

The existing Bawdwin villages and nearby scattered hamlets are located in areas that will be heavily impacted by the project, either through direct expansion of the mine pit and associated facilities or increased exposure to environmental and safety hazards (e.g., reduced air quality, blasting impacts) and reduction in amenity (e.g., noise). To minimise significant impacts to existing Bawdwin communities during the operation of the project, resettlement of those communities is proposed.

The proposed resettlement program and schedule is summarised in Table 6.85.

The timing of resettlement is highly dependent on required government approvals, finding suitable resettlement locations, project financing and reaching an agreeable outcome with the affected communities.

Resettlement due to mining and other large infrastructure developments is common in Asia. Resettlement is a major change process for affected communities and a poorly, planned or implemented resettlement program can have a number of adverse impacts and risks including:

- Disruption to social cohesion. This may include altered social and community dynamics, loss of social networks and governance through the process of resettling and re-organisation of the resettled households, loss or disruption to social networks, isolation and or abandonment of people from the community.
- Livelihood impacts including impoverishment, food insecurity (often due to loss of subsistence agriculture), unemployment or loss of employment. Resettlement can also lead to homelessness, particularly in situations where cash compensation is provided rather than replacement housing.
- Conflict. This can be internal conflict within the resettled community due to perceived inequity between defined social groupings and their eligibility and entitlements. It can also relate to conflict with the host community and project proponent. In conflict settings such as Myanmar it can also relate to changes to the broader level of conflict exposure and security associated with the resettlement location.
- A sense of community loss of identity and sense of place, due to loss of land, homes and assets and potentially important cultural and religious sites. A deeper immersion in the mainstream economy is likely to influence perspectives on identity and sense of place, especially for the next generation. It can also lead to a loss of wellbeing.
- Perceived inequity and potential non-acceptance between resettled communities and host communities due to resettling households being seen as privileged with new housing and facilities and securing mine employment, and potentially imposing additional demands on existing (often inadequate) services such as health and education facilities.

MCRB (2018) noted that resettlement and relocation resulting from mining development often disproportionately affect women, resulting in negative physical, social, cultural, and economic displacement. Gender inequality often commences during the consultation and initial negotiation of resettlement programs, which is typically male-led (MCRB, 2018). Careful planning and consideration of the physical displacement of a community is important for a successful long-term resettlement.

The most significant change as a result of resettlement will be the construction of an entirely new village or villages to host the existing communities that live within the Bawdwin concession area. If implemented well, this has the potential to improve the living conditions of people by providing new and improved housing and access to essential services (e.g., water, electricity, sanitation). Through the resettlement planning process, improvements in village planning, housing, and essential and supporting infrastructure can be agreed in consultation with the resettled communities.

Vanclay (2017) notes that one of the most critical issues facing resettlement is the availability of adequate land to relocate people. In more densely populated areas, unused land is limited and therefore the acquisition of land for the resettlement site itself causes creates social impacts on the host communities. In less populated areas, vacant land might be available, but is not necessarily adequate or equal to the land that is being taken for the project in terms of key attributes (e.g., suitability for agriculture, availability of water, distance of markets and provision of public services and infrastructure).

WMM envisages that a resettlement site(s) will be located in proximity to Namtu, with security of tenure, adequate land and water resources, and access to project employment opportunities. Employment opportunities with WMM will be independent of any agreement with resettled villages and individuals, but ability to access such opportunities is a consideration for determining the suitability of resettlement sites.

Based on reported experiences of resettlement programs elsewhere, the potential socio-economic impacts as a consequence of community resettlement include changes to:

- Standard of housing and infrastructure.
- Quality and level of facilities and services provided (e.g., water supply, sanitation and health care clinics).
- Amenity and health outcomes.
- Trade and business opportunities.
- Livelihoods.

The other key cohort of people potentially impacted by the resettlement of Bawdwin and Tiger Camp villages include people that live in impact Zone 2. These persons reside outside of the Bawdwin concession area but use and rely on services and facilities in Bawdwin and Tiger Camp villages, but. In addition, people in impact Zones 3, 4 and 5 may be impacted by ancillary infrastructure including roads used by the project. This may include people living in, owning land or earning some portion of livelihood from land along the impacted corridors, for example the artisanal miners that operate along the proposed access route.

Closure of existing community services in the Bawdwin wards and Tiger Camp will include:

- Health facilities consisting of a small public hospital, a public sub-health care centre and private clinic operated by WMM.
- Education facilities consisting of one nursery, one preschool, one primary school, two-primary schools and one high school in the Bawdwin villages and one nursery, one primary school and one middle school in Tiger Camp village.
- Commercial services consisting of shops, markets and small-scale business services.
- Policing from the Bawdwin upper village police station.

During community engagement, residents of neighbouring villages and farms outside the Bawdwin concession area stated that they access commercial services from Bawdwin. When asked about alternative locations for accessing these services, Namtu was cited as the most likely alternative, but at least half of those interviewed mentioned the distance and additional expense of accessing services there as a constraint.

Emissions and discharges

The project will result in emissions and discharges to the environment. That environment is already degraded, particularly with high levels of metal, due to historical mining, mineral concentrating and smelting. The projected emissions and discharges will include:

- Discharges of water generated through the mineral concentration process, surface water run-off, and seepage from the Wallah waste dump and TSFs. These discharges are described in detail in Section 6.3 and Section 6.4.
- Vibrations from blasting associated with open mining described in detail in Section 6.7.
- Emissions to air in the form of particulate matter (dust) and gases. These emissions are described in detail in Section 6.5.
- Generation of noise from fixed and mobile machinery and vehicles. Noise and vibration generated by the project described in detail in Section 6.7.
- Production of waste described in Chapter 4.

These have the potential to influence living conditions, health and amenity for people in proximity to the mine.

Health impacts associated with discharges and emissions are described and assessed in Section 6.11.

Physical landscape modification

The presence of the project will alter the visual landscape of the local area by the expansion of the open pit and major landforms including the TSFs and Wallah waste rock dump. Visual amenity may also be temporarily impacted by activities such as vegetation clearance and soil stockpiling. The use of artificial lighting during project construction and operations may also impact visual amenity at night. Increased heavy vehicle traffic as a result of the project may also impact visual amenity, both in the Bawdwin concession area and along the export route. This may impact road users and residents of the Bawdwin concession area, Namtu and villages along the export route.

Views from the Namtu to Manton Road, which passes through the northern section of the concession area, will be altered due to the proximity of proposed facilities and development to the road. In general, the steep topography in the vicinity of Bawdwin, with a significant portion of slopes in excess of 20%, facilitates the screening of development, with the potential to block development from being seen from some locations.

Project infrastructure

A range of new or upgraded infrastructure is proposed as part of the project. Most infrastructure for mining and mineral processing will be within the Bawdwin concession area and will not directly benefit existing communities. Potential infrastructure improvements regionally will include the upgrade of Namtu – Mansam – Lashio road, upgrade of mobile telecommunications and community investment, which may include infrastructure improvements.

The public road between Namtu – Mansam – Lashio will require sections to be upgraded to allow the project to use vehicles up to the maximum Gross Combination Mass limits of 50.5 tonnes in dry season and 48.5 tonnes in wet season. This will include the replacement of two concrete culvert bridges and replacement of one wooden bridge, replacement of several existing steel culvert road crossings which have low load bearing capacity and general widening of tight sectional curves.

While infrastructure improvements have the potential to benefit communities, the use of public infrastructure also has the potential to negatively impact these assets. The transport of supplies to the project, and the export of final concentrates will use public roads including the Manton – Namtu – Lashio public road. This will increase the volume of trucks on the road and may lead to increased road wear and damage, an impact which has been reported elsewhere as a consequence of other mining operations in Myanmar (MCRB, 2018).

At the end of the mine life, fixed infrastructure and mobile equipment will be either decommissioned and demolished or divested to a third party. All assets have management requirements associated with them and the recipient of a transferred asset should have a full understanding of these management requirements and associated liabilities. While there are potential post-closure opportunities related to project infrastructure, the base case is for all infrastructure to be dismantled and removed or disposed of.

While the location and details of resettlement sites have not been finalised and are subject to ongoing consultation, WMM has committed to support the reinstatement/provision of the following, in collaboration with the appropriate government authorities and non-government organisations:

- Essential services (i.e., water, electricity, sanitation, communications, waste management).
- Access to health, education and religious services.

The operation of these services is and will continue to be the responsibility of the government and non-government organisations. WMM will engage with relevant stakeholders to determine the best way to support the delivery of these services to the relocated village(s).

Depending on the final chosen location of the relocated village(s) there is also potential that relocation will indirectly provide residents:

- Closer access to commercial services and to larger markets, which will provide an opportunity for the sale of goods and services, which may encourage the establishment of small-scale family enterprises.
- Access to better transport services (i.e., public road network) providing easier access to educational, health and other commercial services located in Namtu and or Lashio.

Project related employment

The project will require a large construction and operations workforce. Direct and indirect employment created by the project and development of skills and educational and training opportunities have the potential to benefit local and regional communities. However, project-related employment can have several potential negative direct social effects, such as gender imbalances and income inequality, either in the form of new effects or reinforcement of existing social norms. The change in employment patterns and income can indirectly lead to increased drug and alcohol use, disorderly behaviour and prostitution.

The predicted construction workforce is up to 2,285 people at its peak. A steady-state workforce of 1,100 people will be required during operations. This workforce will comprise roughly half WMM employees and half contractor employees. Roles will include mining, laboratory and accommodation camp personnel. WMM wishes to assign as many of the available jobs as possible to local community members, subject to their skills, expertise and experience, and to build the capacity and knowledge of the local workforce. WMM will also work with relevant authorities and organisations to create indirect employment opportunities for local people in the provision of goods and services to the mining operation.

WMM is seeking to optimise the proportion of the workforce that is local, adopting a model of employment similar to the Phu Kham Copper-Gold Operation and Ban Houayxai Gold-Silver Operation operated by Phu Bia Mining (PanAust) in Laos. In 2018, the proportion of local workforce (i.e., Lao nationals) at both mines was 92% (PanAust, 2019). Similarly, the Sepon copper-gold mine has a large proportion of local Lao employees. In 2015, the Sepon workforce consisted of 94% Lao nationals, with most from the local region, of whom 25% were women (MMG, 2016).

High portions of local employment can yield significant benefits, particularly if framed to enable women's economic empowerment or targeting other rights-holders who may be marginalised, discriminated against or otherwise at risk in communities impacted by mining activities (MCRB, 2018). These combined economic benefits have the potential to raise income levels, which in turn provide further opportunities for local businesses, such as trade stores and local markets, stimulating business activity.

Challenges to maximising local employment include the availability of necessary skills that can be sourced locally; ensuring contracting entities have the same objectives for local employment; and ensuring employment is fair and equitable between affected communities. In Laos, laws stipulate that no more than 10% of a company's workforce should comprise foreign employees (Kyophilvong 2016); however, no such laws are currently in place in Myanmar. MCRB (2018) noted that in their research of the limestone, gold and tin mining sectors in Myanmar, only one large-scale mine was found to have a policy for employment of local community members. In most of the large- and small-scale operations visited, only a few local community members were identified to be working for the companies as low-skilled workers (e.g., security guards, cooks), often on a casual daily basis (MCRB, 2018). Despite these findings, MCRB noted that local village officials in many villages cited the prospect of jobs as a positive for the region, and the inclusion of villages in local employment and training programs would enhance this.

The management of workforce accommodation will be a key factor influencing the way the project workforce interacts with the surrounding communities. A portion of the construction and operations workforce will interact with communities close to project activities, which can lead to a range of negative effects on those communities including health (such as facilitating the spread of diseases), increased disorderly behaviour, rates of prostitution and increases in rates of consumption of drugs and alcohol.

Employment either directly through the operating company or indirectly through contractors and suppliers has the potential to negatively impact human rights, including discrimination against vulnerable groups, lack of stakeholder inclusion and respect of indigenous populations (Mancini and Sala, 2018). Income inequality as a result of uneven distribution of the employment can trigger social tensions between those with project-related employment and those without.

In-migration

A typical effect of large resource developments in the context of largely rural and developing economies is in-migration, whereby people are attracted to the site of the development in the hope of gaining employment or other benefits. This can cause a disruption to social dynamics, social wellbeing, and security of the local population, and place greater demands on existing services. In this respect, in-migration is classified as an indirect negative source of impact.

In-migration and subsequent changes in demography caused by resource developments have commonly been shown to reduce social cohesion and wellbeing. There may be tensions between existing residents and in-migrants moving to the area seeking employment and commercial opportunities associated with the project, as different cultures and values can cause conflict.

Based on their assessment of gold and tin mining in Myanmar, MCRB (2018) noted that a significant number of internal migrant workers had moved to work either at large-scale mine sites or as subsistence miners. While employees were usually accommodated in specific areas by the companies and did not have much contact with the local communities, daily workers and subsistence miners lived either in their own villages (created as a result of the in-migration) or in pre-existing villages alongside the local population.

In his paper on migration patterns to the Sepon and Phu Kham copper-gold mining projects in Laos, Jackson (2018) establishes numbers, sources and types of migrants towards these mines and the distribution of project-generated cash flows captured by such groups in comparison with those accruing to pre-existing populations. The bulk of migration was demonstrated to be due to personal ties between migrants and pre-existing residents. He hypothesised that in-migration ultimately tends to dilute and partly undermine the immediate and positive impact of any intentional efforts to maximize local economic opportunities. Prescott, et al. (2020) noted that most migrants in a study of informal gold mining listed economic push and pull factors as the key reason for having migrated. On this basis, it could be expected that there would almost certainly be some level of incentive to migrate to Namtu Township in the expectation that work may be available.

While in-migrants are unlikely to get direct employment from the mine there is potential for them to pursue small business opportunities such as establishing small road-sides stalls selling goods.

Procurement of goods and services to the project

The construction and operation will require significant procurement of goods and services. This has the potential to positively influence local and regional businesses. The magnitude of this benefit is dependent on purposeful company policies on procurement of goods and services locally, and the availability of these goods and services to be provided locally. Typically, high value services (e.g., earth moving, trades, support services) are drawn from larger, regional cities.

In Myanmar however, the MCRB's sector wide impact assessment of limestone, gold and tin mining (MCRB, 2018) concluded that there was often limited local procurement by mining operations in Myanmar. They noted that there were sometimes opportunities to sell products and services (for example selling fresh produce or operating small shops and restaurants) to mining companies, but not on a wide scale. Their field research found that generally mining companies were not sourcing goods and services from neighbouring communities to an extent that meaningfully contributed to local economies.

As a result of increased demand on local goods and services from the project there is also the potential for increased local inflation and pressure on existing services. This pattern has commonly been observed surrounding large resource developments. MCRB (2018) reported that during field investigations of the potential impacts of mining in Myanmar, community members reported higher food prices linked to the increase of the population due to mining activities. They also noted that the local healthcare centre was reportedly overstretched, as only permanent employees of the company had access to the company's healthcare centre while the local population and most migrant workers had to access a single community hospital.

Other economic stimulus

Project related employment and the distribution of project benefits all serve to raise income levels which in turn provide further opportunities for local businesses, such as trade stores and local markets, stimulating business activity.

The Republic of the Union of Myanmar will benefit economically from this project, as will state and local-level governments. Cash will be injected into the regional economy through the procurement of goods and services, payment of wages and the distribution of project benefits such as taxes, royalties and equity dividends. This wealth will filter into other sectors of the economy, thereby increasing market activity at the regional scale and contributing to Myanmar's gross domestic product.

A positive stimulatory effect has been observed for the Sepon copper-gold mine in Laos where over the course of the mine life the overall wealth of the Savanahket province has increased significantly. At the peak of its operation capacity, Sepon mine was the second largest employer in the Lao PDR after the public sector. In 2016, household incomes had increased tenfold since the commencement of operations. The mine has partly influenced rapid regional economic growth and a reduction of poverty at the provincial level.

In addition, development of the Bawdwin project may stimulate mineral exploration in Myanmar and development of other large-scale mineral projects and associated economic stimulus. Whilst this is a potential impact of the project it is not assessed further within the EIA given the high level of uncertainty regarding success of other mining and exploration projects separate to WMM activities.

Traffic

The project will generate additional heavy vehicle traffic. During steady state operations there will be between 60 and 93 additional 30-tonne trucks travelling on public roads between Lashio and Namtu per day. As these roads are narrow and winding, travel will be restricted to daylight hours only, for safety reasons. During the construction phase there will be increased heavy vehicle use initially to bring pioneering supplies to the site, and there will be significant road works to deviate the existing Namtu-Manton road around the proposed process plant site. During the construction of this diversion there will be some disruption to local traffic users and increased truck traffic.

Increased heavy traffic has the potential to reduce amenity of villages along the transport corridor due to increased truck noise and air emissions, which can in turn impair community amenity and promote health concerns because of air emissions (e.g., dust, vehicle emissions) and noise. Increased volumes of traffic also pose a physical safety risk to other road users (predominantly being motorcycles and pedestrians) as well as causing inconvenience due to increased traffic congestion and temporary partial road closures to enable road upgrades.

Safety risks associated with project-related traffic are assessed in Chapter 7 Hazard and risk.

Summary of sources of potential impact

Potential impacts to socio-economic values can be complex as they: can occur at a variety of scales; can be dependent on the context of the social value; can be triggered from multiple sources of impact; and are often interrelated. There may also be multiple impact pathways that cause a single impact. Socio-economic impacts can also lead to secondary or tertiary impacts that may be direct or indirectly caused by the project or may have a cumulative effect. As such, the assessment of potential impacts to socio-economic values is complex, depending not only on the direct actions of the project, but also on the regulatory and political context in the future and human behaviour.

In order to provide a robust and transparent assessment of potential socio-economic impacts, a screening assessment was completed to identify credible impact linkages for subsequent assessment of significance. Whereby a:

- Source is a project component or process that can affect and interact with the socio-economic environment.
- Pathway is a medium by which the effect reaches a receptor from a project source for example employment or relocation.
- Impact zone is defined as a discrete area that can be impacted by from a project source via a pathway.

Where possible the most likely direct impacts are assigned and likely secondary impacts are described, including indirect impacts. When a source – pathway – impact linkage is confirmed for any particular impact zone, mitigation and management measures are developed and an assessment of residual impact significance is completed. The screening assessment does not consider either the sensitivity of defined impact zones or the magnitude of impact that these areas will experience.

The initial screening assessment to identify likely source – pathway – impacts is presented in Table 6.203.

Table 6.203 Screening assessment of sources of impact, pathways and residual impacts across defined impact zones and over time

Sources of impact	Impact pathway	Impact	Nature of residual impact	Impact zones	Timing		
					Construction	Operation	Closure
Physical disturbance and displacement (and emissions and discharges)	Resettlement	Living conditions and livelihood	+/-	1, 3	X	X	
		Altered governance	-	1		X	
		Social cohesion	-	1, 2, 3	X	X	
		Social wellbeing	-	1, 2, 3	X	X	
		Removal of services at Bawdwin (medical, schools, places of worship)	-	2	X	X	
		Increased pressure on services	-	3	X	X	
		Social identity	-	1	X	X	X
		Vulnerable groups	-	1, 2, 3	X	X	
	Loss or reduced access to land or riverbed	Living conditions and livelihood	-	1, 2, 3, 4	X	X	X
	Emissions and discharges	Living conditions, reduced amenity, vulnerable groups	-	1, 2	X	X	
Physical landscape modification and project infrastructure	Physical landscape modification	Altered visual amenity	-	1,2, 4	X	X	X
Project related employment	Employment	Direct and indirect local employment	+	1,2,3,6	X	X	
	In-migration	Social cohesion	-	1,2,3,4	X	X	
		Social wellbeing	-	1,2,3,4	X	X	
		Vulnerable groups	-	1,2,3,4	X	X	
Procurement of goods and services and other economic stimulus	Provision of goods and services	Business opportunities	+	1,2,3,6	X	X	
		Direct and indirect employment	+	1, 2, 3,6	X	X	
		Local inflation	-	1,2,3,4,5		X	
	Regional economic stimulus	Business opportunities	+	1,2,3,6	X	X	
		Direct and indirect employment	+	1,3,5,6	X	X	
Traffic	Emissions (dust, particulate matter, gases) and noise	Living conditions (reduced amenity)	-	1,2,3,4,5	X	X	
	Trucks	Safety hazards (traffic accidents)	-	1,2,3,4,5	X	X	

Residual impacts: + = positive, - = negative; and +/- = both positive and negative
Impact zones: 1 = Bawdwin and Tiger Camp villages and farms within the Bawdwin concession area; 2 = villages in tracts adjoining the Bawdwin concession area; 3 = Namtu Town, 4 = inhabitants of the Nam Pangyun valley downstream of the mine; 5 – transport corridor between Namtu and Lashio; and 6 = Lashio
Timing: X – occurring in this phase

6.10.3 Mitigation and management measures

To minimise the project's potential impacts a range of measures have been proposed to limit the sources of potential impact that are described in Section 6.10.2.

These measures are based on a hierarchy of management and mitigation, which are to:

- Avoid impacts to key socio-economic values (described in Section 5.9.10) where feasible.
- If avoiding an impact is not feasible, implement management and mitigation measures in order to reduce the severity of the impact.

Due to the proximity of the Bawdwin and Tiger Camp communities (i.e., Impact Zone 1) to the project, the key proposed avoidance measure is a resettlement program to remove these communities from most of the physical impacts associated with the project in the long term. This proposed resettlement program is significant (affecting around 3,800 people) and will take time to plan and implement properly. The timing of resettlement has been phased into three stages (see Table 6.85). The phasing of resettlement reflects the necessity for WMM to carefully manage capital expenditure during the period before revenue is being generated from production and sale of mineral concentrate.

The mitigation strategy for directly affected communities is to:

- Resettle communities from potentially hazardous conditions in the Bawdwin concession area in the longer term through a formal resettlement and livelihood replacement program.
- Ensure sustainable livelihoods are maintained for directly affected communities.
- Maintain the community structure and cohesion.
- Maintain or improve the quality and availability of health and educational services at the resettlement destination, compared to existing services at Bawdwin and Tiger Camp.
- Implement a community development plan to guide investment in projects that will contribute to sustainable development while being respectful of human rights, culture and community aspirations of project-affected communities.

Socio-economic impacts associated with all project construction and operation activities will be managed through implementation of the integrated project environmental and social management framework. The environmental and social management framework will manage socio-economic impacts and support the capture of socio-economic opportunities through implementation of the environmental and social management plan (ESMP) subplans, including the community development plan, cultural heritage management plan and the outline of the land access and resettlement plan. The environmental and social management framework is presented in Chapter 10.

Plans aimed at maximising project benefits and minimising potential negative impacts, addressing the sources of project impact outlined above, include:

- Community and business development plans
  - Employment and Training Plan
  - Community Development Plan
  - Business Development, Supply and Procurement Plan
  - Community Health, Safety and Security Management Plan
- Outline of the Land Access and Resettlement Plan

- Public Participation Plan that also includes a Grievance Procedure, which are essential for maintaining a constructive dialogue with affected people. Details regarding stakeholder engagement and participation are outlined in Chapter 9.

In addition, an Occupational Safety and Health Plan will manage employee health and safety whilst working for the project.

The following section outlines the key commitments and measures that will be contained within the plans listed above. In addition, there are a range of specific measures that WMM have committed to implementing to avoid or minimise potential adverse social impacts.

Employment and training

WMM will promote local employment and training through a recruitment policy and process with the goal of maximising local participation in the workforce. In addition, WMM will establish and operate the accommodation camp in a manner that is conducive to an ongoing environment of mutual respect within the workforce and between the workforce and surrounding communities, while building workforce awareness of environmental health and personal wellbeing.

A central part of maximising employment benefits from the project will be development and implementation of a Preferential Employment Policy that targets employment of local residents (from communities in proximity to the project) on the basis that it is they who stand to be most impacted by the presence of the project. The policy will outline where two or more equally skilled and experienced candidates are considered for an applicable position, WMM will preferentially seek to employ candidates from the following zones in order of preference:

1. Residents of local communities.
2. Residents of Shan State.
3. Other Myanmar citizens.
4. Expatriates.

While a preferential recruitment system will be implemented, candidates must possess the relevant skills and experience to be able to fulfil the requirements of each position, or demonstrate aptitude in the absence of formal education. If suitably qualified and experienced candidates cannot be sourced from local communities, candidates will be sourced from Shan State, nationally or internationally in that order, on a preferential basis. Best efforts will be made to identify suitable candidates locally, provincially or nationally before considering the need to source expatriates.

WMM will develop and implement an employment and training plan that includes:

- A Preferential Employment Policy that targets employment of local residents (from communities in proximity to the project) on the basis that it is they who stand to be most impacted by the presence of the project, and maximises employment that is linked to preservation and maintenance of cultural heritage relating to the mine.
- A baseline skills assessment and skills gap assessment of the local workforce to identify priority training areas.
- Robust procedures for hiring practices which promote equal opportunity, non-discrimination and measures to discourage in-migration (e.g., a no-gate hire employment or similar).
- A community pre-employment training program that will be implemented in the pre-construction phase of the project, to maximise local employment during the construction phase of the project.
- Training and development initiatives to ensure that workforce capability is developed and maintained. This will include on the job professional development opportunities for all roles and genders, such as industry

training, apprenticeships, traineeships, and graduate programmes, as well as personnel development initiatives such as literacy, numeracy and financial training.

- A scholarship program to support local residents and employees pursuing opportunities to gain tertiary qualifications.
- Measures to support the participation of women in training, employment and business development activities.
- An inclusive communications and engagement strategy to clearly articulate proposed employment and commercial participation (through business development, supply, procurement) policies and systems, including the designated preferential zones, and ensure that stakeholders have clear and regularly updated information on how to access employment and procurement opportunities.

WMM will develop and implement a workforce Code of Conduct that serves as the foundation of a governance framework. The Code of Conduct will:

- Prohibit drugs, gambling and prostitution in camps and project sites.
- Mandate fitness-for-work and return-to-work examinations for project workers, including testing for the presence of communicable disease diagnosis, drugs and alcohol.
- Stipulate WMM's zero tolerance stance on forced labour, child labour, human trafficking and unfair discrimination for employees and contractors and throughout the supply chain.
- Require the rights of fellow employees and local communities to be respected, and any suspected human rights abuse to be reported to management.
- Include a worker grievance process.

Business development, supply and procurement

WMM will seek to maximise the opportunities for local, state and national companies to contract to WMM, subject to meeting cost and quality considerations. WMM will also seek to identify opportunities to assist local businesses to develop their skills and products in order to facilitate contractual opportunities with WMM. Proposed mitigation and management measures include:

- Conduct a baseline business assessment of the regional economy to identify areas of potential business involvement in the project. A program to address how opportunities can be optimised for regional businesses will then be developed.
- Develop and implement a Business Development, Supply and Procurement Plan that will include:
  - Targets for local business participation for procurement of local and regional goods and services to the project.
  - Assessment requirements of local content as part of the selection of contract tenders.
  - Contract conditions that include protocols to comply with local procurement, equal opportunity, non-discrimination and human rights.
  - Advertisement of procurement opportunities readily available and accessible to regional small and medium enterprises and locally-based businesses.
  - A household-scale development program developed in consultation with affected people. This may include:

        - Agricultural development support such as food production, processing (e.g., fruit, vegetables, chickens etc)
        - Small-scale service provision program (transport, retail, mechanical maintenance etc)
    - A medium scale enterprise development program to facilitate local businesses to participate in the project supply chain. This may include:
        - Road maintenance, quarrying, and labour hire.
        - Nursery and revegetation services.
- Set out clear expectations of suppliers and contractors in a Supplier Code of Conduct written in Shan, Myanmar, and English languages and publicly available.
- Develop and implement a Supplier Risk Management program that integrates human rights risk evaluations into key stages of the supplier lifecycle, including pre-qualification, scope of work risk assessments, ongoing supplier management and closeout.
- Develop a supplier human rights training program.

Resettlement and livelihoods restoration

Resettlement and livelihood restoration planning has been guided by seven principles that will dictate the subsequent planning stages of resettlement, through to implementation and then ongoing monitoring and evaluation. These principles are:

- The need to resettle communities will be avoided or minimised through effective project design and planning to the extent possible.
- Establish clearly defined responsibilities, commitments and governance mechanisms for all aspects of resettlement planning and implementation, ensuring that staff have the required skills and alignment with the adopted standards.
- Promote cooperation, inclusive planning and co-ownership of resettlement plans and processes with all relevant stakeholders.
- Resettlement will be approached as an opportunity for achieving long-term improvements in the socio-economic status of resettling and host communities and ensure that these communities are no worse off.
- Resettlement activities will foster social cohesion and respect the cultural integrity of affected communities.
- Dealings with households and communities affected by resettlement, and related planning and implementation, will be undertaken in a thorough, fair, equitable and transparent manner that fosters full participation, avoids forced eviction and respects human rights.
- Resettlement activities will comply with WMM social policies and standards as well as Myanmar law and international standards where appropriate, ensuring that resettling and host communities are aware of their legal rights.

The project has developed an Outline of the Land Access and Resettlement Plan (Attachment 4) to guide resettlement planning and livelihoods restoration. The detail of this plan is commensurate with the current level of project definition and noting the requirement of participatory engagement with affected people and communities.

Resettlement planning is a sequential process with steps that need to be completed in succession before physical relocation can take place. No physical relocation of people will occur until the resettlement site is constructed and commissioned. This will be achieved through a series of progressively more detailed planning steps covering:

- Land Access and Resettlement Plan – Development of this plan will guide the assessment, planning and community approval process. It will include but is not limited to the establishment of resettlement committees, asset identification and declaration of cut-off, a draft eligibility and compensation framework, and options for the type and delivery of livelihood restoration support.
- Detailed Resettlement Action Plan(s) – this plan(s) will includes detailed asset surveys, documentation of agreed compensation and livelihood restoration assistance, detailed schedule and arrangements for physical relocation, outcomes of all participatory planning, consultations and negotiations, proposed compensation arrangements, valuation methodologies, site selection issues and decisions, the design of the proposed resettlement housing, planned livelihood restoration activities, anticipated arrangements for vulnerable people, and monitoring and evaluation arrangements.
- Implementation and handover – including construction of resettlement housing and related infrastructure; sign-off and payment of all compensation; and the process of moving people and settling-in. A handover process completes this stage of resettlement.
- Livelihood restoration and enhancement – this involves all the activities around restoring people's livelihoods and income earning activities and/or assisting them to transform into other activities that enhance their wellbeing.
- Monitoring and evaluation – includes ongoing performance (process) monitoring, impact monitoring and a completion audit.

In accordance with the Outline of the Land Access and Resettlement Plan (Attachment 4), WMM proposes the following stages for resettlement and livelihoods restoration:

- Inception phase, including:
    - Identification and consideration of issues and the development of the RPF to guide further planning.
    - Initiate a community engagement strategy with the convening of a Resettlement Oversight Group (ROG) with members of WMM and key government regulatory agencies. This group will be required to agree on approach regarding the resettlement process and framework.
    - Following agreement with the ROG formal disclosure to affected communities will be scheduled and a resettlement forward work plan will be developed and integrated with mine and support infrastructure planning and technical assessments.
- Land Access and Resettlement Plan phase, including:
    - Ongoing close consultation with the ROG and affected communities through the establishment of resettlement committees comprised of PAP and relevant government representatives.
    - Asset identification based on household asset and census surveys.
    - Development of an overarching Land Access and Resettlement Plan (LARP) based on the identification, technical assessment and selection of resettlement sites in consultation with the ROG and affected communities.
    - Development and agreement of entitlement criteria and evaluation of technical options for housing replacement and infrastructure provision.
    - Requirements and options for livelihood restoration support will be assessed and a draft Livelihood Restoration Plan prepared.
    - Formal 'cut-off' date will be announced in conjunction with the implementation of a detailed Asset Survey (AS) and population census in conjunction with the Government.

- Resettlement Action Plan phase, including:
  - A resettlement project management unit will be established within WMM to deliver subsequent phases of Resettlement Implementation and Resettlement Monitoring and Evaluation.
  - Resettlement Action Plans (RAPs) will be prepared for affected villages.
  - Development and supervision of contracting arrangements for the provision of physical infrastructure, housing, logistics support for household movement and the delivery of transitional support for short to medium-term livelihood maintenance and long-term livelihood restoration.
  - On-going stakeholder engagement during the phase through the ROG and Village Tract Development Support Committees where established.
- Implementation phase (including monitoring and evaluation), including:
  - Establishment an internal Resettlement Steering Committee (RSC) to ensure that the joint venture partners at director level remain abreast of resettlement issues and are able to consider and input to policy positions required to effectively address these issues.
  - Establishment of a WMM resettlement planning team led by the Safety, Health, Environment & Community (SHEC) Manager. This team will be supported by experienced planning advisors drawn from consulting and social research organisations.
  - Maintain coordination and input from the Resettlement Oversight Group (ROG) with ME-1, the Namtu General Administrative Department (GAD) and Village Tract Administrators.

Other measures related to resettlement and livelihood restoration include:

- Consult with communities in advance of potential changes to land resources (productivity and access) and accommodate arrangements, where required. If changes affect livelihoods, manage in accordance with physical and economic displacement principles.
- Manage the loss of, or restricted access to land or assets, by WMM accessing land in a transparent manner that enables landowners the opportunity to relinquish access to an area in a culturally appropriate manner.
- Ensure that fair and equitable compensation is provided to parties affected by project related impacts on subsistence resource use or existing income generating resources or activities.
- Establish a museum and cultural centre that promotes the history and culture of the Bawdwin operation (see Section 6.9).
- Interview and record the history of the Bawdwin mine from current Bawdwin residents.

Community development

WMM will engage with relevant directly affected communities and other stakeholders, including township / district / state / national government and external parties to identify community investment priorities.

It is recognised that the government and civil society organisation play a vital role in delivering health, education and policing, services and therefore any investments in the services will be made in consultation with service providers to maximise benefits and sustainability.

WMM will develop and implement a detailed Community Development Plan. This plan will comply with the current Myanmar Mining Law and Rules that require all mining companies to allocate a percentage of their revenue into Community and Social Responsibility initiatives. WMM will continue to develop its knowledge of community conditions and needs through a formal process of community engagement and will use this knowledge to progressively refine the Community Development Plan. WMM wishes to align investment priorities with the hierarchy of impact zones. That is, development investment would prioritise the communities directly affected by the project (e.g., Impact Zone 1), followed by the other impact zones. This approach is dependent on further stakeholder engagement and endorsement by key stakeholders such as the district authority.

It is anticipated that investment priorities are likely to focus on:

- Improvement or expansion of health services to affected communities including villages in tracts adjoining the Bawdwin concession area that are impacted by the removal of health services at Bawdwin, and Namtu residents following resettlement. Investment will most likely be in the form of upgraded health infrastructure and supplies.
- Improvement or expansion of education services, most likely in the form of upgraded school and training infrastructure and supplies.
- Improvement of infrastructure to provide or improve access to clean water, electricity, sanitation, and mobile telecommunications.
- Business development.

Community safety and security

The objective of the Community Health, Safety and Security Management Plan is to establish measures to manage potential Project-related risks to community health, safety and security. The plan will apply to villages immediately surrounding the project area that are potentially subject to impact from project construction and operation.

The success of implementation of the Community Health, Safety and Security Management Plan will be influenced by relevant state and district level governments and therefore close engagement with key stakeholders regarding the content and implementation of the plan is required. Community health measures are described in Section 6.11.

Community safety measures will include:

- Implement the Traffic Management Plan to prevent injuries to road users, which includes measures for the management of road and pedestrian traffic, include:
  - Ensuring WMM (and contractor) drivers have the relevant level of competency for the vehicle they need to drive and carry relevant licences
  - Establishing and enforcing speed limits on project roads and for project vehicles
  - Conducting regular vehicle inspections
  - Journey management protocols including driver fatigue management
  - Avoiding, where practicable, dangerous routes and times of day e.g., night time driving
  - Running safety awareness and education programs for impacted communities, including school programs
  - Coordinating with emergency responders to provide first aid in the event of accidents
  - Notify relevant communities as required about of significant changes in traffic conditions (e.g., high project traffic periods or road/ river diversions/ blockages) and the associated hazards with these changes.
- Deliver a program to project-affected communities including schools in project-affected communities to raise awareness of risks to safety posed by project activities, and personal behaviours which can reduce risk and improve safety.
- Implement a Project-wide induction process that covers, as a minimum: ethics; human rights; health; environment; safety; alcohol and drug use; workforce diversity; harassment; and cultural and social sensitivities of workers and communities

- Develop, implement and monitor compliance with a workforce code of conduct that governs internal workforce interaction and interaction between the workforce and project-affected communities.
- Complete a human rights impact assessment for the project that is continually reviewed to ensure impacts to human rights are appropriately identified, assessed and addressed over life of mine.

Measures to limit the effects of in-migration will include:

- Communicate potential impacts of in-migration to local communities to assist them to devise strategies to manage in-migration.
- Engage with the state, township and village-level government representatives to assist them to devise strategies to prepare for in-migration.
- Select workers in accordance with the geographic priorities determined by the project (Preferential Employment Policy).
- Establish multiple points of hire that provide access to affected communities and do not encourage people to move to project sites.
- Communicate to the community the recruitment process that requires applicants' place of origin to be identified.
- Do not allow public access to services (such as health and transportation services) provided to project employees.

  Security measures will include:

- Implement a Security Management Plan that includes the following measures:
  - Implement security controls to protect the safety of project employees.
  - Conduct background checks on security personnel and train them in the Voluntary Principles on Security and Human Rights.
  - Provide training in the use of force and conduct toward workers and the local community for all security workers.
  - Conduct evaluations on the performance of security providers.
  - Conduct community engagement on security arrangements.
  - Actively monitor and restrict incursions of non-workers onto or across work sites, particularly if the sites are unfenced.
  - Establish a checkpoint on roads to monitor traffic and admit authorised vehicles only.
- Maintain a neutral company position with regard to internal conflicts within Shan State and being a good neighbour.

6.10.4 Residual impact assessment

This section assesses the residual significance of impacts identified in Section 6.10.2 after implementation of the mitigation and management measures outlined in Section 6.10.3. The magnitude of each residual impact is assessed based on the impact's geographic extent, severity and duration, taking into consideration the existing conditions of the features and their importance, vulnerability and resilience. Table 6.204 presents the criteria used to determine the magnitude of each impact. An overall magnitude rating was produced based on subjective weighting of extent, severity and duration.

Table 6.204 Criteria used to determine the magnitude of socio-economic impacts

Factor	Magnitude Ratings				
	Very low	**Low**	**Medium**	**High**	**Very high**
Spatial extent	Local scale social impacts that effect a small number of people (<5%) within the defined impact zone.	Mostly local scale social impacts that effect some people (5 – 15%) within the defined impact zone.	Intermediate scale social impacts that effect a notable proportion of people (15 – 50%) within the defined impact zone.	Far reaching social impacts that effect the majority (i.e. 50 – 75%) of people within the defined impact zone.	Far reaching social impacts that effect the almost all people (>75%) within the defined impact zone.
Severity	Impacts are very minor in nature. Impact to the community will probably recover on its own or require minimal management.	Impact is minor and can is straightforward to remedy or manage using standard management measures.	Impact is of moderate severity to the community. Impact can be partly remedied or managed by implementing management measures	Impact is of high severity and/or results in high levels of social disruption to affected community. Impact is very difficult to mitigate despite implementation of management measures.	Impact is of very high severity and/or has very high levels of social disruption to affected community. Impact cannot be avoided despite implementation of management measures.
Duration	Impact is very short in duration (i.e., days)	Impact is short term (i.e., months or less)	Impact is medium term (1 to 2 years).	Impact is long term (3 to 15 years).	Impact is greater than 15 years or permanent.
Positive	Some limited value to the community.	Impacts some value to community.	Impacts can provide substantial social value to community.	Impacts can provide high value to communities.	Impacts can provide very high value to communities.

Local economies, land use and livelihoods

The socio-economic component covering local economies, land use and livelihoods focuses largely on direct impacts generated by the project. Social values covering employment, business opportunities and land use are discussed and assessed. These direct impacts can also result in secondary or indirect impacts that are not purely financial, but can encompass a range of other social aspects (such as social cohesion, living conditions and disadvantaged vulnerable groups). These secondary and indirect impacts are discussed in the following section.

Employment

The project has the potential to provide, stimulate or influence diverse employment opportunities, which has been defined as a key social value.

The creation of jobs (both in the mining sector and indirectly in other sectors) is a positive impact of mining at local, regional and national level. Educational opportunities offered by the company and employee skill development are further potential positive outcomes. WMM will seek to maximise the proportion of available jobs that are allocated to members of local communities, through its Preferential Employment Policy.

Although detailed procedures to implement the commitments contained in the Preferential Employment Policy have not yet been developed, it is expected that the ‘local workforce’ will largely comprise persons currently living in the Bawdwin villages, Namtu Town and villages in tracts adjoining the Bawdwin concession area. The exact breakdown between these localities will depend on the skills of residents and the types of skills required. While the exact number of construction positions sourced from each impact zone for the project have not been determined it is expected that between 1,000 and 1,500 construction positions will be sourced locally. If suitable skills are not available within these areas, a broader catchment focussing on Namtu village tract is likely. During operations it is estimated that WMM will directly employ approximately 450 Myanmar nationals, with approximately 560 Myanmar nationals positions employed by contractors. Remaining positions will be filled by expatriates.

Direct employment opportunities will, to large degree, be influenced by the procurement strategy of WMM, which will see contractors responsible for project construction and also key aspects of mining (e.g., using a mining contractor). WMM is likely to engage lead contractor(s) to provide engineering, procurement and construction management services, including management of subcontractors and vendors. WMM will add local content requirements as part of contract conditions with these third parties; however, will not be directly responsible for employment decisions as part of these contracts.

In Myanmar the mining sector is not well developed and therefore skills required in a modern mining operation may be limited nationally. For example, in 2018 mining and quarrying accounted for only 1.2% of the nation's employment (GoM 2017). WMM recognises that training will be required for the local workforce, although some local residents may have previously worked at the Bawdwin mine or in other industries and therefore may already have experience and skills acquired through relevant training. Changes to employment opportunities (defined as a key social value) either directly or indirectly as a result of the project are identified in Impact Zone 1 (Bawdwin and Tiger Camp villages and surrounding farms), Impact Zone 2 (villages in tracts adjoining the Bawdwin concession area, Impact Zone 3 (Namtu Town) and Impact Zone 6 (Lashio). The magnitude and significance of these impacts are assessed in the following section. However, direct employment for existing inhabitants of the Nam Pangyun valley and in the villages along the export corridor is assessed to be unlikely and therefore no impacts are predicted.

Impact Zone 1 – Villages within the Bawdwin concession area

In contrast to greenfield mining developments in remote locations, the Bawdwin communities have a long association with mining and mineral processing (albeit limited over the last decade). This provides greater potential for the existing community to be re-employed in the project workforce. However, it is noted that the current WMM Bawdwin employees are typically from older age groups, who may be approaching or past the maximum working age permitted under national law and may hence have limited employment potential in terms of remaining years of work at Bawdwin. Although younger people may have greater employment potential because of their age, they may not have had the opportunity to be directly involved in the previous mining operations, due to the long tenure of older workers.

Following resettlement and development of the project, it is expected that a portion of resettled households will derive income from residents who will be employed by the project. Bawdwin and Tiger Camp residents will also have preferential access to employment and training opportunities associated with the mine. The higher level of skills, and settlement in proximity to Namtu Town (the likely centre for the resettlement villages), will allow residents of resettled households to access a more diverse range of employment opportunities as Namtu develops over time as a supply and maintenance centre providing services to the re-developed mine.

WMM will implement measures to maximise local employment, increase the skills base through training and development. In addition, the Resettlement Action Plan will contain measures to restore livelihoods or to provide alternative livelihood opportunities. On this basis, the residual impact of creation of jobs (both in the mining sector and indirectly in other sectors) for the Bawdwin communities during the construction and operations phases will be of **positive (high) significance**, based on the **medium impact magnitude** and the **high sensitivity** of employment conditions within the defined impact zone (see Table 6.205).

Table 6.205 Residual impact significance summary – construction and operations phases – employment for villages within the Bawdwin concession area (Impact Zone 1)

Value	Sensitivity of current employment conditions			
Diverse employment opportunities	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Due to the nature of these communities with employment and	**High** Due to the ability to earn an income and participate in the cash	**Low** Bawdwin and Tiger Camp villages are highly dependent on the Bawdwin	**High**

Value	Sensitivity of current employment conditions			
	accommodation linked to the Bawdwin and Namtu concession permits, the Bawdwin mine is highly important to their livelihoods and economic security. There are few other sources of income or other livelihoods in these communities.	economy being intrinsically related to the Bawdwin mine with few other sources of income the villages are highly vulnerable to any material changes in their existing employment arrangements.	mine for employment and support of the local economy and therefore have limited resilience.	
Impact	**Magnitude of impact**			
Mining related employment opportunities for the Bawdwin communities	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Mostly local scale social impact that is predicted to affect between 5 and 15% of people of the Bawdwin and Tiger Camp communities.	**High** Impact can provide high social value to the affected people within the defined impact zone, providing a more diversified employment base.	**High** Long-term impact term with the potential to extend over the mine life however the experience and skills developed through this employment may lead to further opportunities after mine closure.	**Medium (positive)**
	Residual impact significance			**Positive (high)**
	Assessment of uncertainty			
	Medium The number of people in the communities with suitable skills to transition to a modern mining operation is currently unknown.			

Impact Zone 2 – Villages in tracts adjoining the Bawdwin concession area

Employment opportunities during construction and operation of the project will provide value to villages in tracts adjoining the Bawdwin concession area. The residual impact will be of **positive (low) significance**, based on the **low impact magnitude** and the **low sensitivity** of employment conditions within the defined impact zone (Table 6.206).

Table 6.206 Residual impact significance summary – construction and operations phases – employment for villages in tracts adjoining the Bawdwin concession area (Impact Zone 2)

Value	Sensitivity of current employment conditions			
Diverse employment opportunities	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Livelihoods in the area are dependent on agriculture as their main source of livelihoods. The Bawdwin concession area is of low importance to their livelihoods or local economies.	**High** Low vulnerability due to changes to the Bawdwin concession area due to their high reliance on agriculture and limited economic connectivity with Bawdwin villages.	**Low** Livelihoods and local economies are based almost exclusively on agriculture, which is susceptible to drought and environmental changes.	**Low**
Impact	**Magnitude of impact**			
Mining related employment opportunities for communities in tracts adjoining	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very low Local scale impact that is predicted to affect less than 5% of	**High** Impact can provide high social value to the affected people within the defined	**High** Long-term impact term with the potential to extend over the mine life however the experience	**Low (positive)**

the Bawdwin concession area	the defined impact zone.	impact zone, providing a more diversified employment base.	and skills developed through this employment may lead to further opportunities after mine closure.	
	Residual impact significance			**Positive (low)**
	Assessment of uncertainty			
	Medium The number of people in the communities with suitable skills to transition to a modern mining operation is currently unknown.			

Impact Zone 3 – Namtu Town

WMM will implement measures to maximise local employment, increase the skills base through training and development and provide business and supply opportunities for businesses in Namtu to support the project during the construction and operations phases. The residual impact of creation of jobs (both in the mining sector and indirectly in other sectors) for the Namtu communities will be of **positive (low) significance**, based on the **medium impact magnitude** and the **medium sensitivity** of employment conditions within the defined impact zone (Table 6.207).

Table 6.207 Residual impact significance summary – construction and operations phases – employment opportunities for Namtu (Impact Zone 3)

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Diverse employment opportunities</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>Medium
Currently mining provides a small proportion of jobs for Namtu based on the last census. The broader Namtu community is less dependent on the Bawdwin operations with other employment opportunities including government and other services.</td><td>Medium
Namtu town is somewhat vulnerable to changes in the local economy and livelihoods as many residents are employed in the mining sector, however there are alternative forms of employment in the area.</td><td>Medium
Namtu town is somewhat resilient to changes in the local economy or livelihoods as a result of mining as employment/income is more diversified and the town is less reliant on the Bawdwin mine than residents in the Bawdwin concession area.</td><td>Medium</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact</th></tr>
<tr><td rowspan="6">Mining related employment opportunities for the Namtu Town</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Very low
While there may be job opportunities created for residents of Namtu as a proportion of the total population these are predicted to affect less than 5% of the defined impact zone.</td><td>Medium
Namtu is proposed to be a central employment hub for employment providing access to existing Namtu residents and probably the resettled Bawdwin communities.
This impact can provide social value to the affected people within the defined impact zone.</td><td>High
Long-term impact term with the potential to extend over the mine life however the experience and skills developed through this employment may lead to further opportunities after mine closure</td><td>Low (positive)</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Positive (low)</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">Medium
The number of people in Namtu Town with suitable skills to transition to a modern mining operation is currently unknown.</td></tr>
</table>

Myanmar

Skilled workers will be required to be sourced from across Myanmar and internationally. The residual impact of employment opportunities during construction and operation of the project will be of **positive (low) significance**, based on the **low impact magnitude** and the **low sensitivity** of employment conditions within the defined impact zone (Table 6.208).

Table 6.208 Residual impact significance summary – construction and operations phases – employment opportunities for Myanmar

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Diverse employment opportunities</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>Low
Mine related employment is minor at a national and international scale</td><td>Low
Due to many alternative employment opportunities available at a national and international scale</td><td>Medium to High
Communities have some resilience to changes to the current arrangement</td><td>Low</td></tr>
<tr><td>Impact</td><td colspan="4">Magnitude of impact</td></tr>
<tr><td rowspan="6">Mining related employment opportunities for skilled workers located across Myanmar and internationally</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Very low
While there will be job opportunities created for residents of Myanmar these represent a very small proportion of the defined area.</td><td>Medium
This impact can provide social value to the affected people within the defined impact zone.</td><td>High
Long-term impact term with the potential to extend over the mine life however the experience and skills developed through this employment may lead to further opportunities after mine closure</td><td>Low (positive)</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Positive (low)</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">Low
There is relatively high confidence that suitable skills would be expected to be available at the national scale.</td></tr>
</table>

Economy

Business sectors providing goods and services has been defined as a key social value with the potential to be influenced by the project.

Economic impacts are likely to occur at a local, regional and national scale. Mining often gives stimulus to the local economy and increases population income and business opportunity, also in other sectors. However, income inequality, i.e., an unfair distribution of the benefits coming from resource extractions and corruption due to the bad management of mineral wealth, can trigger social tensions (Mancini and Sala, 2018).

The direct capital investment to construct the project is estimated to be around US$360 million in real terms. Recurrent operating expenditure, including a level of local spending on support services, is estimated to be US$1 billion over the life of the mine. The purchase of such materials and services from within Myanmar is predicted to result in a higher level of activity in the local, regional and national economy. This growth will lead to the creation of additional employment opportunities and stimulate further growth and development of the economy.

The same system of preference will apply towards commercial opportunities related to the project. These may include business contracts, supply of goods and services or procurement of local goods.

WMM will seek to procure goods and services required during the construction phase from local businesses. Where the goods or services offered are competitive in quality and price, and subject to compliance with WMM's standards for safety, commercial and human rights management, WMM will give procurement preference to (from highest to lowest preference):

- Businesses based within the Namtu Town and resettled communities.
- Businesses based in proximity to the project e.g., neighbouring village tracts.
- Business based in other parts of Shan State.
- Businesses based elsewhere in Myanmar.
- Business based outside Myanmar.

The project is expected to generate economic activity across numerous business in the local region. This will primarily occur through the procurement of goods and services, payment of wages and the distribution of project benefits. Economic activity associated with construction and operation (through local contracts for the procurement of materials, goods and services) will also lead indirectly to the creation of employment opportunities in the local economy. This will increase the capacity of people employed by the project to purchase goods, health and education services and other items. Flow-on effects from the injection of wealth into the local economy has the potential to allow new businesses to establish and existing businesses to expand operations.

The types of goods and services the project could procure locally include but are not limited to:

- Provision of food (e.g., vegetables)
- Camp support services such as cooking and cleaning.
- Labour hire business providing machinery operators and drivers and trade skills.
- Fabrication and metalwork.
- General supplies.
- Provision of work clothing.

WMM will support current business enterprises to relocate to the resettlement location. This will require adjustment to the new conditions. These businesses may benefit due to proximity to a large population centre of Namtu (should this be the chosen resettlement location). But there is also the potential that current businesses may struggle to re-establish at the relocation site, due to increased competition with existing commercial businesses.

There may be an increase in business turnover through participation in the mine supply chain or supply to relocated population. Currently, Namtu businesses are likely to be supplying to Bawdwin and Tiger Camp retail outlets so the effect of an increased population on business may be limited. After mining, the main business sectors in Namtu are construction, retail sales and services with a small manufacturing capacity. Each of these sectors could be expected to grow with the redevelopment of the mine which will have a local procurement and business support policy.

Expenditure occurring locally will constitute income for other individuals or businesses, thereby distributing cash more generally throughout the community. Operators of shops and stalls are among those who would benefit from this redistribution of wealth.

A potential negative impact associated with a stimulated local economy is the potential for local inflation of the price of goods and services. While a potential positive impact for providers of goods and services, people whose incomes do not increase proportionally to inflation may be negatively impacted.

Economic stimulus and business opportunities are assessed to effect impact zone 1 (Bawdwin and Tiger Camp communities), Impact Zone 2 (villages in tracts adjoining the Bawdwin concession area), Impact Zone 3 (Namtu Town) and Impact Zone 6 (Lashio). The magnitude and significance of these impacts are assessed in the following section. However, business opportunities for inhabitants of the Nam Pangyun valley (Impact Zone 4) and in the villages along the export corridor (impact Zone 5) is assessed to be unlikely and therefore no impacts are predicted.

Impact Zone 1 – Villages within the Bawdwin concession area

Businesses currently in operation in Bawdwin are largely shops, markets and services providing goods and services to the Bawdwin community. With measures implemented to maximise local business opportunities with the project, facilitate the development of new businesses and measures to re-establish existing businesses, local and regional economic stimulus is assessed to have a positive overall impact, noting that there is the potential for some negative effects. Business opportunities as a result of the project have the potential to provide value to Bawdwin communities. The residual impact will therefore be of **positive (moderate) significance**, based on the **low impact magnitude** and the **high sensitivity** to changes of the current business sector provided management measures and commitments are successfully implemented (Table 6.209).

Table 6.209 Residual impact significance summary – construction and operations phases – business opportunities for villages within the Bawdwin concession area (Impact Zone 1)

Impact	Sensitivity of the current business sector			
Business sectors providing goods and services	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Due to the nature of these communities with employment and accommodation linked to the Bawdwin and Namtu concession permits, the Bawdwin mine is highly important to their livelihoods and economic security. There are few other sources of income or other livelihoods in these communities.	**High** Due to the ability to earn an income and participate in the cash economy being intrinsically related to the Bawdwin mine with few other sources of income the villages are highly vulnerable to any material changes in their existing employment arrangements.	**Low** Bawdwin and Tiger Camp villages are highly dependent on the Bawdwin mine for employment and support of the local economy and therefore have limited resilience.	**High**
Impact	**Magnitude of impact**			
Business opportunities and economic stimulus created by the project and impact on the Bawdwin and Tiger Camp villages	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very low While preferential business opportunities will be investigated there are likely to be few local businesses with capacity to directly provide goods and services to the project. Therefore, few existing businesses within Bawdwin are expected to benefit.	**Medium** Impacts can provide substantial value to businesses that are able to provide goods and services to the project.	**High** Long-term impact with the potential to extend over the mine life.	**Low (positive)**
	Residual impact significance			**Positive (moderate)**
	Assessment of uncertainty			
	Medium Economic stimulus as a result of the project is reasonably certain; however, there a moderate degree of uncertainty regarding the magnitude of consequent impacts of businesses within the Bawdwin and Tiger Camp communities economic stimulus and the flow on effects to local and regional economies. It is assumed that the proposed Community and Business Development Plans will be successfully implemented, however, the plans have not yet been developed			

Impact Zone 2 – Villages in tracts adjoining the Bawdwin concession area

Livelihoods for these villages are primarily based on agriculture, with cultivation of seasonal crops such as maize and vegetables, and raising of poultry, goats and cattle. There are likely to be few new business and economic development opportunities in future for these villages as livelihoods and local economies are based almost exclusively on agriculture. Business opportunities would therefore largely be restricted to providing produce such as vegetables for the mine. Nonetheless regional economic development could have a positive impact. Conversely, the resettlement of Bawdwin communities may reduce the demand for agricultural goods currently sold by the surrounding communities to Bawdwin village residents.

Business opportunities as a result of the project have the potential to provide value to Hu Hsar, Hin Poke and Kyu Hsawt village tracts communities, however resettlement of Bawdwin communities may reduce demand for local business. Therefore, the residual impact is of **neutral significance**, based on the **neutral impact magnitude** and the **low sensitivity** to changes of the current business sector (Table 6.210) provided management measures and commitments were successfully implemented.

Table 6.210 Residual impact significance summary – construction and operations phases – change in existing demand for business including business opportunities for villages in tracts adjoining the Bawdwin concession area

Value	**Sensitivity of the current business sector**			
Business sectors providing goods and services	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Livelihoods in the area are dependent on agriculture as their main source of livelihoods. The Bawdwin concession area is of low importance to their livelihoods or local economies.	**Low** Low vulnerability due to changes to the Bawdwin concession area due to their high reliance on agriculture and limited economic connectivity with Bawdwin villages.	**Low** Livelihoods and local economies are based almost exclusively on agriculture, which is susceptible to drought and environmental changes.	**Low**
Impact	**Magnitude of impact**			
Change in existing demand for business, including opportunities and potential economic stimulus created by the project and impact on villages in tracts adjoining the Bawdwin concession area	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium The proportion of people impacted by change in existing demand is probably intermediate scale given the agricultural livelihoods. Whereas only a very small number of businesses within the defined impact zone are likely to benefit from business opportunities or project related economic stimulus	**Medium (positive)** Impacts can provide value to businesses that are able to provide goods and services to the project. **Medium (negative)** Benefits may be offset by adverse impacts to those businesses that currently sell goods in Bawdwin villages.	**High** Long-term impact with the potential to extend over the mine life.	**Neutral**
	Residual impact significance			**Neutral**
	Assessment of uncertainty			
	Medium Understanding of the current businesses that operate in these villages is not well understood, including the reliance on Bawdwin communities for demand for agricultural goods. Economic stimulus as a result of the project is reasonably certain; however, there is a moderate degree of uncertainty regarding the magnitude of consequent impacts of businesses within these communities, the economic stimulus and the flow on effects to local and regional economies. It is assumed that the proposed Community and Business Development Plans will be successfully implemented, however, the plans have not yet been developed.			

Impact Zone 3 – Namtu Town

As the closest major town with commercial, government and support services, regional economic development is likely to be focussed in this area. As it has a reasonably diversified business sector, it is likely that business opportunities, particularly small to medium sized enterprises, will be available in Namtu, particularly if measures are implemented to maximise local business opportunities.

The residual impact of economic (business-related) opportunities during construction and operation of the project will provide value to Namtu communities and will be of **positive (low) significance**, based on the **low impact magnitude** and the **medium sensitivity** to changes of the current business sector (Table 6.211).

Table 6.211 Residual impact significance summary – construction and operations phases – business opportunities for Namtu

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Business sectors providing goods and services</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>Medium
Currently mining provides a small proportion of jobs for Namtu, based on the last census. The broader Namtu community is less dependent on the Bawdwin operations with other employment opportunities including government and other services.</td><td>Medium
Namtu town is somewhat vulnerable to changes in the local economy and livelihoods as many residents are employed in the mining sector, however there are alternative forms of employment in the area.</td><td>Medium
Namtu town is somewhat resilient to changes in the local economy or livelihoods as a result of mining as employment/income is more diversified and the town is less reliant on the Bawdwin mine than residents in the Bawdwin concession area.</td><td>Medium</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact</th></tr>
<tr><td rowspan="6">Business opportunities and economic stimulus created by the project and impact on Namtu</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Low
Mostly local scale impacts that is predicted to affect some within the defined impact zone.</td><td>High
Impacts can provide substantial value to businesses that are able to provide goods and services to the project.</td><td>High
Long-term impact with the potential to extend over the mine life.</td><td>Medium (positive)</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Positive (low)</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">Medium
Understanding of the current businesses that operate in Namtu that could provide goods and services is not well understood.
Economic stimulus as a result of the project is reasonably certain; however, there a moderate degree of uncertainty regarding the magnitude of consequent impacts of businesses within these communities economic stimulus and the flow on effects to local and regional economies.
It is assumed that the proposed Community and Business Development Plans will be successfully implemented, however, the plans have not yet been developed</td></tr>
</table>

Impact Zone 6 – Lashio

Lashio and other major population centres are likely to benefit from larger project contracts. The residual impact of economic stimulus as a result during construction and operation of the project will be of **positive (low) significance**, based on the **medium impact magnitude** and the **low sensitivity** (Table 6.212).

Table 6.212 Residual impact significance summary – construction and operations phases – business opportunities for Lashio

Value	**Sensitivity of value**			
Business sectors providing goods and services	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Very low No businesses currently depend on the Bawdwin mine.	**Low** Due to many alternative business opportunities available within the city and regionally.	**High** The business sector within Lashio have resilience as a well-developed economy.	**Low**
Impact	**Magnitude of impact**			
Business opportunities and economic stimulus created by the project and impact on Lashio	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low While larger contracts may be sourced from businesses in Lashio, these would represent a small proportion of the business sector within the city.	**High** Business opportunities can provide substantial value to those businesses that are able to provide goods and services to the project.	**High** Long-term impact term with the potential to extend over the mine life.	**Medium (positive)**
	Residual impact significance			**Positive (low)**
	Assessment of uncertainty			
	Medium - Regional economic benefits will to a large degree depend on the location of successful contracting companies, which is not yet known.			

Land use

Secure access to productive agricultural land or access to the Nam Pangyun riverbed / Bawdwin hillsides for fossicking for mineral waste were defined as social values.

The project infrastructure will be located within the current Bawdwin and Namtu concession areas and supporting infrastructure easements (e.g., the rail corridor) that have been established to support the historic mining operations. The Bawdwin project will continue to use the concession areas for the purpose for which they were established (i.e., to support mining, processing and export operations). As such there will be no change to land tenure type and no change to the primary land uses of the concession areas as defined by the government in concession leases. Notwithstanding this, construction of project infrastructure, particularly expansion of the mine pit, development of three TSFs, a waste rock dump and industrial areas, will result in some loss of land within the Bawdwin concession area that is currently used for agricultural or other land uses by community members. In addition, the development will restrict the use of remaining land within the Bawdwin concession area that will not be disturbed (e.g., for grazing cattle), in order to minimise health and safety risks.

The dominant land type of the Bawdwin concession area is grassland and more limited areas of bamboo forest. Both of these vegetation types are likely to have been influenced by many centuries of disturbances from mining activities. It is likely that topsoils in the area have been largely eroded from hills and steep-sided slopes leaving poor quality soils with low organic material. Periodic burning of grasslands also occurs during the dry season to stimulate vegetation regrowth for grazing cattle.

At Bawdwin, there is limited agricultural activity, although there are some areas used to grow vegetables and crops that are sold in local markets and some also sold in Namtu and Lashio with jengkol and corn being the primary produce being sold. During social baseline surveys most (86%) survey respondents of the Bawdwin study area stated that they use the land for residential purposes, with only smaller areas/garden plots of land being used for growing vegetable and crops and raising domestic animals. While generally there is limited commercial agriculture in the Bawdwin concession area, it is likely that there is some level of household dependence on agriculture for livelihoods (i.e., growing and selling crops in local markets, Namtu and Lashio), particularly since the mine was placed on care and maintenance in 2009 and overall employment was reduced since this time.

There are four main areas where there are rural residences or hamlets that pursue primarily agriculturally based livelihoods. These consist of:

- Rural houses and sheds to the south and southeast of Bawdwin south village.
- Rural houses and sheds to the northeast and south of Tiger Camp.
- Houses (seven in total) and sheds in the northwest corner of the Bawdwin concession area, which are linked to the Loi Mi village.
- Houses (seven in total) and sheds in the northeast corner of the Bawdwin concession area, which are termed here as Nam La Farms.

These hamlets contain one or a number of families that either permanently live there or reside within Bawdwin and Tiger Camp and temporarily reside in these locations. These families raise livestock (such as cows, goats and chickens) and grow vegetables and other crops. These hamlets typically access shops and services at Bawdwin and children often attend the Bawdwin schools.

With the development of the project there will be some losses of cultivatable and grazing land. Further, there will be access constraints within the Bawdwin concession area. WMM acknowledge that for farming hamlets adjacent to Tiger Camp and south of the open pit there will be significant impacts and therefore propose that these residents are included within the proposed resettlement program of Bawdwin and Tiger Camp communities. The farming hamlet on the north-northwestern edge of the Bawdwin concession area, referred to as Loi Mi village farms, may be resettled depending on engagement and further investigation of impacts. While direct impacts to this hamlet is unlikely, there is the potential to impact or restrict some land used for grazing and agricultural crops.

The valley between Tiger Camp and the Myitnge River junction is also periodically inhabited by artisanal miners who fossick for the lead-zinc slag which was discarded during the historical smelting in the Chinese period of occupation and has washed into the Nam Pangyun. Due to proximity of the proposed Namtu – Tiger Camp access road there is some potential for these people to be temporarily impacted by the project for example some access restrictions.

Impacts to land and associated effects on livelihoods are assessed to affect Impact Zone 1 (Bawdwin and Tiger Camp communities) and Impact Zone 4 (inhabitants of the Nam Pangyun valley). The magnitude and significance of these impacts are assessed in the following section. However, no adverse changes to land use or livelihoods as a result of the project are predicted to affect Namtu Town (Impact Zone 3), villages along the export corridor (Impact Zone 5) or Lashio (Impact Zone 6).

Impact Zone 1 – Villages within the Bawdwin concession area

Within Impact Zone 1 there are residents that reside within formal village settings i.e., within Bawdwin village (upper and lower) and Tiger Camp, and rural residents that practice agricultural livelihoods. Given this difference this assessment of impacts to access of productive agricultural land was been separated into within villages (termed Impact Zone 1a) and then rural residents and farms (Impact Zone 1b). In addition, the village of Loi Mi is partly located within the Bawdwin concession area and while it is a formal village practice, the residents largely agricultural livelihoods. This community has been separated for assessment and is termed Impact Zone 1c.

Communities in Impact Zone 1a will be resettled and lose access to the land/resources that help to support current livelihoods. As part of the resettlement program these communities will be assisted by compensation as appropriate and the implementation of a Livelihood Restoration Program. The residual impact of loss of land for livelihood purposes for the communities in Impact Zone 1a (Bawdwin villages and Tiger Camp) during the construction and operations phases is predicted to be of **low significance**, based on the **medium impact magnitude** and the **low sensitivity** of secure access to productive agricultural land (Table 6.213).

Table 6.213 Residual impact significance summary – construction and operations phases – impacts to livelihoods – affecting villages within the Bawdwin concession area

Value	**Sensitivity of Value**			
Access to productive agricultural land and scavenging sites	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium Smaller gardens and areas of fruit trees provide households with seasonal foods, although few residents reported being reliant on agriculture. Scavenging for slag residues is conducted by some residents of the Bawdwin and Namtu concession areas.	**Low** Few residents reported being reliant on agriculture, but are somewhat vulnerable to losses of supplementary seasonal food supply.	**High** Agriculture plays a minor role supporting the Bawdwin community.	**Low**
Impact	**Magnitude of impact**			
Loss of or access to land/resources for livelihood purposes for the Bawdwin village communities (Impact Zone 1a)	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	High With relocation the majority of people will be affected.	**Low** Existing land use and livelihoods will be disrupted by the project with most residents losing access to current gardens and agricultural plots. WMM has committed to providing access to land of similar quality if the persons concerned wish to continue to pursue agricultural opportunities.	**Medium** With provision of alternative land there is still predicted to be a medium-term impact (i.e., 1 to 2 years) until this land provides similar produce and livelihood security	**Medium**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	High Given the stage of resettlement planning there is a high degree of uncertainty associated with livelihood restoration. The assessment assumes that access to adequate cultivatable land is available at the relocation site for resettled communities. This will be further investigated as resettlement planning progresses.			

Impact Zone 1b consists of six households located to the south and southeast of Bawdwin lower village (but which are recognised as part of the village), 14 households located to the northeast of Tiger Camp and four households located to the south of Tiger Camp, and seven households in the northeast corner of the Bawdwin concession area, which are termed here as Nam La Farms. Livelihoods for of these hamlets area are primarily based on agriculture. Common crops include maize, jengkol, wheat and seasonable vegetables. Livestock including cattle, goats and chickens are also typically kept.

Communities in Impact Zone 1b (estimated to be in the order of 100 people) will be resettled and will lose access to the land/resources that help to support current livelihoods. As part of the resettlement program these communities will be assisted by compensation as appropriate and the implementation of a Livelihood Restoration Program.

The residual impact of loss of land for livelihood purposes for the Impact Zone 1b during the construction and operations phases is predicted to be of **high significance**, based on the **medium impact magnitude** and the **high sensitivity** of secure access to productive agricultural land (see Table 6.214).

Table 6.214 Residual impact significance summary – construction and operations phases – impacts to livelihoods - affecting farms within the Bawdwin concession area

Value	**Sensitivity of value**			
Access to productive agricultural land	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High These communities are primarily agricultural and access to land for these purposes is highly important.	**High** Residents are dependent on agriculture for livelihoods and they have high vulnerability to change as a consequence of changes to the Bawdwin operations due to their locations.	**Low** These households have limited resilience to reduced access to productive agricultural land.	**High**
Impact	**Magnitude of impact**			
Loss of or access to land/resources for livelihood purposes for the Bawdwin farm communities (Impact Zone 1b)	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very high All households within these defined areas will be affected.	**Low** Existing land use and livelihoods will be disrupted by the project with these residents losing access to current agricultural areas. WMM has committed to providing access to land of similar quality if the persons concerned wish to continue to pursue agricultural opportunities. However, this will take time to establish and reach the required level of livelihood support.	**Medium** With provision of alternative land there is still predicted to be a medium-term impact until this land provides similar produce and livelihood security in the interim period livelihood support is likely to be required for the affected community.	**Medium**
	Residual impact significance			**High**
	Assessment of uncertainty			
	High Given the stage of resettlement planning there is a high degree of uncertainty associated with livelihood restoration. The assessment assumes that access to adequate cultivatable land is available at the relocation site for resettled communities. This will be further investigated as resettlement planning progresses.			

Impact Zone 1c consists of the village of Loi Mi partly within the northwestern edge of the Bawdwin concession area, and two associated hamlets consisting seven households residents, which are located totally within the Bawdwin concession area. The area is located approximately 500 m from the proposed TSF-B. The population of the Impact Zone 1c community is estimated to be 50 people. Impact Zone 1c may be resettled dependent on further engagement and investigation of impacts. Development of the project is not predicted to result in the direct loss or access to cultivatable land. However, due to the proximity of project infrastructure, there is the potential for impacts on cultivatable land for example from dust deposition.

Whether they are resettled or not resettled, the residual impact of loss of land for livelihood purposes for the Impact Zone 1c (Loi Mi village) during the construction and operations phases is predicted to be of **high significance**, based on the **medium impact magnitude** and the **high sensitivity** of secure access to productive agricultural land (Table 6.215).

Table 6.215 Residual impact significance summary – construction and operations phases – impacts to livelihoods – affecting farms within the Bawdwin concession area

Value	**Sensitivity of value**			
Secure access to productive agricultural land	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High The livelihoods of people in this community are primarily agricultural and access to land for these purposes is highly important.	**High** Residents are dependent on agriculture for livelihoods and have high vulnerability to change as a consequence of changes to the Bawdwin operations due to their location.	**Low** These households have limited resilience to reduced access to productive agricultural land.	**High**
Impact	**Magnitude of impact**			
Loss of or access to land/resources for livelihood purposes for the Loi Mi community (Impact Zone 1c)	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	IF RESETTLED (those receptors within the Bawdwin concession area)			
	Medium The development of the project is not predicted to result in the direct loss or access to cultivatable land. However, there are potential impacts on existing land use and potential for access constraints.	**Medium** While noting that there is considerable uncertainty, impacts on agricultural land from dust deposition prior to resettlement could be partly remedied or managed by implementing management measures if necessary and agreements regarding access will need to be established.	**Medium** Impact is medium term (1 to 2 years), prior to resettlement (if resettled).	**Medium**
	Residual impact significance			**High**
	IF NOT RESETTLED			
	Medium The development of the project is not predicted to result in the direct loss or access to cultivatable land. However, there are potential impacts on existing land use and potential for access constraints.	**Medium** While noting that there is considerable uncertainty, impacts on agricultural land from dust deposition could be partly remedied or managed by implementing management measures if necessary and agreements regarding access will need to be established.	**High** Long-term impact (3 to 15 years).	**Medium**
	Residual impact significance			**High**
	Assessment of uncertainty			
	High There is a high degree of uncertainty regarding potential dust impacts from the project. While the community is located in the adjacent catchment, the village is located in close proximity (~500m) to the TSF-B location with some farms closer.			

Impact Zones 4a and 4b – Nam Pangyun valley

Residents within the Nam Pangyun valley (Impact Zone 4) have been differentiated into two sub-groups.

- Permanent residents that live along the river with subsistence agricultural livelihoods, termed Impact Zone 4a. It is estimated that between 15 and 20 households live within this area. Like villages in tracts adjoining the Bawdwin concession area, these rural residents rely on agricultural to support livelihoods.
- Temporary occupants that fossick within the Nam Pangyun riverbed for discarded slag primarily during the dry season, termed Impact Zone 4b.

Due to key differences in livelihoods between these two groups, the assessment of land use change within this area has been assessed individually. Permanent residents practicing subsistence agricultural livelihoods along the Nam Pangyun valley have the potential to impacted by land use changes as a result of the project. The project proposes to construct a two-lane sealed access road within the existing railway easement from Namtu to Tiger Camp. While there is unlikely to be direct loss of agricultural land for residents of Impact Zone 4a, the rail/ road corridor may be temporarily restricted and therefore there may be access constraints. WMM will engage with the affected residents to identify options for maintaining safe access to Namtu and also across the Namtu-Tiger Camp access road as required. Potential approaches may include, for example, providing safe transport during construction and construction of an access track that parallels the Namtu-Tiger Camp access road, with crossing points as necessary. There may also be construction impacts such as the generation and deposition of dust, which could impact crops in close proximity to the construction zone. Considering this, the residual impact to residents of Impact Zone 4a during the construction and operations phases from constraints to access to land currently used for agricultural purposes will be of **moderate significance**, based on the **low impact magnitude** and the **high sensitivity** of secure access to productive agricultural land (Table 6.216).

Table 6.216 Residual impact significance summary – construction and operations phases – impacts to livelihoods – affecting permanent inhabitants of the Nam Pangyun valley

Value	**Sensitivity of value**			
Secure access to productive agricultural land	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Very high The livelihoods of people in this community are primarily agricultural and access to land for these purposes is highly important.	**Medium** Residents are dependent on agriculture for livelihoods and therefore vulnerable to any changes in their access to productive agricultural land. Noting their location well beyond the Bawdwin concession area, their vulnerability to altered access is moderately vulnerable.	**Low** These households have limited resilience to reduced access to productive agricultural land.	**High**
Impact	**Magnitude of impact**			
Loss of or access to land/resources for livelihood purposes for the permanent residents that live along the river with subsistence agricultural livelihoods (Impact Zone 4a)	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	High It is likely that most households within these defined areas will be affected to some degree.	**Low** While noting that there is considerable uncertainty impacts on cultivatable land, it is likely that most impacts will consist of temporary access restrictions during the construction of the Namtu – Tiger Camp access road.	**Low** Most effects will be short-term (i.e., months) during the construction of the Namtu – Tiger Camp access road.	**Low**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High Due to access and security concerns at the time of the socio-economic field survey this area, there has not been detailed investigation and documentation regarding the details of inhabitants along the Nam Pangyun valley. As such, estimates regarding the number and location of residences has been based on analysis of satellite imagery.			

The development of the access road will be located within the current rail corridor, which runs alongside the Nam Pangyun. In some locations, there may be some disturbance to the existing river cross-section to improve geotechnical stability, for example the construction of gabion weirs. In addition, there is the potential for some access restriction to ensure safety, particularly during construction. Therefore, the construction and operation of the road may have a disruptive effect on the ability of artisanal miners to work in certain areas of the river bed.

Artisanal miners who temporarily reside in the Nam Pangyun to fossick for lead-zinc slag are likely to still access the Nam Pangyun riverbed.

The residual impact to occupants of Impact Zone 4b during the construction and operations phases from constraints to the access to the Nam Pangyun riverbed currently used for artisanal mining/fossicking will be of **moderate significance**, based on the **low impact magnitude** and the **high sensitivity** of secure access to the Nam Pangyun riverbed for fossicking for mineral waste (Table 6.217).

Table 6.217 Residual impact significance summary – construction and operations phases - impacts to livelihoods – affecting temporary inhabitants of the Nam Pangyun valley

Value	**Sensitivity of value**			
Access to the Nam Pangyun river bed for fossicking for mineral waste	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium People are able to support livelihoods through artisanal mining of the river bed for minerals. These people are thought to reside in the location temporarily to exploit discarded minerals.	**High** Livelihood (at least temporarily) is vulnerable to change if ability to continue artisanal mining changes due to mining activities.	**Low** Communities have little capacity to recover from changes to livelihood due to limited resources for alternative income	**High**
Impact	**Magnitude of impact**			
Loss of or access to Nam Pangyun riverbed for livelihood purposes for temporary occupants that fossick within the Nam Pangyun river bed during the dry season (Impact Zone 4b)	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium It is likely that only a portion of people will be affected at any given time.	**Low** While noting that there is considerable uncertainty, it is likely that most impacts will consist of temporary access restrictions during the construction of the Namtu – Tiger Camp access road.	**Low** Most effects will be short-term (i.e., months) during the construction of the Namtu – Tiger Camp access road.	**Low**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High There is a high degree of uncertainty regarding the livelihoods and land use of artisanal miners along the Nam Pangyun.			

Living conditions, social cohesion and security

This social component covers a broad range of values that relate to the ability of communities to have access to suitable housing and services, in a safe, equitable, harmonious and amenable environment. The project will have a direct impact on living conditions (in the case of the Bawdwin and Tiger Camp communities), infrastructure and amenity. In addition to these direct impacts, it is predicted that the project will influence social values due to secondary or indirect impacts. These impacts include changes to social dynamics (i.e., cohesion, wellbeing, and identity), security and governance, which may have a disproportionate effect on vulnerable groups.

Physical living conditions

Living conditions and infrastructure is defined as a discrete social value (Section 5.9.11). Physical living conditions are defined as the circumstances affecting the way in which people live with a focus on their well-being.

The most material change to living conditions of potential affected communities will be the resettlement of villages and farms on the Bawdwin concession area. This will result in the establishment of a new settlement(s) in a mutually agreed location with:

- Newly constructed houses access with adequate ventilation and floor space equal to or greater than current conditions.
- Access to clean, running water.

- Reliable electricity, sanitation in the form of toilets and solid waste management.
- Access to arable land for the purposes of kitchen garden/agricultural plot.
- Proximity to supporting health, educational, commercial and religious services.

These measures will be further developed as part of the resettlement planning and consultation processes, primarily through the development of agreed Resettlement Action Plans (RAPs).

The resettlement of the communities will also remove the people from their current exposures to a range of hazardous contaminants (predominantly lead) in the current location due to historical mining activities (see Section 6.11).

As a consequence of resettlement, the following positive effects are predicted to occur when compared to the current conditions:

- Security of land tenure in mutually agreed location (note WMM intend to provide land tenure if legally feasible to do so). Achievement of this is subject to regulatory approval.
- Higher standard of housing and infrastructure.
- Improved facilities including water supply, with probable positive health outcomes.

Living conditions may also indirectly be influenced by increased employment (direct and indirect), and economic stimulus through greater business opportunities, resulting in higher incomes. This impact has the potential to extend beyond the immediate resettlement communities and positively impact Namtu Town and villages outside the Bawdwin concession area. In addition, the WMM will implement a Community and Business Development Plan, which ultimately aims to improve living conditions of project affected communities.

Resettlement for the project is planned to occur in three phases. The first phase will see Bawdwin upper village, Nam La farms and farms along the plant access road relocated ahead of major construction works to enable the construction of key pieces of project infrastructure. The second and third phases of resettlement will relocate Tiger Camp and Bawdwin lower villages and surrounding rural farms. However, these phases of resettlement are currently scheduled to commence after the project is in operation and mining of ore has started. As such, the living conditions at Tiger Camp and Bawdwin lower villages and rural farms within the mining concession area will be negatively impacted by project construction activities and initial operations activities for a period.

The project will also directly negatively affect the physical living conditions of potentially affected communities during construction and operation of the project. Sources of impact include:

- Emissions of dust and particulate matter generated by earthworks and operation of the mine.
- Generation of noise and vibration generated by construction activities and mining.
- Disturbance from increased local traffic, temporary restrictions of access or inconveniences cause by delays.
- Introduction of night time lighting sources.
- Reduced water quality caused by earthworks and associated construction activities.

Given that living conditions will be affected by a variety of sources, the following assessment takes a holistic approach to consider changes (both positive and negative) in a cumulative fashion. Given that separate assessments have been completed for changes in air quality (see Section 6.5), noise (see Section 6.7), water quality (see Section 6.3 and Section 6.4).

Access to services (e.g., schools and medical facilities) do affect overall living conditions but are assessed as separate values in Table 6.238 to Table 6.245).

Impacts to physical living conditions are assessed to affect all defined impact zones with the exception of Lashio (Impact Zone 6). Considering that resettlement will be conducted in several phases, future living conditions of communities in Impact Zone 1 are assessed in respect of two periods:

- Prior to resettlement, during construction and initial operations.
- Following resettlement.

Impact Zone 1 – Tiger Camp Village and surrounding rural farms prior to resettlement

Tiger Camp Village and surrounding farms will experience adverse impacts to their living conditions during construction and early operations until they are relocated.

Initial construction and infill to form the Wallah waste rock dump will progress down-gradient in the Wallah valley, eventually reaching the planned toe of the dump, a short distance up-gradient of the community in Wallah Gorge. Sediment dams will also be constructed at the latter location and access will be required from Tiger Camp, passing through the current location of the Wallah Gorge community.

Under the current resettlement schedule all Tiger Camp and surrounding rural farms will be resettled prior to the time at which initial construction of the Wallah waste rock dump approaches the Wallah Gorge community and before sediment dams are constructed. There are also some rural residents of Tiger Camp area that will be resettled as part of the first phase of resettlement ahead of construction of the road due to the direct physical impact on those properties. Project activities and effects that will influence living conditions include:

- Emissions of particulate matter and dust generated by earthworks and associated construction activities to construct the Namtu to Tiger Camp access road; the plant road and the subsequent use of these roads. These effects have been assessed in Section 6.5, and which concluded the significance of increased project-related airborne particulate matter and dust deposition to Tiger Camp village and surrounding farms during construction and is considered to be of high significance. Impact to the village and surrounding farms during mining operations is considered major and moderate significance, respectively.
- Noise generated by earthworks and associated construction activities to enable the construction of the Namtu to Tiger Camp access road; the plant road; and the subsequent operation of these components. This effect has been assessed in Section 6.7, and which concluded the significance of increased noise and vibration to Tiger Camp village and surrounding farms during construction and early operations is considered to be of moderate and low significance, respectively.
- Access restrictions and inconvenience due to permanent restriction of movement north to the Manton – Namtu road via the Bawdwin villages, and temporary restrictions south during construction of the Namtu – Tiger Camp access road within the existing rail corridor.
- Disturbance from increased local traffic during construction and operation of the aforementioned infrastructure components.

The adverse effect on living conditions of residents from Tiger Camp Village and surrounding farms prior to their resettlement will extend over the construction and initial operation phases of the project and will impact the existing amenity, convenience and liveability. The residual impact during the construction and initial operation phase prior to resettlement is rated as **high significance**, based on the **medium impact magnitude** and the **high sensitivity** to changes of living conditions and infrastructure due to proximity to these activities (Table 6.218).

Table 6.218 Residual impact significance summary – construction and initial operation phase – impacts on living conditions – affecting Tiger Camp Village and surrounding farms, prior to resettlement

Value	**Sensitivity of value**			
Living conditions and infrastructure	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Reasonable living conditions within the Bawdwin and Tiger Camp villages, which are the accommodation facilities for the former	**High** Due to the intrinsically related linkages between the communities and the mine the villages are highly vulnerable to any material	**Low** Limited resilience due to organisational structure influenced by the operation of the Bawdwin mine (e.g.,	**High**

	mine and associated infrastructure workforce.	changes caused by the project. Most housing in Bawdwin and Tiger Camp villages is leased from ME-1. Living conditions are influenced by numerous exposure pathways to contaminants associated with legacy mine operations with limited prevention of exposure to potentially harmful or hazardous materials.	land tenure, house ownership etc).	
Impact	**Magnitude of impact**			
Adverse physical living conditions for the Tiger Camp community as a result of project construction activities	**Spatial extent**	**Severity**	**Duration**	**Magnitude**
	Very high Adverse living conditions are predicted to affect most people (>75%) within the defined impact zone.	**Medium** The effect will have a noticeable effect on living conditions from increase dust, noise and traffic during construction activities. The most severe impacts will be during the construction of the roads.	**Medium** Medium-term impact (1 to 2 years). The construction periods for the roads is less than 12 months and after this the severity of impacts reduces.	**Medium**
	Residual impact significance			**High**
	Assessment of uncertainty			
	Medium Resettlement planning is at the early stages and a resettlement location has not been chosen.			

Impact Zone 1 – Bawdwin Lower Village and surrounding farms prior to resettlement

Bawdwin lower village and surrounding farms will experience adverse impacts to their living conditions during construction and operations until they are relocated. Project activities and effects that will influence living conditions include:

- Emissions of particulate matter and dust generated by earthworks and associated construction activities to construct haul roads, supporting mine infrastructure and preparatory works around the open pit (e.g., pre-stripping); and subsequent operation of these infrastructure components including blasting and open pit mining with subsequent haulage of ore and waste rock. These effects have been assessed in Section 6.5, and which concluded the significance of increased project-related airborne particulate matter and dust deposition to Bawdwin lower village and surrounding farms during construction and is considered to be of high and low significance, respectively. During early operations, the impact to the village and surrounding farms is considered of major and low significance, respectively.
- Noise generated by earthworks and associated construction activities to enable the construction of components noted above; and subsequent operation of these components. This effect has been assessed in Section 6.7, and which concluded the significance of increased noise and vibration to Bawdwin lower village during construction and early operations is considered to be of low and high significance, respectively.
- Vibration from blasting in the open pit from mining. These effects are discussed and assessed in Section 6.7.
- Risk of fly rock from blasting in the open pit from mining. These effects are discussed and assessed in Chapter 7.

- Access restrictions and inconvenience due to permanent restriction of movement north to the Manton – Namtu road via the Bawdwin villages. While the existing track between Bawdwin South Village and Tiger Camp will be upgraded there will also be temporary restrictions and potential inconvenience during construction of the Namtu – Tiger Camp access road within the existing rail corridor.
- Potential disruption to the existing water supply due to placement of infrastructure covering springs that provide existing potable water. These effects are assessed in Section 6.3. WMM will provide alternative water sources for any affected households to mitigate this impact.
- Disturbance from increased local traffic.

The adverse effect on physical living conditions of residents from Bawdwin lower village and surrounding farms prior to their resettlement will extend over the construction and initial operation phases of the project and will impact the existing amenity, convenience and liveability. The residual impact is rated as **high significance**, based on the **high impact magnitude** and the **medium sensitivity** to changes of living conditions and infrastructure due to proximity to these activities (Table 6.219).

Table 6.219 Residual impact significance summary – construction and operations phases – impacts on living conditions – affecting Bawdwin Lower Village and surrounding farms, prior to resettlement

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Living conditions and infrastructure</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>High
Reasonable living conditions within the Bawdwin and Tiger Camp villages, which are the accommodation facilities for the former mine and associated infrastructure workforce.</td><td>High
Most housing in Bawdwin and Tiger Camp villages is leased from ME-1.
Living conditions are influenced by numerous exposure pathways to contaminants associated with legacy mine operations with limited prevention of exposure to potentially harmful or hazardous materials.</td><td>Low
Limited resilience due to organisational structure influenced by the operation of the Bawdwin mine (e.g., land tenure, house ownership etc).</td><td>Medium</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact</th></tr>
<tr><td rowspan="6">Adverse physical living conditions for Bawdwin lower community as a result of project activities</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Very high
Adverse living conditions are predicted to affect most people (>75%) within the defined impact zone.</td><td>High
The effect will have a noticeable effect on living conditions from increase dust, noise and traffic during construction and operation activities. Due to the close proximity of the villages to the mine the severity is high.</td><td>Medium
Medium-term impact (1 to 2 years)</td><td>High</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>High</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">Medium
Resettlement planning is at the early stages and a resettlement location has not been chosen.</td></tr>
</table>

Impact Zone 1c – Loi Mi village

Loi Mi village and associated farms are located around 500 m southwest of TSF-B. The village and farms may experience adverse impacts to their living conditions during construction and operations. Residents may be resettled during early operations, depending on the outcomes of engagement and further investigation of impacts.

Project activities and effects that will influence living conditions include:

- Dust generated by earthworks and associated construction activities mostly related to the construction of the TSFs. These effects are discussed and assessed in Section 6.5.
- Noise generated by earthworks and associated construction activities, mostly related to the construction of the TSFs. These effects are discussed and assessed in Section 6.7.
- Access constraints during construction of the bypass around the process plant on the Manton-Namtu Road.

If Loi Mi village is not resettled, the adverse effect on living conditions of residents will extend over the construction and operation phases of the project and will impact the existing amenity and convenience. If resettled, the impact will be shorter duration.

The residual impact is rated as **moderate significance**, based on the **medium impact magnitude** and the **medium sensitivity** to changes of living conditions and infrastructure due to proximity to these activities (Table 6.220).

Table 6.220 Residual impact significance summary – construction and operations phases – impacts on living conditions – affecting Loi Mi village

Value	**Sensitivity of value -**			
Living conditions and infrastructure	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium Typical living conditions of rural Myanmar supported by agriculture. Utilise some social services in Bawdwin concession area.	**Medium** Dependent on agriculture for livelihoods, which also influences living conditions. Adequate infrastructure with linkages to major villages. Some vulnerability to change due to social services and markets accessed in the Bawdwin concession area.	**Medium** Due to their isolated nature there is some resilience to changes in living conditions, social cohesion and security.	**Medium**
Impact	**Magnitude of impact**			
Adverse physical living conditions for Loi Mi village as a result of project construction and operation activities (Impact Zone 1c)	**Spatial extent**	**Severity**	**Duration**	**Magnitude**
	IF RESETTLED (those receptors within the Bawdwin concession area)			
	Medium Adverse living conditions are predicted to affect a notable proportion of people within the defined impact zone.	**Low** The effect will have a low but noticeable effect on living conditions with most of the construction activity being distant from the residents.	**Medium** Impact is medium term (1 to 2 years), prior to resettlement (if resettled).	**Medium**
	Residual impact significance			**Moderate**
	IF NOT RESETTLED			
	Medium Adverse living conditions are predicted to affect a notable proportion of people within the defined impact zone.	**Low** The effect will have a low but noticeable effect on living conditions with most of the construction activity being distant from the residents.	**High** Impact will occur over mine life with construction periods and rehabilitation periods having the higher amenity impacts.	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High As the bulk of Loi Mi village is located on the opposite side of a catchment divide from the project area, some of the village will have no direct line of sight to the project area. There is uncertainty whether this community will be exposed to project generated dust and what noise conditions will be like. Modelling is required to quantify these impacts.			

Impact Zone 1 - Bawdwin villages (upper and lower), Tiger Camp village and surrounding farms including Nam La farms, following resettlement

Provided the resettlement commitments are implemented effectively, the living conditions of Bawdwin and Tiger Camp communities and farming communities on the Bawdwin concession area following resettlement are predicted to improve. With provision of standards of housing and improved essential services, the residual impact to living conditions for the Bawdwin communities is rated as **positive (major) significance**, based on the **high impact magnitude** and the **high sensitivity** to changes of living conditions and infrastructure (Table 6.221).

Table 6.221 Residual impact significance summary – altered living conditions – affecting Bawdwin and Tiger Camp villages and farms within the Bawdwin concession area following resettlement

Value	**Sensitivity of value**			
	Importance	***Vulnerability***	***Resilience***	***Sensitivity***

Living conditions and infrastructure	**High** Reasonable living conditions within the Bawdwin and Tiger Camp villages, which are the accommodation facilities for the former mine and associated infrastructure workforce.	**High** Due to the intrinsically related linkages between the communities and the mine the villages are highly vulnerable to any material changes caused by the project. Most housing in Bawdwin and Tiger Camp villages is leased from ME-1. Living conditions are influenced by numerous exposure pathways to contaminants associated with legacy mine operations with limited prevention of exposure to potentially harmful or hazardous materials.	**Low** Limited resilience due to organisational structure influenced by the operation of the Bawdwin mine (e.g., land tenure, house ownership etc).	**High**
Impact	**Magnitude of impact**			
Improved physical living conditions for resettled Bawdwin communities	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very high The entire resettled population will be affected.	**Medium** If planned and implemented effectively resettlement will provide substantial value to resettled communities	**Very high** Long-term social impacts that will extend indefinitely.	**High (positive)**
	Residual impact significance			**Positive (major)**
	Assessment of uncertainty			
	High Resettlement planning is at the early stages and a resettlement location has not been chosen. Realised benefits relating to living conditions will be heavily influenced by the success of constructive participation and engagement, planning and implementation of the resettlement program.			

Impact Zone 2 – villages in tracts adjoining the Bawdwin concession area

Villages in tracts adjoining the Bawdwin concession area are located more than 3 km from the Bawdwin concession area boundary, and therefore typical environmental living conditions (e.g., ambient noise and air quality) within these villages are unlikely to materially change, with the exception of infrequent changes to air quality during abnormal events (see Section 6.5).

These villages are accessed and interconnected via a network of smaller roads and tracks that connect to the Namtu – Manton public road. While WMM does not propose to use Namtu – Manton road for project access there is still likely to be some increased traffic, particularly during construction of the Namtu to Tiger Camp road. In addition, the project includes diversion of the Namtu-Manton Road to enable construction of the process plant. During the construction of this diversion there would be expected to be some disruption and increased truck traffic.

The residual impact to living conditions of residents of villages in tracts adjoining the Bawdwin concession area due to traffic delays, and to a lesser extent impacts to amenity is rated of **low significance**, based on the **low impact magnitude** and the **medium sensitivity** to changes of living conditions and infrastructure (Table 6.222).

Table 6.222 Residual impact significance summary – construction and operations phases – altered living conditions - affecting villages in tracts adjoining the Bawdwin concession area

Value	**Sensitivity of value**			
Living conditions and infrastructure	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium Typical living conditions of rural Myanmar supported	**Medium** Dependent on agriculture for livelihoods, which also influences living conditions.	**Medium** Due to their isolated nature there is some resilience to changes in	**Medium**

Value	Sensitivity of value			
	by agriculture. Utilise some social services in Bawdwin concession area.	Adequate infrastructure with linkages to major villages. Some vulnerability to change due to social services and markets accessed in the Bawdwin concession area.	living conditions, social cohesion and security.	
Impact	**Magnitude of impact**			
Adverse effects of traffic in terms of delays, access and amenity	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Mostly local scale impacts that effect some people within the defined impact zone.	**Low** The effect will have a limited effect on living conditions from increased traffic and reduced amenity.	**High** Long-term impact for the life of the mine.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	High The level of use of the Namtu – Manton Road is uncertain. There is some potential opportunity following the implementation of Community and Business Development Plans and from broader regional economic stimulus as a result of the project. However, this benefit has not been formally assessed due to the degree of uncertainty as to whether this benefit would be realised.			

Impact Zone 3 – Namtu Town

There is potential for living conditions for Namtu Town to be positively influenced as a result of increased employment and regional economic development. However, the overall population will substantially increase (approximately 25% increase in population) if the chosen resettlement location is near Namtu. In addition, it is predicted that the project may indirectly cause in-migration, which will result in an influx of migrants to Namtu in search of project-related opportunities. The substantial increase in the total population of Namtu has the potential to reduce the living conditions of existing residents by placing increased pressure on services, and reducing overall liveability. However, these impacts will be mitigated by the support and investment in existing or new services for the relocated village. Namtu will also experience a notable increase in project related traffic that will generate noise and emissions to air.

Namtu will experience increased traffic due to project vehicles commencing in construction, but continuing throughout the operation of the project. Both construction and operational traffic will pass through residential areas of Namtu. While Namtu does have a range of industrial activities and there is already some truck traffic present, there will be a substantial increase in 30-tonne trucks. Based on yearly estimates of truck movements and consideration of the baseline estimate of existing truck traffic, operational project traffic is expected to equate to an increase of 40-60% of daily truck traffic on public roads that are used by project vehicles.

As a result of the project, there may also be positive influences on living conditions for residents of Namtu. These include benefits associated with increased disposable income associated with direct and indirect project employment and business opportunities, regional economic stimulus, and community investment by the WMM.

The residual impact to living conditions of residents of Namtu due to reduced amenity due to project traffic delays, and to a lesser extent from the effects of in-migration is rated of **low to moderate significance**, based on the **low impact magnitude** and the **medium to high sensitivity** to changes of living conditions and infrastructure (Table 6.223).

Table 6.223 Residual impact significance summary – construction and operations phases – impacts on living conditions – affecting residents of Namtu during construction and operations

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Living conditions and infrastructure</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>High
The community is accustomed to reasonable living conditions within Namtu Town</td><td>Medium
Due to the linkages between the town and the mine, Tha Ta La Wards 1-7 wards are vulnerable to material changes caused by the project.
Some exposure pathways to contaminants associated with legacy mine operations.</td><td>Medium
Some resilience due to distance to the mine and the size of the town with a range of other sectors.</td><td>Medium to high</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact</th></tr>
<tr><td rowspan="6">Changes in physical living conditions for residents of Namtu due to changes in living conditions</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Medium
Intermediate scale impact that is predicted to affect the living conditions of a notable proportion of the defined impact zone.</td><td>Low
Increased total population size due to resettlement and in-migration as a result of the project is predicted to result in increased pressure on services however will be mitigated by WMM support and investment in existing or new services for the relocated village. Project related noise and emissions from project traffic will reduce overall liveability. However, benefits may also be realised from project related employment, economic stimulus and business opportunity.</td><td>High
Long-term impact for the life of the mine.</td><td>Low</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Low to moderate</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">High
Resettlement planning is at the early stages and a resettlement location has not been chosen.</td></tr>
</table>

Impact Zone 4 – Nam Pangyun valley

It is proposed that the project will construct a two-lane sealed access road from Namtu to a point 2km downstream of Tiger Camp along the existing rail corridor, which runs adjacent to the Nam Pangyun. This road will carry all project-related traffic once constructed for the duration of the project. This will result in the introduction of new road, traffic and associated effects to amenity (e.g., generation of noise and exhaust emissions) to residents (both permanent and temporary) along the valley.

The residual adverse impacts of project traffic and operation of this road during construction and operations phases on residents of the Nam Pangyun valley due to access restrictions and reduced amenity is rated of **moderate significance**, based on the **medium impact magnitude** and the **medium sensitivity** of this community due to proximity to these activities (Table 6.224).

Table 6.224 Residual impact significance summary – construction and operations phases - traffic impacts – affecting Namtu

Value	**Sensitivity of value**			
Living conditions and infrastructure	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium Some permanent inhabitants with agricultural livelihoods along the valley. However, most inhabitants are artisanal miners that are believed to be displaced persons seeking livelihoods that access the area on an as needs/temporary basis.	**High** The permanent inhabitants are located on the upper banks of the Nam Pangyun and have some vulnerability to changes along the valley. The artisanal miners have no legal status or rights and are therefore vulnerable to changes.	**Medium** The permanent inhabitants are likely to have some resilience to change so long as livelihoods are maintained. The artisanal miners reside in temporary shelters along the Nam Pangyun valley and are expected to have some resilience to changes due to mobility.	**Medium**
Impact	**Magnitude of impact**			
Adverse effects of traffic in terms of delays, access and amenity	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Intermediate scale impacts that effects a notable proportion of people immediately adjacent to the export corridor in Namtu.	**Medium** Introduction of traffic from project vehicles (during construction and operations), which will reduce amenity (noise and dust)	**High** Long-term impact for the life of the mine.	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High Due to access and security concerns at the time of the socio-economic field survey this area, there has not been detailed investigation and documentation regarding the details of inhabitants along the Nam Pangyun valley.			

Impact Zone 5 - Export corridor

There are several villages along the export route (see Figure 5.56) of varying sizes and road conditions. During operations the Namtu-Manton road between Namtu and the intersection with National Highway 3, will experience higher traffic particularly trucks for the export of concentrate and import of reagents, supplies and fuel. During steady state operations there will be between 60 and 93 additional trucks travelling on public roads between Lashio and Namtu per day. Over the mine life this equates to an average annual increase in truck traffic between 105% to 186% at Man Sam based on the baseline weekday estimate. This traffic will negatively influence the amenity of villages located along the road corridor. Given the volume of traffic there is also the potential for congestion around intersections particularly during peak road use times.

The residual adverse impacts of project traffic on villages along the export corridor due to traffic delays, and amenity impacts is rated of **moderate significance**, based on the **medium impact magnitude** and the **medium sensitivity** of this community due to proximity to these activities (Table 6.225).

Table 6.225 Residual impact significance summary – construction and operations – traffic impacts – affecting Namtu to Lashio road

Value	**Sensitivity of value**			
Living conditions and infrastructure	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium Typical living conditions of rural Myanmar supporting agriculture.	**Medium** Due to proximity to the proposed transport corridor, these communities are moderately vulnerable to material change in the road use.	**Medium** Communities have some capacity and/or resources to absorb, adapt to and recover from changes to current conditions.	**Medium**
Impact	**Magnitude of impact**			
Adverse effects of traffic in terms of delays, access and amenity	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Intermediate scale impacts that is predicted to affect a small proportion of people who live within villages along the proposed transport corridor between Namtu and Lashio.	**Medium** Marked increased traffic from project vehicles (during construction and operations), which will reduce amenity (noise and dust)	**High** Long-term impact for the life of the mine.	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	Medium In the absence of air quality modelling and limited baseline data collection for this receptor.			

Visual amenity

Visual amenity is defined as social value for assessment.

The project area is predominantly steep mountainous terrain, covered in modified vegetation, primarily grassland and bamboo forest. Historic mining has left infrastructure, the open pit and waste rock material in the vicinity of Bawdwin and the Nam Pangyun Valley, as well as residential infrastructure associated with the upper and lower Bawdwin villages, Tiger Camp, and small informal settlements in the Nam Pangyun Valley.

The visual amenity of the area surrounding the central Bawdwin mining area (i.e., open pit, haul roads and waste dump), the process plant and other industrial areas will be substantially changed. The impacts of altered visual amenity on people or groups will vary due to the subjective nature of visual amenity. Affected people may have differing perspectives on what is considered visually important and whether changes are positive or negative, and to what degree, based on their personal experiences and relationship with the mine. Bawdwin has experienced extensive mining in the past and mining-related infrastructure and changes may not be perceived as significant or negative to residents of Bawdwin and Tiger Camp. Instead, increased development associated with the mine may be perceived positively due to its association with potential employment and income for local people. Contrastingly, residents of nearby areas and visitors to the area who currently do not see evidence of mining activities and may not experience the benefits of mining may be more sensitive to changes in visual amenity.

The assessment of visual amenity assumes receptors are sensitive to changes in visual amenity and the degree of change. As complete resettlement is proposed for the residents on the Bawdwin concession area, exposure to many impacts to amenity of mining operations that would normally be experienced by the Bawdwin communities will largely be removed. However, construction related amenity impacts will still occur for a portion of the communities.

Factors influencing the degree of change in visual amenity as a result of the project include:

- The ability to absorb and screen development.
- The distance between the viewpoint and development.
- The size of the development from the viewpoint (e.g. how much of the view is changed by development).

The hilly topography in the vicinity of Bawdwin is likely to obscure views of a significant portion of the development from surrounding areas. Views of the Bawdwin concession area from the high-elevation Namtu to Manton Road will be altered, as well as views from Tiger Camp and Upper Bawdwin village. At greater distances from the Bawdwin concession area at lower elevations, there is likely to be minimal impact to visual amenity due to the hilly topography.

Changes in visual amenity are presented in figures 6.30, 6.31 and 6.32. These show visualisations of the current views from selected viewpoints as well as predicted views of the project from the same locations. Except for views of the project area from the Namtu to Manton Road, visual changes as a result of the project, will largely be avoided due to residents on the Bawdwin concession area being resettled.

Impact Zone 1 – Bawdwin Lower Village, Tiger Camp Village and farms on the Bawdwin concession prior to resettlement

Bawdwin lower village, Tiger Camp Village and surrounding farms will experience adverse impacts to their visual amenity during construction and early operations until they are relocated.

The visual amenity of the Bawdwin open and surrounding areas will be significantly modified with large-scale permanent landforms created and industrial activity expanded in the form of construction of a modern process plant, mining services area with workshops, haul roads, stockpiles, and conveyors. Changes to visual amenity may occur due to the use of artificial lighting associated with the construction and operations phases of the project that be visible at night, and increased numbers of heavy vehicles.

Visual changes within the Bawdwin concession area will be significant. However, the impact of landform changes and artificial lights to people is expected to be minimal once Bawdwin and Tiger Camp residents are resettled.

The residual adverse impacts to visual amenity of residents from Bawdwin Lower Village, Tiger Camp Village and farms on the Bawdwin concession area during the construction and operations phases will be substantially modified due to extensive construction activities and development of new infrastructure and landforms prior to their resettlement. The impact is rated as **moderate significance**, based on the **medium impact magnitude** and the **medium sensitivity** to changes of visual amenity (Table 6.226).

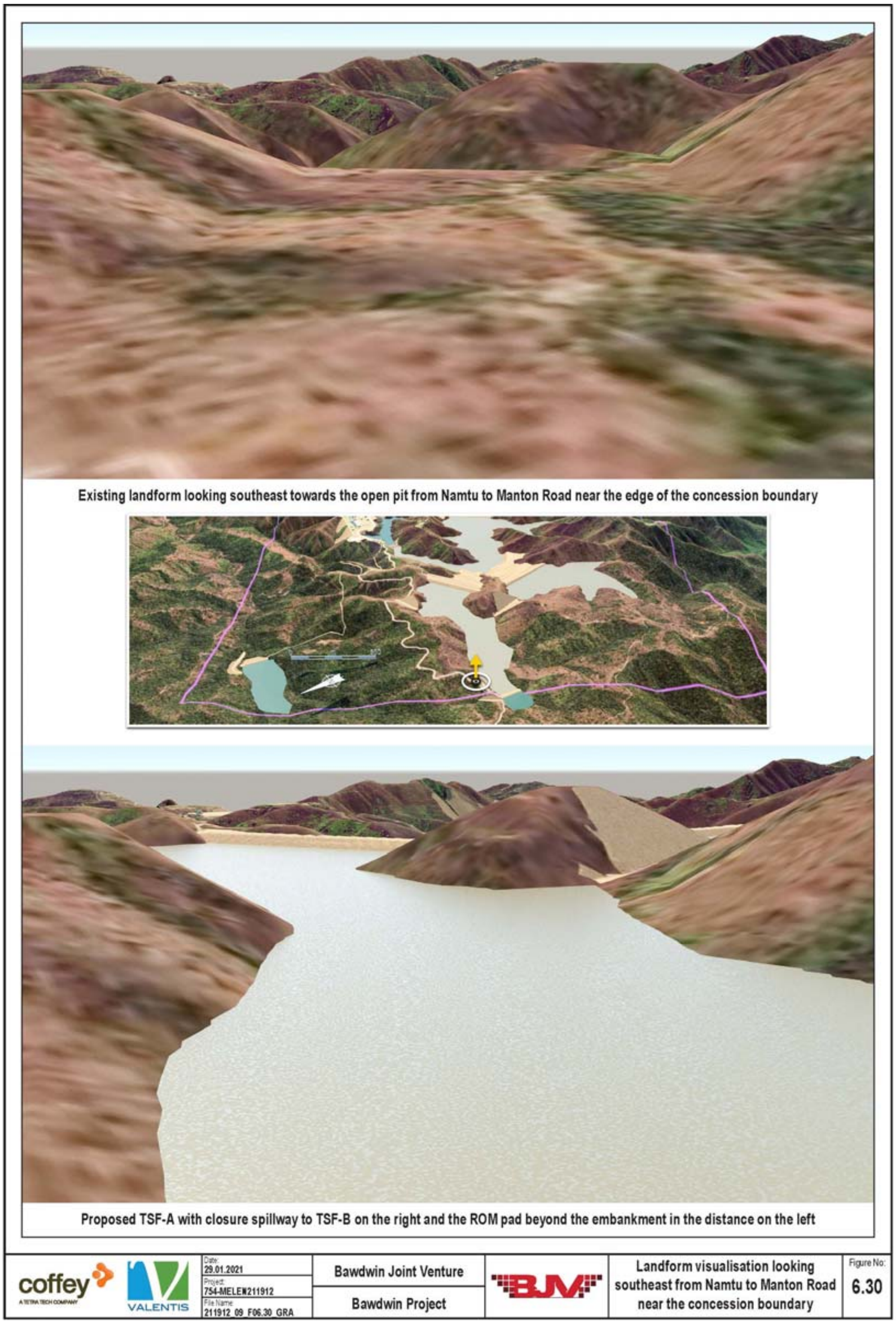


Figure 6.30 Landform visualisation looking southeast from Namtu to Manton Road near the Bawdwin concession area boundary

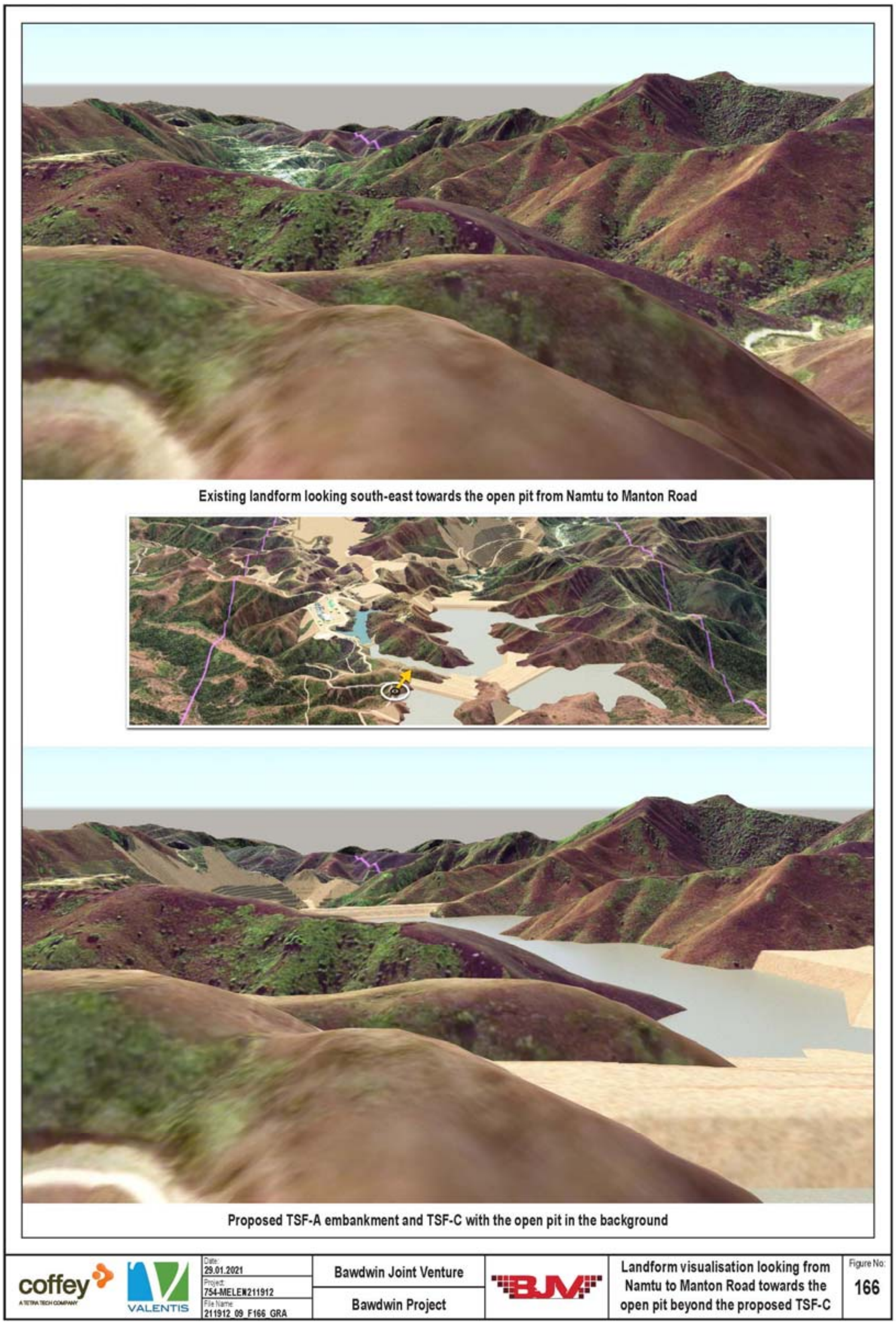


Figure 6.31 Landform visualisation looking from Namtu to Manton Road towards the open pit beyond the proposed TSF-C

Figure 6.32 Visualisation photomontage: View of proposed process plant and power station area

Table 6.226 Residual impact significance summary – construction and operations phases – impacts on visual amenity – affecting Bawdwin Lower and Tiger Camp communities and farms within the Bawdwin concession area prior to resettlement

Value	**Sensitivity of value**			
Living conditions and infrastructure	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium The existing visual amenity is influenced by the historical mining activities. However, views are picturesque and valued.	**High** Visual amenity is intrinsically linked to the Bawdwin operation and therefore somewhat vulnerable to changes in the local landscape.	**High** Communities have high resilience to changes to the altered visual amenity due to their connection to mining.	**Medium**
Impact	**Magnitude of impact**			
Reduced visual amenity through construction and operation of the project.	**Spatial extent**	**Severity**	**Duration**	**Magnitude**
	High Visual modification noticeable to the majority (i.e. 50 – 75%) of people within the defined impact zone.	**Medium** The effect will have a noticeable effect on visual conditions for these communities prior to resettlement, but unlikely to result in high social impact.	**Medium** Medium-term impact (1 to 2 years) until complete resettlement has occurred.	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	Medium Perceptions of communities to visual changes of the Bawdwin concession area are not well understood. The impacts of altered visual amenity on people or groups will vary due to the subjective nature of visual amenity. The impact assessment assumes receptors are sensitive to changes in visual amenity and the degree of change.			

Impact Zone 2 – Villages on Namtu to Manton Road

Two locations along the Namtu to Manton road were selected to compare the visual amenity of the existing view with the view after the proposed development, as well as one location near the road at the proposed site of the Process Plant (see Figure 6.32). The Namtu to Manton road traverses the hills on the western side of the Bawdwin concession area. One location is at the northern end of the Bawdwin concession area, facing southeast (Figure 6.30), and the other is located north of the open pit, facing southeast (Figure 6.31). The area viewed from these viewpoints is steep mountainous terrain (see Figure 6.2), with several ridges and valley slopes visible. The area is modified, with the vegetation on the hills largely grassland (see Figure 5.43).

From the location at the northern end of the Bawdwin concession area (Figure 6.30), there is currently no evidence of historic mining visible. After development of the mine and associated infrastructure, TSF-A and the closure spillway to TSF-B will be prominent features visible from this viewpoint, as tailings will fill the valleys to a height where it will not be obscured by the terrain. The outwards view will be largely unchanged, with only a small amount of infrastructure (the ROM pad) visible. Figure 6.30 displays the existing landform and the landform after development of proposed infrastructure.

From the location north of the open pit (Figure 6.31), the Nam Pangyun valley and existing open pit can be seen. After development of the mine and associated infrastructure, the expanded open pit will be more prominent, and the TSF-A embankment and TSF-C will be visible. Figure 6.31 displays the existing landform and the landform after development of proposed infrastructure.

The view towards the open pit from the proposed Process Plant shows evidence of historic mining and the open pit in the distance. This area will be heavily impacted by changes in landform, with processing infrastructure and the expanded open pit visible from this location.

The people using the Namtu to Manton Road are not fixed receptors therefore will be impacted for a very short period as they travel through the Bawdwin concession area. Despite an increase in heavy vehicles through Namtu and along the export route, this is not likely to have a significant impact on the visual amenity of these areas due to the existing usage of the roads by trucks and heavy vehicles. For those who live near the Bawdwin concession area and who will experience changes in visual amenity due to the construction of new infrastructure and mine development, the presence of similar landscapes in the surrounding area should be considered, as well as the context of extensive historic mining in Bawdwin and the presence of existing infrastructure.

The residual adverse impacts of altered visual amenity on villages in tracts adjoining the Bawdwin concession during the construction and operations phases is rated of **low significance**, based on the **low impact magnitude** and the **medium sensitivity** to changes in the visual landscape (Table 6.227).

Table 6.227 Residual impact significance summary – construction and operations phases – impacts to visual amenity – affecting residents of villages in tracts adjoining the Bawdwin concession area

Value	**Sensitivity of value**			
Visual amenity	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium Typical viewsheds up rural upland areas in Shan State.	**Low** Low vulnerability to change as a consequence of changes to the Bawdwin	**Medium** Due to their isolated nature there is some resilience to changes to the current conditions	**Medium**
Impact	**Magnitude of impact**			
Reduced visual amenity for villages in tracts adjoining the Bawdwin concession area	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Local scale visual impacts that effect some people within the defined impact zone.	**Very low** Due to the distance from the project, the visual amenity within villages in tracts adjoining the Bawdwin concession area is unlikely to materially change.	**Very high** The infrastructure that may be visible in the viewshed will be permanent, however the impact associated with artificial lighting will not extend past mine closure.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Medium Changes to the visual landscape as a result are well understood. However, the impacts of altered visual amenity on people or groups will vary due to the subjective nature of visual amenity. The impact assessment assumes receptors are sensitive to changes in visual amenity and the degree of change.			

Governance

Governance in the form of democratically elected leaders to represent the Bawdwin and Tiger Camp communities is defined as a social value.

As described in Chapter 2, the Region and State Government Law (2010) established the General Administrative Department (GAD) as the administration for all State or Region governments. Below the state and regions are District Administrators and Township Administrators. The Township Administrator provides direction to the Village Tract and Ward Administrators. The Namtu township GAD Officer is the focal contact person to coordinate and communicate with Namtu and Bawdwin Administrations, including Tiger Camp. At village level, elections are held for Ward or Village Tract Administrators. Under the current system, representatives from each household elect a Household Leader which represents 10 households, who in turn elect a Household Leader to represent 100 households.

Impacts to village governance in relation to the project are assessed to effect villages within the Bawdwin concession area and their residents (Impact Zone 1). However, no material changes to governance are predicted to occur as a result of the project for the remaining impact zones.

Impact Zone 1 – Villages within the Bawdwin concession area

The current governance structure for Bawdwin and Tiger Camp villages is based on the Baw Twin Village Tract. This representation may change dependent on the relocation site. If relocated to or near Namtu Town, this may alter the influence of village leaders in Namtu Township administration depending on the classification of the relocation site. However, these changes would be expected to be determined democratically and therefore some control would remain with the Bawdwin communities.

The greatest shift in governance is likely to be the formation of a single settlement with altered power dynamics as opposed to three fairly discrete villages. However, it is unlikely that the Namtu Township administrative structure would change as a result of the resettlement site being located within the Township. With resettlement planning undertaken in a thorough, fair, equitable and transparent manner with relevant stakeholders, and a focus on establishing responsibilities, commitments and governance mechanisms, the residual impact on village governance during the construction and operations phases is rated of **low significance**, based on the **low impact magnitude** and the **medium sensitivity** (Table 6.228).

Table 6.228 Residual impact significance summary – construction and operations phases – impacts to governance – affecting Bawdwin and Tiger Camp communities, following resettlement

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Governance in the form of democratically elected leaders to represent communities</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>High
Currently Bawdwin villages have supportive and stable social structures and value is placed in supportive systems of social organisation</td><td>Medium
The existing governance framework is vulnerable to changes due to the intrinsically related linkages between the Bawdwin communities and the mine</td><td>Medium
Communities have some resilience to changes to the current arrangement.</td><td>Medium</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact</th></tr>
<tr><td rowspan="6">Altered governance of Bawdwin villages as a result of resettlement for the project</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Medium
While village governance will change as a result of the project, negative impacts are not likely to be experienced for all residents.</td><td>Low
Altered governance is likely to affect individuals differently; however, overall the impact is predicted to be of low severity.</td><td>Very high
Long-term social impacts that will extend indefinitely</td><td>Low</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Low</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">High
Resettlement planning is at the early stages and a resettlement location has not been chosen.</td></tr>
</table>

Social cohesion

Social cohesion within and between communities is defined as a social value. Social cohesion is defined as the bonds, common values, beliefs, and behaviours that enable the community to operate in a cooperative way.

The social cohesion or fabric of a community is influenced by a range of measures, including the availability of work, security of land access and shelter, recreation opportunities, perceptions of fair treatment and the bonds that result from living in proximity to members of one's ethnic or religious group. There is potential for this fabric to be impaired through the development of the project.

Social cohesion is complex and can be influenced by a range of interrelating factors. Furthermore, negative impacts may not be uniform and can change over time. As such the following assessment aims to provide a holistic assessment for impact zones as a whole, but recognises that impacts may differ between village wards, households and individuals.

The key driver with the potential to alter the social cohesion of communities (both host and Bawdwin communities) is the resettlement of existing Bawdwin communities. This will alter the existing social network, relationships and structures at the village level. The impact on social cohesion may be amplified by disparities in income due to non-uniform participation in project opportunities and the receipt of project benefit entitlements may invoke division, inequality and conflict within and between communities.

Population relocation through a resettlement program has the potential to cause social discord as existing households in proximity to the relocation site may perceive the resettling households to be privileged with new housing and facilities, and potentially imposing additional demands on existing (often inadequate) services such as health and education facilities. While cultural differences between resettling and host populations may exacerbate this discord, this should not be an issue in this case, where Bamar is the dominant ethnicity in both Namtu and Bawdwin (70% and 90% respectively).

There is potential for the social cohesion of resettled communities to be impaired if the resettlement planning process does not recognise and collaborate with resettling households and host communities to address issues that cause social disruption and implement management measures to mitigate potential adverse effects. The resettlement of Bawdwin and Tiger Camp residents may be accompanied by issues regarding perceptions by existing residents neighbouring the resettlement site that resettling households are privileged in employment which is detrimental to the exiting residents securing mine employment. The perceived inequity may cause tension between resettled communities and host communities and potential non-acceptance.

In a similar way, there may be internal conflict within the resettled community. The process of resettlement of Bawdwin communities involves assessing eligibility and entitlements. However, there may be perceived inequity between defined social groupings (e.g., WMM housing residents and informal settlements or hamlets), which could have social consequences. For example, the proposed staging of resettlement groups, with Bawdwin upper village being resettled two years before the remainder of the community, may result in resentment in the remaining communities that will experience negative impacts to current living conditions. There is high potential that there will be negative impacts to social cohesion due to the need to resettle all residents in a similar fashion. Tensions may be created if residents feel that one group of residents have been disadvantaged over another or one group gained a disproportionate benefit. Tension within the communities could arise and impact the existing harmonious social relations in the communities.

Finally, while not confirmed, it is likely that a single resettlement site will be chosen to accommodate all residents. This has the potential to alter the existing community dynamics. Currently there are three fairly discrete villages – Bawdwin upper and lower villages, and Tiger Camp. In addition, there are smaller hamlets and single dwellings outside these formal villages. With the formation of a single, larger village social dynamics will change. In addition, it is likely that the chosen resettlement location will have different neighbouring communities and new relationships will be formed. The removal of the existing villages will also influence social linkages of the Bawdwin community to surrounding villages. These villages currently access commercial, educational and health services from Bawdwin (see Section 5.9.5).

In recognition of the potential impacts on social cohesion, WMM intend to implement community development programs that will focus on leadership, problem solving and conflict resolution, and will be implemented in partnership with non-government organisations. The Resettlement Action Plan will address resettlement eligibility and entitlement determination to ensure equity and identify measures to mitigate perceived inequity. The project will also provide support for community and government administration and seek to partner with government and non-government development agencies to sustain stable and safe living environments, particularly for women, children and those who are vulnerable.

Impacts to social cohesion are assessed to effect villages within the Bawdwin concession area and their residents (Impact Zone 1), villages in tracts adjoining the Bawdwin concession area (Impact Zone 2) and Namtu (Impact Zone 3); however, no material changes to social cohesion as a result of the project are predicted to be experienced for the Nam Pangyun valley (Impact Zone 4), villages along the export corridor (Impact Zone 5) or Lashio (Impact Zone 6).

Impact Zone 1 – Villages within the Bawdwin concession area

While assessing social cohesion for any community is complex, the current situation is made more difficult due to that fact that resettlement planning is at the early stages and a resettlement location has not been chosen. Acknowledging these uncertainties, and with implementation of community development programs, support for community and government administration and partnerships with government and non-government development agencies, the residual impact of impaired social cohesion within and between resettled communities (all phases) is rated as **high significance**, based on the **medium impact magnitude** and **high sensitivity** to disruption the existing social cohesion (Table 6.229).

Table 6.229 Residual impact significance summary – all phases – impacts to social cohesion – affecting Bawdwin and Tiger Camp communities, following resettlement

Value	**Sensitivity of value**			
Social cohesion within and between communities	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High A high value is placed in harmonious family and community relationships and supportive systems of social organisation.	**High** Due to the intrinsically related linkages between the communities and the mine the villages are highly vulnerable to any material changes caused by the project.	**Low** Limited resilience due to organisational structure influenced by the operation of the Bawdwin mine (e.g., land tenure, house ownership etc).	**High**
Impact	**Magnitude of impact**			
Altered social cohesion of Bawdwin communities as a result of the project	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Impaired social cohesion is not likely to be experienced for all residents, but is predicted to effect a notable portion of the community.	**Medium** Impaired social cohesion is likely to affect individuals differently; however, the overall impact is predicted to be of medium severity.	**High** Long-term social impacts (3 to 15 years). Whilst resettlement is permanent, any hostility caused by changes in social cohesion are predicted to dissipate over time.	**Medium**
	Residual impact significance			**High**
	Assessment of uncertainty			
	High Resettlement planning is at the early stages and a resettlement location has not been chosen.			

Impact Zone 2 – villages in tracts adjoining the Bawdwin concession area

Villages in tracts adjoining the Bawdwin concession area have differing degrees of social connectivity to the Bawdwin communities but have the potential to be impacted by their relocation and the closure of existing Bawdwin services and facilities, and while not confirmed the potential to be affected by the new resettlement village in the case of Namtu.

Surrounding village tracts (Hu Hsar and Hin Poke) have important social links to Bawdwin villages based on education (children attending Bawdwin schools and boarding in Bawdwin in mine-provided housing) and interaction with religious institutions (such as the monastery and churches). The removal of this interaction due to the resettlement of Bawdwin villages will have an impact on the social fabric of surrounding villages as residents may have to establish relationships with new religious institutions. The development and implementation of a local Community Development Program that supports the presence of religious communities in proximity to the Bawdwin concession area, and that considers overall community investment needs will mitigate some of the effect of stress caused by reduced interaction with religious facilities.

It is predicted that development of the project will result in impaired social cohesion within and between villages in tracts adjoining the Bawdwin concession area and the resettled communities. This residual impact is rated of **low significance**, based on the **low impact magnitude** and **medium sensitivity** to disruption the existing social cohesion (Table 6.230).

Table 6.230 Residual impact significance summary – all phases - impacts of impaired social cohesion – affecting villages in tracts adjoining the Bawdwin concession area

Value	**Sensitivity of value**			
Social cohesion within and between communities	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Supportive and stable social structures and value is placed in harmonious family and community relationships and supportive systems of social organisation and social cohesion.	**Medium** Dependent on agriculture for livelihoods, which also influences living conditions. Adequate infrastructure with linkages to major villages. Some vulnerability to change as a consequence of changes to the Bawdwin due to social services and markets accessed in the Bawdwin concession area.	**Medium** Due to their isolated nature there is some resilience to changes in living conditions, social cohesion and security.	**Medium**
Impact	**Magnitude of impact**			
Altered social cohesion of villages in tracts adjoining the Bawdwin concession area as a result of the project and resettling of Bawdwin communities	**Spatial extent**	**Severity**	**Duration**	**Magnitude**
	Low Local scale social impact that is predicted to affect some people within the defined impact zone.	**Low** Tensions caused as a result of the resettlement of the Bawdwin communities is predicted to be of low severity.	**High** The impact may be long-term (3 to 15 years). Whilst resettlement is permanent, any hostility caused by changes in social cohesion may dissipate over time.	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	High Resettlement planning is at the early stages and a resettlement location has not been chosen			

Impact Zone 3 – Namtu Town

Social cohesion of Namtu Town has the potential to be impacted if the chosen resettlement location that is selected is in close proximity. While some residents may welcome the resettled Bawdwin and Tiger Camp communities, there may also be negative reactions or opposition. While perceptions are difficult to predict, communities of Namtu Town may feel disadvantaged in comparison to the resettled village. They may also feel that the resettled communities will place additional strain on existing public services. The key management measure to limit this impact will be for to conduct consultation and provide opportunities for input into the resettlement planning from residents of the host community. In addition, the project is predicted to indirectly cause in-migration, which will result in an influx of migrants to Namtu in search of project-related opportunities. This additional population may also adversely affect social cohesion within Namtu.

It is predicted that development of the project will result in impaired social cohesion within and between Namtu and the resettled communities. This residual impact is rated as **moderate significance**, based on the **medium impact magnitude** and **medium sensitivity** to disruption of the existing social cohesion (Table 6.231).

Table 6.231 Residual impact significance summary – all phases – impacts to social cohesion – affecting Namtu, following resettlement

Value	**Sensitivity of value**			
Social cohesion within and between communities	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Currently there are supportive and stable social structures. Value is placed in harmonious community relationships and supportive systems of social organisation and cohesion	**Medium** Due to the linkages between the town and the mine, Tha Ta La Wards 1-7 wards are vulnerable to material changes caused by the project.	**Medium** Some resilience due to distance to the mine and the size of the town with a range of other sectors.	**Medium**
Impact	**Magnitude of impact**			
Altered social cohesion of Namtu as a result of the project and resettling of Bawdwin communities	**Spatial extent**	**Severity**	**Duration**	**Magnitude**
	Medium Intermediate scale social impacts that effect a notable proportion of people in Namtu	**Medium** Measures to be implemented by WMM to be outlined in a Land Access and Resettlement Plan will foster social cohesion and respect the cultural integrity of affected communities. Effects of in-migration are more challenging for WMM to manage.	**High** The impact may be long-term (3 to 15 years). Whilst resettlement is permanent, any hostility caused by changes in social cohesion may dissipate over time.	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High Resettlement planning is at the early stages and a resettlement location has not been chosen			

Social wellbeing

Social wellbeing is defined as a social value. Social wellbeing is defined as people's personal security, positive social relationships and physical and mental health. Personal and community wellbeing of villagers neighbouring the project also has the potential to be affected by the interactions with the project workforce and potentially in-migrants.

People have social and cultural lives that are incredibly intricate. Being resettled, or having livelihoods disrupted by a project, can create a major upheaval to people, their lives, and to the effective functioning of culture and society (Vanclay, 2017). The disruption to people's lives and livelihoods also creates harm, sometimes on a long-term basis, especially when there is not adequate restoration of the livelihoods and/or income-earning activities of the resettled people. Being displaced, even if the resettlement is conducted according to world's best practice, is likely to create some degree of stress and anxiety in the people being relocated (Bisht, 2009).

Based on experiences in communities surrounding large resource developments, there is the possibility for interaction between existing communities, migrant workforces and in-migrants. Changes in demography such as a gender imbalance, tensions between existing residents, project workers and in-migrants, inequality of incomes and gender-based violence have been associated with reduced social wellbeing. MCRB (2018) reported that communities surrounding tin and gold mines in Myanmar felt that theft and crime had increased as a result of the presence of large numbers of mine migrant workers in the area. Women sometimes expressed that they felt unsafe due to the presence of a large male workforce in the area. Some cases of harassment and rape were reported. Local community members interviewed linked the increase in drug use to the presence of mining, as this meant money was more readily available. Community members in these areas also expressed concerns about children starting to use drugs at an early age.

To minimise these potential impacts the project will support community capacity to develop and sustain an environment conducive to the physical, spiritual and emotional wellbeing of its members, in particular women, children and those who are vulnerable. The project will implement a workforce code of conduct and induction process to guide workplace behaviour and respectful interaction with host communities. WMM will work in consultation with the GAD to manage administrative governance and potential in-migration.

Impacts to social wellbeing are assessed to effect people from villages within the Bawdwin concession area and their residents (Impact Zone 1), people from villages in tracts adjoining the Bawdwin concession area (Impact Zone 2) and residents of Namtu Town (Impact Zone 3), and residents of the Nam Pangyun valley (Impact Zone 4); however, no material changes to social cohesion as a result of the project are predicted to be experienced for people from villages along the export corridor (Impact Zone 5) or Lashio (Impact Zone 6).

Impact Zone 1 – Villages within the Bawdwin concession area

It is predicted that development of the project will result in impaired social wellbeing within Bawdwin and Tiger Camp communities. This residual impact is rated of **moderate significance**, based on a **medium impact magnitude** and **medium sensitivity** to changes in social wellbeing (Table 6.232).

Table 6.232 Residual impact significance summary – all phases – impacts to social wellbeing – affecting Bawdwin and Tiger Camp communities

Value	**Sensitivity of value**			
Social wellbeing	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Currently the Bawdwin communities place value in harmonious family and community relationships and supportive systems of social organisation and social cohesion	**Medium** Communities have supportive and stable social structures but are vulnerability to changes in the existing social dynamics due to the intrinsically related linkages between the Bawdwin communities and the mine	**Medium** Communities having some resilience to changes to the current arrangement, particularly since they are mine villages.	**Medium**
Impact	**Magnitude of impact**			
Reduced personal and community wellbeing of Bawdwin villages as a result of resettlement and in-migration generated by the project	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Impaired social wellbeing is not likely to be experienced for all residents and it may even improve for some, but overall it is predicted to effect a notable portion of the community.	**Medium** Impaired social wellbeing is likely to affect individuals differently; however, overall the impact is predicted to be of medium severity as the project will support community capacity to develop and sustain an environment conducive to the physical, spiritual and emotional wellbeing of its members.	**High** The impact may be long-term (3 to 15 years). Whilst resettlement is permanent, any effects on social wellbeing from hostility caused by changes in social cohesion may dissipate over time	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High Resettlement planning is at the early stages and a resettlement location has not been chosen.			

Impact Zone 2 – villages in tracts adjoining the Bawdwin concession area

While there is a possibility of in-migration of people seeking work, some of whom may reside in surrounding villages, the effects are expected to be minor as WMM administration responsible for recruitment and training is likely to be based with existing facilities in Namtu rather than at the mine itself. This should act to encourage jobseekers to Namtu rather than to surrounding villages.

It is predicted that development of the project will result in impaired social wellbeing within communities in tracts adjoining the Bawdwin concession area. This residual impact is rated of **low significance**, based on a **low impact magnitude** and **medium sensitivity** to changes in social wellbeing (Table 6.233).

Table 6.233 Residual impact significance summary – all phases – impacts to social wellbeing – affecting residents of villages in tracts adjoining the Bawdwin concession area

Value	**Sensitivity of value**			
Social wellbeing	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High While there is uncertainty regarding this aspect it is assumed that these communities place value in harmonious family and community relationships	**Medium** Communities have supportive and stable social structures but are vulnerability to regional district level and village structures.	**Medium** Villages are typically remote and somewhat isolated and therefore have a degree of resilience to regional changes in village structures.	**Medium**
Impact	**Magnitude of impact**			
Reduced personal and community wellbeing of villages in tracts adjoining Bawdwin as a result of in-migration generated by the project	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Local scale social impacts that affects some people within the defined impact zone.	**Very Low** In-migration would probably be minor and WMM will work with the GAD to manage administrative governance. Mine workers will operate under a Code of Conduct.	**High** The impact may be long-term with the potential to extend over the mine life	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	Medium There is reasonable uncertainty regarding the extent of potential in-migration, as it is outside the control of WMM.			

Impact Zone 3 - Namtu

It is predicted that development of the project will result in impaired social wellbeing within the Namtu Town community due to in-migration and influx of mine workers. This residual impact is rated of **moderate significance**, based on a **medium impact magnitude** and **medium sensitivity** to changes in social wellbeing (Table 6.234)**.**

Table 6.234 Residual impact significance summary – all phases – impacts to social wellbeing – affecting residents from Namtu

Value	**Sensitivity of value**			
Social wellbeing	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Currently Namtu Township has supportive and stable social structures and value is placed in harmonious family and community relationships and supportive systems of social organisation and social cohesion	**Medium** The broader Namtu community is less influenced on the Bawdwin operations, with separate governance and other services. However its position to the operations and status as the main centre outside of the Bawdwin concession area make it vulnerable to change.	**Medium** As a large regional town there is some capacity and/or resources to absorb, adapt to and recover from changes to current conditions	**Medium**
Impact	**Magnitude of impact**			
Reduced personal and community wellbeing of Namtu due to in-migration and influx of mine workers	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Local scale social impacts that affects some people within the defined impact zone.	**Low** In-migration would probably be minor and WMM will work with the GAD to manage administrative governance. Mine workers will operate under a Code of Conduct.	**High** The impact may be long-term with the potential to extend over the mine life	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	Medium There is reasonable uncertainty regarding the extent of potential in-migration, as it is outside the control of WMM.			

Impact Zone 4 – Residents of Nam Pangyun valley

It is predicted that development of the project will result in impaired social wellbeing within the inhabitants of the Nam Pangyun valley due to in-migration and influx of mine workers. This residual impact is rated of **low significance**, based on a **low impact magnitude** and **medium sensitivity** to changes in social wellbeing (Table 6.235)**.**

Table 6.235 Residual impact significance summary – all phases – impacts to social wellbeing – affecting residents Nam Pangyun valley

Value	**Sensitivity of value**			
Social wellbeing	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Low Rural inhabitants with little social structure and organisation in place	**High** Artisanal miners within the valley have no legal status or rights and therefore vulnerable to changes.	**Medium** Given the lack of permanent residents some resilience is expected	**Medium**
Impact	**Magnitude of impact**			
Reduced personal and community wellbeing of inhabitants of the Nam Pangyun valley as a result of in-migration generated by the project	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Local scale social impacts that affects some people within the defined impact zone.	**Very Low** In-migration is not expected within Nam Pangyun valley however may occur in proximity (i.e., Bawdwin and surrounding village tracts).	**High** The impact may be long-term with the potential to extend over the mine life	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	High Due to access and security concerns at the time of the socio-economic field survey this area, there has not been detailed investigation and documentation regarding the details of inhabitants along the Nam Pangyun valley. Estimates regarding the number and location of residences has been based on analysis of satellite imagery. There is reasonable uncertainty regarding the extent of potential in-migration, as it is outside the control of WMM.			

Social identity

Social identity is defined as a social value. Social identity is defined as person's sense of who they are based on their connection to place.

The Bawdwin communities and, to a somewhat lesser extent, Namtu are intrinsically linked to the Bawdwin mine and mineral processing. The majority of families at Bawdwin and some at Namtu have worked at the mine or supporting facilities over a number of generations. Even while the mine has been in care and maintenance over the last decade a large workforce has been employed and has continued to maintain certain infrastructure elements. Interviews with the community revealed that there is a strong sense of pride and recognition of the historical importance of the Bawdwin operation. With complete resettlement of the Bawdwin communities, there is a strong likelihood that there will be a sense of community loss in community identity. This sense of community loss may also be influenced by the loss of access to mine area and potentially importance cultural sites. This impact is likely to be experienced more severely by the older members of these communities who have greater connections to the earlier mining and processing operations.

The development of the project will necessitate the decommissioning of much of the existing mine infrastructure. The project will ultimately continue mining of the Bawdwin deposit by developing a modern mine. Without such development it is likely that this infrastructure would continue to degrade. Nonetheless the mine in its current form in terms of layout, amenity and scale will be changed permanently. Although some historical elements will be retained, the area will consist of a large-scale mining operation with restricted access for health and safety reasons.

Another element of social identity is associated with the current roles and skills that the Bawdwin and Namtu employees currently have. The workforce has continued to maintain infrastructure including but not limited to mineral processing infrastructure and the Marmion head frame winder,. With the project development, new modern infrastructure such as the mineral process plant will be constructed and the need for the current skill sets will not necessarily be required. In some instances, these skills may be transferrable, but in many instances they will not.

To minimise the potential impact of the Bawdwin communities losing or altering their social identity with respect to their relationship with the Bawdwin mine, WMM will:

- Establish a museum and cultural centre that promotes the history and culture of the Bawdwin operation (see Section 6.9 cultural heritage).
- Interview and record the history of the Bawdwin mine from current Bawdwin residents.
- Maximise local employment, which is likely to include employment that is linked to preservation and maintenance of cultural heritage relating to the mine.

Impacts to people's social identity as a result of the project is assessed to be restricted to the Bawdwin and Tiger Camp villages (Impact Zone 1).

With measures implemented to promote the cultural history of the Bawdwin mine, providing preferential employment opportunities and training programs, the residual impact of loss or reduction of social identity for the Bawdwin communities is rated of **high significance**, based on a **medium impact magnitude** and **high sensitivity** to changes in people's social identity (Table 6.236).

Table 6.236 Residual impact significance summary – all phases –loss of community identity – affecting Bawdwin and Tiger Camp communities

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Social identity</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>High
Bawdwin communities have a long history and association with the Bawdwin mine with many households working on the mine for a number of generations and their identity is closely linked to the mine.</td><td>High
Due to the intrinsically related linkages between the Bawdwin communities and the mine they are vulnerable to changes in the existing arrangements.</td><td>Low
Communities have low resilience to changes to the current arrangement</td><td>High</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact</th></tr>
<tr><td rowspan="6">Loss or reduction of social identity of Bawdwin communities as a result of resettlement</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Low
Mostly local scale impacts that is predicted to affect some people within the defined impact zone.</td><td>Medium
The impacts would be moderately severe for those people affected and can only be partly remedied by implementation of management measures</td><td>High
The impact may be long-term with the potential to extend over the mine life</td><td>Medium</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>High</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">High
Resettlement planning is at the early stages and a resettlement location has not been chosen.</td></tr>
</table>

Social equality

Social equality is defined as a social value. Social equality is defined as the right of different groups of people to have a similar social position and receive the same treatment.

Experiences of mining developments around the world has shown that socio-economic impacts as a result of these developments are rarely gender neutral. Vulnerable groups within communities (e.g., elderly and people with disabilities) can also experience socio-economic impacts in differing degrees to the community as a whole. Women typically experience both direct and indirect impacts of mining developments in different ways and often of greater magnitude compared to men. In addition, the potential benefits that are produced as a result of mining developments have typically been shown to be less for females than for male counterparts (Jenkins, 2014).

In the context of Myanmar, there are also additional regulatory and cultural barriers to achieving social equality. As described in MCRB (2018), there is no legal definition of discrimination against women in the 2008 Constitution or other legislation. This ultimately hinders the formulation, interpretation, and dissemination of laws and policies impacting women's rights. Furthermore, while there are some references to equal opportunity and non-discrimination based on sex, there are still a range of laws and policies that reinforce restrictive gender stereotypes and hinder gender equity.

As described above, one of the benefits of the mining industry for local communities is the potential direct and indirect employment opportunities it can provide. Historically the workforce within mining operations is male dominated. In recent times, there have been efforts to increase the proportion of females within the mining workforce and this has been shown to increase the benefits to the local community.

Even if employment is secured by woman within a mine, in Myanmar women are often faced with issues of sexual harassment and abuse, salary inequity, and other types of discrimination (MCRB, 2018). Culturally, there is also an expectation that woman maintain their traditional domestic role as well as their new role as an income earner.

While mining can provide positive benefits and create economic opportunities for family units, evidence suggests that mining can also increase the level and extent of economic inequality through redistribution of financial resources (MCRB, 2018). Negative changes to community life that woman often experience can also be triggered by one of the key benefits of increased disposable income. The sudden influx of cash from direct or indirect employment (usually of men) can result in adverse social and health impacts for women, including an increase in alcohol related abuse, gender-based violence and general social disruption (see above). This will be difficult to influence for the WMM since it is planned that most of the local workforce will be transported to site each day and will not be accommodated in the project accommodation camp. This can lead to decreased security for women and children and an increase in inter-personal violence. There may also be violence and other forms of inappropriate behaviour by project workers or security personnel.

MCRB (2018) noted that resettlement and relocation resulting from mining development often disproportionately affect women, resulting in negative physical, social, cultural, and economic displacement. In Myanmar, rural communities are especially dependent upon women for tasks ranging from raising families to tending to crops and animals. The loss of access to arable land as a result of resettlement can have negative impacts on families, even though they may be compensated for this loss. Gender inequality often commences during the consultation and initial negotiation of resettlement programs, which is typically male-led (MCRB, 2018).

During public consultation to date, WMM has publicly and unequivocally stated that the company sees no barrier to women applying for any job and has committed to assessing all job applications equally, irrespective of the gender of the applicant. Within other mining operations in neighbouring countries (e.g., Phu Kham in Laos) there has been good success in employment of women in operational roles of the operations (e.g., truck driving) and WMM intends to employ similar approaches to what has succeeded in these locations to training and recruitment of women at Bawdwin. While the project does plan to implement a range of measures (see Section 6.10.3), cultural and institutional barriers remain.

Impacts to people's social identity as a result of the project is assessed to be restricted to the Bawdwin and Tiger Camp villages (Impact Zone 1).

It is predicted that development of the project including implementation of measures for equal access to employment and the community development and business plans will have some positive impacts on social and physical wellbeing of women and vulnerable groups, however it is possible some women and vulnerable people in the communities may still have adverse impacts associated with the project due to social changes that will occur (e.g., resettlement).. This residual impact is rated of **moderate significance**, based on a **medium impact magnitude** and **medium sensitivity** of this group to change (Table 6.237).

Table 6.237 Residential impact significance summary – all phases – impacts to women and vulnerable groups – affecting Bawdwin and Tiger Camp communities

Value	**Sensitivity of value**			
Social equality	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Currently the Bawdwin communities have levels of social inequality even though the context is a generally supportive and stable social structures. Engagement indicated gender equality is valued by females.	**Medium** There are existing levels of social inequality and communities are somewhat vulnerable to changes in the existing arrangements	**Medium** Communities have low resilience to changes to the current arrangement	**Medium**
Impact	**Magnitude of impact**			
Negative effects on women and other vulnerable groups as a result of the project	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium Confined to some members of the Bawdwin communities	**Medium** WMMs employment approach and code of conduct will help to improve existing inequalities. However, some impacts may be difficult to manage despite implementation of management measures, due to the limited influence WMM will have over employees in private residences, contractors and subcontractors	**High** The impact may be long-term with the potential to extend over the mine life	**Medium**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	Medium The success of management measures has been assumed however WMM will have limited influence over employees in private residences, contractors and subcontractors			

Access to health, education and other services

The socio-economic component covering access to services and facilities focuses largely on direct impacts generated by the project.

Resettlement of Bawdwin and Tiger Camp will result in existing health and education services, religious and spiritual facilities, markets, shops and other commercial services becoming closed in their current location.

Access to health services

It is predicted that villages in tracts adjoining the Bawdwin concession area (Impact Zone 2) and Namtu (Impact Zone 3) will experience impaired access to medical and health services as a result of the project. No material changes to access of medical facilities as a result of the project are predicted to be experienced for the Bawdwin and Tiger Camp communities (Impact Zone 1), residents of the Nam Pangyun valley (Impact Zone 4), residents of villages along the export corridor (Impact Zone 5) or Lashio (Impact Zone 6).

Impact Zone 1 – Villages within the Bawdwin Concession Area

WMM has committed to providing the same or improved access to health services for resettled communities. Since Bawdwin lower village, Tiger Camp Village and surrounding farms will not be resettled until after operations have commenced, WMM will ensure that access to medical facilities for these communities is maintained. As a result, there is no material impairment to accessing the current level of medical facilities.

While the resettlement location has not been confirmed, following resettlement there may also be positive impacts for the resettled residents who will gain greater access to health facilities from existing facilities at Namtu and Lashio, where there is a public hospital (150 beds) that is in reasonable condition compared to other township hospitals in Myanmar. While this hospital has many deficiencies in equipment and level of service provided, it is superior to the current facilities at Bawdwin. While presentations to the Namtu Hospital can be expected to increase following resettlement, it is apparent that Bawdwin and Tiger Camp residents currently use Namtu Hospital due to the inadequate level of service from the Bawdwin Hospital, indicating that the population/staff ratio at the Namtu Hospital should not change significantly. The potential benefit has not been formally assessed since the resettlement location has not been confirmed.

Impact Zone 2 – villages in tracts adjoining the Bawdwin concession area

Removal of health services currently within Bawdwin and Tiger Camp villages will impact residents of villages in tracts adjoining the Bawdwin concession area that currently use these services. During consultation with village officials from surrounding village tracts it was stated that there is a significant level of dependence on services available in Bawdwin village. Health services accessed include trauma treatment, obstetrics, supply of medicine and referrals to higher order centres. While all considered the level of services provided was mediocre (primarily due to a lack of doctors and nurses), all expressed a high level of concern should the service not be available at Bawdwin due the next alternative location for health services (Namtu) being distant with travel and accommodation being expensive.

As part of the Community and Business Development Plans for the project, it is anticipated that one of the investment priorities will be the provision of health services most likely in the form of upgraded health infrastructure and supplies. WMM will provide basic medical facilities for all project employees.

It is predicted that development of the project will result in impaired access to health services due to the removal of medical facilities at Bawdwin villages. This residual impact is rated of **moderate to high significance**, based on a **medium impact magnitude** and **medium to high sensitivity** of this group to changes in the existing medical facilities (Table 6.238).

Table 6.238 Residual impact significance summary – all phases – impaired access to health services – affecting residents of villages in tracts adjoining the Bawdwin concession area

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Access to medical and health facilities</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>Medium to High
Many of the surrounding villages have a significant level of dependence on Bawdwin healthcare services and the services are important to the community</td><td>Medium to High
Due to the reliance on services within Bawdwin villages, there is moderate to high vulnerability to any changes of these services with limited alternative options.</td><td>Low to Medium
Due to the remote nature of these villages, there is limited alternatives and therefore a lower level of resilience due to changes of these existing services.</td><td>Medium to high</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact</th></tr>
<tr><td rowspan="6">Impaired access to health services for villages in tracts adjoining the Bawdwin concession area due to resettling of Bawdwin communities</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Low
Mostly local scale impacts that effects some people (5 – 15%) within the defined impact zone.</td><td>Medium
Due to the current reliance of the villages on Bawdwin facilities and the lack of alternative locations nearby. WMM plan to work with the district authority to implement a plan to minimise the severity of this impact.</td><td>Very high
The impact will be permanent, as healthcare facilities in Bawdwin will be permanently closed</td><td>Medium</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Moderate to high</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">High
Resettlement planning is at the early stages and a resettlement location has not been chosen.
There is some uncertainty regarding the project’s investment priorities as the Community and Business Development Plans are yet to be developed and will require consultation with the district authority. The investment priorities are likely to include provision of health services however the nature, extent and responsibilities are yet to be defined.</td></tr>
</table>

Impact Zone 3 – Namtu Town

Given the WMM has committed that access to health facilities will be provided to the resettled communities there is potential for investment in local services which may improve access to and quality of healthcare services in Namtu. In addition, some of the increased demand may be offset by greater proportions of the Namtu population being employed by the mine and thus being eligible for private healthcare. However, there may be slight impairment in access to services due to increased pressure on existing health services due to the additional demand generated by the resettled communities and potentially in-migrants seeking employment by the mine.

The residual impact of impaired access to health services due to increased demand for existing healthcare facilities is rated of **low significance**, based on a **low impact magnitude** and **medium sensitivity** of this group to changes in the existing medical facilities (Table 6.239).

Table 6.239 Residual impact significance summary – all phases – impaired access of health services – affecting residents of Namtu

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Access to medical facilities</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>High
As there are existing health facilities at Namtu and these services are important to the community</td><td>Low
As the health facilities are not affiliated with the mine and therefore have low vulnerability to change as a result of mining activities.</td><td>High
There are several health facilities in Namtu and these are not influenced by mining activities/organisational structure</td><td>Medium</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact</th></tr>
<tr><td rowspan="6">Impaired access to health services due to increased demand pressure from resettled populations</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Very low
Local scale impact that effects a small number of people (<5%) within the defined impact zone.</td><td>Low
The increased demand is not expected to be significant and may be offset by a greater proportion of the population being employed by the mine and being eligible for private healthcare</td><td>High
Long-term impact with the potential to extend over the mine life</td><td>Low</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Low</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">High
Resettlement planning is at the early stages and a resettlement location has not been chosen.
There is some uncertainty regarding the project’s investment priorities as the Community and Business Development Plans are yet to be developed and will require consultation with the relevant district administrations. The investment priorities are likely to include provision of health services however the nature, extent and responsibilities are yet to be defined.</td></tr>
</table>

Access to education

It is predicted that villages in tracts adjoining the Bawdwin concession area (Impact Zone 2) will experience impaired access to schools as a result of the project. No material changes to access of education facilities as a result of the project are predicted to be experienced for the Bawdwin and Tiger Camp communities (Impact Zone 1), residents of the Nam Pangyun valley (Impact Zone 4), residents of villages along the export corridor (Impact Zone 5) or Lashio (Impact Zone 6).

Impact Zone 1 – villages within the Bawdwin concession area

Resettlement of the population of Bawdwin communities will involve upgrading existing education facilities near the resettlement location (likely to be near Namtu) to cater for the increase in student numbers or to build new facilities at the resettlement destination or other agreed location. It is expected that educational authorities of Namtu Township, Kyaukme District and possibly Shan State will provide input on their preferences in this regard. WMM has committed that access to the same or improved education facilities will be provided to the resettled communities. The upgraded or newly constructed facilities at the relocation site are expected to be of higher building standard than the facilities currently present in the Bawdwin concession area. While the resettlement location has not been confirmed, there may also be positive impacts for the resettled residents who will gain greater access to education and training from existing facilities at Namtu and Lashio where there are two universities and additional opportunities for training and skill acquisition. Access to a more diverse business sector in Namtu and Lashio should also afford more opportunities for training and associated employment. As a result, no adverse impact on Bawdwin or Tiger Camp is predicted, with potential for minor positive impact. However, there is uncertainty regarding the potential for positive impact given the resettlement location and design of the new or upgraded education facilities is not yet known.

Since Bawdwin lower village, Tiger Camp Village and surrounding farms will not be resettled until after operations have commenced, WMM will ensure that access to educational facilities for these communities is maintained. As a result, there is no material impairment to accessing to access the current level of education facilities.

Impact Zone 2 – villages in tracts adjoining the Bawdwin concession area

Survey data indicated that almost 800 students attended schools in Bawdwin and Tiger Camp. Of these students, approximately 20% of all students reside outside the Bawdwin concession area and travel or temporarily reside to attend school. Most of the students who travel from villages outside Bawdwin to attend school attend the high school (68%), with the remainder attending primary schools. Of the students travelling from outside Bawdwin, 69% come from villages in Namtu township and 23% from villages in Manton township. Of the 22 villages students travel from, students from five villages (Lon Jar, Hai Taung, Hu Ngwe and Hu Hsar villages in Namtu and the Man Pat village in Manton) make up 60% of the total number of students travelling to Bawdwin.

While most villages in tracts adjoining the Bawdwin concession area currently have a primary school, they rely on the high-school services only available at Bawdwin where the quality of schooling was considered acceptable with good teachers overall. Based on interviews with leaders from these villages, there was a high level of concern with the potential loss of the high school in Bawdwin, with the cost of attending school in Namtu (the next alternative location) being a significant impediment.

In recognition of this potential impact, WMM will work will the district authority to implement a plan to minimise this impact. This may involve investigating educational options for providing regional educational support as part of the community development program.

It is predicted that development of the project will result in impaired access to educational services due to the removal of schools facilities at Bawdwin villages. This residual impact is rated of **moderate to high significance**, based on a **medium impact magnitude** and **medium to high sensitivity** of this group to changes in the existing schooling facilities (Table 6.240).

Table 6.240 Residual impact significance summary – all phases - impaired access to schools due to removal of school services at Bawdwin – affecting children in villages in tracts adjoining the Bawdwin concession area

Value	**Sensitivity of value**			
Access to schools and training facilities	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium to High Many of the surrounding villages have a significant level of dependence on Bawdwin education facilities and are important to the community	**Medium to High** Due to the reliance on facilities villages within the Bawdwin concession area, there is moderate to high vulnerability to any changes of these services with limited alternative options	**Low to medium** Due to the remote nature of the villages and limited alternatives. While there are similar services available at Namtu, these would be less convenient and costlier.	**Medium to high**
Impact	**Magnitude of impact**			
Impaired access to education facilities for villages in tracts adjoining the Bawdwin concession area due to resettling of Bawdwin communities	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Mostly local scale impacts that effects some people (5 – 15%) within the defined impact zone.	**Low** High severity due to the current reliance of the villages on Bawdwin facilities and the lack of alternative locations nearby, however WMM will work with the district authority to implement a plan to minimise the severity of this impact	**Very High** The impact will be permanent, as education facilities in Bawdwin will be permanently closed	**Low**
	Residual impact significance			**Moderate to low**
	Assessment of uncertainty			
	High Resettlement planning and community development planning is at the early stages.			

Impact Zone 3 – Namtu Town

In terms of access to education services for Namtu, there may be an increase in demand on current education facilities. This will be completely mitigated by WMM's commitment to either upgrade the existing facilities at Namtu to cater for the increase in student numbers or to build new facilities at the resettlement destination or other agreed location. It is expected that educational authorities of Namtu Township, Kyaukme District and possibly Shan State will provide input on their preferences in this regard.

Access to religious support

It is predicted that the Bawdwin and Tiger Camp communities (Impact Zone 1), villages in tracts adjoining the Bawdwin concession area (Impact Zone 2) and Namtu Town (Impact Zone 3) will experience impaired access to religious institutions and support venues and services. No material changes to access of religious institutions as a result of the project are predicted to be experienced for residents of the Nam Pangyun valley (Impact Zone 4), residents of villages along the export corridor (Impact Zone 5) or Lashio (Impact Zone 6).

Impact Zone 1 – villages within the Bawdwin concession area

There are currently seven monasteries, three Sikh temples and two churches in Bawdwin. As a result of the project, these institutions will need to be re-established as a component of resettlement support. Individuals may experience a sense of loss or anxiety associated with this process due to the time taken for this to occur and the potential changes in physical distance people are from the re-established institutions. Rebuilding shrines and pagodas may take some time as typically community members will have contributed their labour and funds for the original institutions and may wish to undertake construction in the new location to engender the required sense of ownership. Furthermore, if the location of re-established institutions in the resettlement area is distant from the community for whatever reason, there may be a sense of loss that accompanies the separation, inducing a level of anxiety, or at least a level of inconvenience to fulfilling religious obligations.

Re-establishment of religious institutions will be conducted in close engagement with religious leaders, congregations and authorities. It is noted that through the engagement process the head monks have indicated that Buddhist pagoda and special inauguration relics should not be intentionally destroyed by human hand' and if facilities are no longer able to be used, decay or become damaged and the local people have agreed to creation of new facilities 'that will be okay'. Further engagement is required to determine the appropriate management of these sites on a case by case basis. Further details on mitigation and management of religious infrastructure is contained in the CHMP (Attachment 4) and Section 6.9.

The residual impact of impaired access to religious support due to the relocation or rebuilding of places of worship in Bawdwin is rated of **moderate significance**, based on the **low impact magnitude** and the **high sensitivity** of this group to changes to access of existing religious institutions (Table 6.241).

Table 6.241 Residual impact significance summary – impaired access to religious institutions and community support due to relocation or rebuilding of existing institutions during resettlement - affecting Bawdwin communities

Value	**Sensitivity of value**			
Access to places of worship and religious support	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High As there are existing religious institutions at Bawdwin and Tiger Camp and access to these services is important to the community	**High** Access to places of worship and religious support is vulnerable to changes due to the intrinsically related linkages between the Bawdwin communities and the mine	**Low** Limited resilience due to organisational structure influenced by the operation of the Bawdwin mine.	**High**
Impact	**Magnitude of impact**			
Impaired access to places of worship due to increased demand pressure from resettled populations	**Spatial extent**	**Severity**	**Duration**	**Magnitude**
	Very High Far reaching social impacts that effect the almost all people (>75%) within the defined impact zone.	**Low** Whilst the severity of the sense of loss or anxiety surrounding religious support will be managed through the relocation process with the implementation of the Livelihood Restoration Plan and facilities will be replaced/rebuilt.	**Medium** The majority of effects will be short term (i.e., months), concentrated in the relocation phase while institutions are being relocated or rebuilt.	**Low**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High Resettlement planning is at the early stages and a resettlement location has not been chosen. There is a degree of uncertainty surrounding where religious institutions will be relocated to. Detailed procedures for relocation have not yet been developed.			

Impact Zone 2 – villages in tracts adjoining the Bawdwin concession area

The villages in tracts adjoining the Bawdwin concession area currently utilise the religious institutions in Bawdwin for attending services, visiting shrines and engaging with religious community leaders. These institutions will no longer be available for use by the villagers, which may reduce the ability of these communities to easily interact with religious institutions. A sense of loss and anxiety may result from the loss of religious institutions from Bawdwin and Tiger Camp due to the resettlement process.

The development and implementation of a local Community Development Program that supports the presence of religious communities in proximity to the Bawdwin concession area, and that considers overall community investment needs, will mitigate some of the effects and stress caused by reduced interaction with religious institutions.

The residual impact to villages in tracts adjoining the Bawdwin concession area from possible separation from religious institutions will be of **high to major significance**, based on the **high impact magnitude** and the **medium to high sensitivity** of this group to changes to access of existing religious institutions (Table 6.242).

Table 6.242 Residual impact significance summary – all phases – impaired access to religious institutions and community support due to closure of places of worship – affecting residents of villages in tracts adjoining the Bawdwin concession area

Value	**Sensitivity of value**			
Access to places of worship and religious support	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium to High Bawdwin religious institutions are highly valued by residents of adjoining villages	**Medium to High** Due to the reliance on institutions within Bawdwin villages there is moderate to high vulnerability to any changes of these services with limited alternative options	**Low to Medium** Due to the remote nature of these villages, there is limited alternatives and therefore a lower level of resilience due to changes of these existing services.	**Medium to high**
Impact	**Magnitude of impact**			
Impaired access to places of worship from closure of places of worship	**Spatial extent**	**Severity**	**Duration**	**Magnitude**
	Very High Far reaching social impacts that effect the almost all people (>75%) within the defined impact zone.	**Medium** As the loss of this interaction may be a significant cause of personal stress for residents in these communities and there is a degree of uncertainty surrounding where religious institutions will be located after relocation	**Medium to Very High** The majority of effects will be short term (i.e., months), concentrated in the relocation phase while institutions are being relocated or rebuilt, if the new location is accessible. However, the effects associated with separation may be permanent if the new location is difficult to access.	**High**
	Residual impact significance			**High to major**
	Assessment of uncertainty			
	High Resettlement planning is at the early stages and a resettlement location has not been chosen. There is a degree of uncertainty surrounding where religious institutions will be relocated to. Detailed procedures for relocation have not yet been developed.			

Impact Zone 3 – Namtu Town

The additional population in Namtu following resettlement of Bawdwin and Tiger Camp villages is likely to result in increased use of existing places of worship and may reduce accessibility for the existing Namtu community who rely on the institutions. The additional pressure on existing services is expected to be met by relocation of the Bawdwin institutions as a component of the resettlement process.

The residual impact to Namtu township from increased demand for religious and spiritual institutions is rated of **very low significance**, based on the **very low impact magnitude** and the **medium sensitivity** of this group to changes to access of existing religious institutions (Table 6.243).

Table 6.243 Residual impact significance summary – all phases – impaired access to places of worship due to increased demand pressure from resettled populations – affecting residents of Namtu

Value	**Sensitivity of value**			
	Importance	***Vulnerability***	***Resilience***	***Sensitivity***

Value	Sensitivity of value			
Access to places of worship and religious support	**High** As there are existing religious institutions at Namtu and access to these services is important to the community	**Low** As the existing religious institutions are not affiliated with the mine	**High** There are several, religious institutions in Namtu and these are not influenced by mining activities/organisational structure.	**Medium**
Impact	**Magnitude of impact**			
Impaired access to places of worship due to increased demand pressure from resettled populations	**Spatial extent**	**Severity**	**Duration**	**Magnitude**
	Very Low Local scale social impacts that effect a small number of people (<5%) within the defined impact zone.	**Low** The increased demand is expected to be met through relocation of Bawdwin institutions or upgrades to existing Namtu institutions	**Medium to Very High** The majority of effects will be short term (i.e., months), concentrated in the relocation phase while institutions are being relocated or rebuilt, however the effects associated with increased demand for existing institutions at Namtu may be longer-term and extend over at least one generation.	**Very Low**
	Residual impact significance			**Very low**
	Assessment of uncertainty			
	High Resettlement planning is at the early stages and a resettlement location has not been chosen. There is a degree of uncertainty surrounding where religious institutions will be relocated to. Detailed procedures for relocation have not yet been developed.			

Access to commercial services

It is predicted that development of the project will result in changes in access to commercial services that will affect the Bawdwin and Tiger Camp communities (Impact Zone 1) and villages in tracts adjoining the Bawdwin concession area (Impact Zone 2). It is predicted that no material changes to access of commercial services as a result of the project will be experienced by Namtu (Impact Zone 3), residents of the Nam Pangyun valley (Impact Zone 4), residents of villages along the export corridor (Impact Zone 5) or Lashio (Impact Zone 6).

Impact Zone 1 – villages within the Bawdwin concession area

There is currently a limited range of commercial services and shops located within the Bawdwin villages. Support and assistance will be provided to relocate these to the chosen resettlement location.

To support local businesses and the relocation of commercial services and shops WMM will develop and implement Community and Business Development Plans, which shall include aim to maximise local business contracts for goods and services; and target investment priorities based on need, but likely to include a component of business development and microfinance.

As a large regional town with a more diversified economy, there is likely to be improved access to markets, shops and other services if the communities are resettled near Namtu.

The residual impact of improved access to commercial services from the relocation site will be of **positive (low) significance**, based on the **low impact magnitude** and the **medium sensitivity** of this group to changes in the existing commercial facilities (Table 6.244).

Table 6.244 Residual impact significance summary – all phases – improved access to commercial services – affecting Bawdwin and Tiger Camp communities, following resettlement

Value	**Sensitivity of value**			
Access to commercial services	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium There are existing commercial services and shops used and valued by the Bawdwin communities	**Medium to High** Due to the reliance on services within Bawdwin villages and lack of alternative options available	**Medium** Communities have some capacity to adapt to new conditions at the relocation site	**Medium**
Impact	**Magnitude of impact**			
Improved access to commercial services from the relocation site for resettled Bawdwin communities	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	High Social impacts may be widespread but will depend on location and configurations of the resettled communities	**Low** Improved access to markets, shops and other commercial services will be of minor benefit to resettled communities	**High** Long-term impact (3 to 15 years)	**Low (positive)**
	Residual impact significance			**Positive (low)**
	Assessment of uncertainty			
	High Resettlement planning is at the early stages and a resettlement location has not been chosen.			

Impact Zone 2 – villages in tracts adjoining the Bawdwin concession area

During community engagement, residents of villages in tracts adjoining the Bawdwin concession area stated that they currently access commercial services in Bawdwin. This mostly occurs when convenient, but some services are accessed more regularly, such as buying fuel and mechanical repairs. When asked about alternative locations for accessing these services, Namtu was cited as the most likely alternative. However, at least half of those interviewed mentioned the distance and additional expense of accessing services there as a constraint. Retail services were most valued, with use of the food market being a service of minor value.

The residual impact of impaired access to commercial services will be of **low to moderate significance**, based on the **low impact magnitude** and the **medium to high sensitivity** of this group to changes in the existing commercial services (Table 6.245).

Table 6.245 Residual impact significance summary – all phases – impaired access to commercial services due to closure of services – affecting residents of villages in tracts adjoining the Bawdwin concession area due to closure of services

Value	**Sensitivity of value**			
Access to commercial services	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	Medium to High The adjoining villages value the minimal distance and low expense associated with accessing commercial services in Bawdwin	**Medium to High** Due to the reliance on facilities within Bawdwin villages and lack of alternative options available	**Low to Medium** Due to the remote nature of the villages and limited alternatives. While there are similar services available at Namtu, these would be less convenient and costlier.	**Medium to high**
Impact	**Magnitude of impact**			
Impaired access to commercial services for villages in tracts adjoining the Bawdwin concession area due to resettling of Bawdwin communities	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very High Far reaching social impacts that effect the almost all people (>75%) within the defined impact zone.	**Low** Despite the additional distance and expense associated with alternatives there are available alternatives and the implementation of a regional Community Development Program aimed at servicing villages near the Bawdwin concession area, which may mitigate some of these effects.	**Medium** The majority of effects will be short (i.e., months) to medium term (1 to 2 years) during the period of adjustment	**Low**
	Residual impact significance			**Low to moderate**
	Assessment of uncertainty			
	Medium Understanding of the current businesses that operate in these villages is not well understood.			

Impact Zone 3 – Namtu Town

Economic stimulus generated by the project and investment by WMM via the Community Development Program may encourage growth of local commercial services in Namtu. However, the additional population and demand on these services due to resettlement of Bawdwin and Tiger Camp may restrict access to these services for the broader Namtu community. Overall, a neutral impact is predicted.

Summary of residual impacts

Table 6.246 provides a summary of the residual impacts and their significance.

Table 6.246 Summary of assessment of residual social impacts

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Mining related employment opportunities	Villages within the Bawdwin concession area – Impact Zone 1 – Diverse employment opportunities • High sensitivity	Construction and operations	Medium (positive) magnitude • Low spatial extent • High severity • High duration	• Maximise local employment • Implement the resettlement action plan and livelihood restoration measures therein • Training and Development Plan • Development and implementation of the Preferential Employment Policy	Positive (high)	The project will create jobs (both directly and indirectly), and educational opportunities will be provided. Bawdwin and Tiger Camp residents will have preferential access to employment and training opportunities associated with the mine. Resettled households will probably have access to employment opportunities in Namtu. This will lead to a more diversified employment based, and skills developed may lead to further opportunities after mine closure.	Medium • The number of people in the communities with suitable skills to transition to a modern mining operation is currently unknown.

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
	Villages in tracts adjoining the Bawdwin concession area – Impact Zone 2 –diverse employment opportunities • Low sensitivity		Low (positive) magnitude • Very low spatial extent • High severity • High duration	• Maximise local employment • Training and Development Plan • Development and implementation of the Preferential Employment Policy	Positive (low)	The project will create jobs (both directly and indirectly), and educational opportunities will be provided. it is expected that the 'local workforce' will largely comprise persons currently living in the Bawdwin villages, Namtu Town and villages in tracts adjoining the Bawdwin concession area. This will lead to a more diversified employment based, and skills developed may lead to further opportunities after mine closure	Medium • The number of people in the communities with suitable skills to transition to a modern mining operation is currently unknown.

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
	Namtu – Impact Zone 3 – Diverse employment opportunities • Medium sensitivity		Low (positive) magnitude • Very low spatial extent • Medium severity • High duration	• Maximise local employment • Training and Development Plan • Development and implementation of the Preferential Employment Policy	Positive (low)	The project will create jobs (both directly and indirectly), and educational opportunities will be provided. it is expected that the 'local workforce' will largely comprise persons currently living in the Bawdwin villages, Namtu Town and villages in tracts adjoining the Bawdwin concession area. Skills developed may lead to further opportunities after mine closure	Medium • The number of people in Namtu Town with suitable skills to transition to a modern mining operation is currently unknown.
Mining related employment opportunities	Myanmar – Diverse employment opportunities • Low sensitivity		Low (positive) magnitude • Very low spatial extent • Medium severity • High duration	• Training and Development Plan • Development and implementation of the Preferential Employment Policy	Positive (low)	Jobs will be created for residents of Myanmar, particularly for skilled workers. Skills developed may lead to further opportunities after mine closure	Low • There is relatively high confidence that suitable skills would be expected to be available at the national scale.

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Business opportunities and economic stimulus created by the project and impact to zones	Villages within the Bawdwin concession area – Impact Zone 1 – Business sectors providing goods and services • High sensitivity	Construction and operations	Low (positive) magnitude • Very low spatial extent • Medium severity • High duration	• Development and implementation of the Business Development, Supply and Procurement Plan	Positive (moderate)	The few local businesses with capacity to directly provide goods and services to the project may benefit over the life of the mine. Economic stimulus will be created by the project. There may be some negative effects however overall the impact is positive as the project will explore preferential business opportunities and facilitate the development of new businesses and re-establish existing businesses.	Medium • Uncertainty regarding the magnitude of consequent impacts of businesses economic stimulus and the flow on effects to local and regional economies • Success of the proposed Community Development Plan is assumed.

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
	Villages in tracts adjoining the Bawdwin concession area – Impact Zone 2 – Business sectors providing goods and services • Low sensitivity		Neutral magnitude • Medium spatial extent • Medium (positive) and medium (negative) severity • High duration	• Development and implementation of the Supply and Procurement Management Plan	Neutral	Tracts adjoining the Bawdwin concession area are expected to benefit slightly from business opportunities or related economic stimulus. The minimal benefits may offset the effects to businesses that currently sell goods in Bawdwin. These businesses may be impacted by reduced demand for goods (e.g. vegetables) in the Bawdwin area.	Medium • Understanding of the current businesses that operate in these villages is not well understood • Uncertainty regarding the magnitude of consequent impacts of businesses economic stimulus and the flow on effects to local and regional economies • Success of the proposed Community Development Plans is assumed
Business opportunities and economic stimulus created by the project and impact to zones	Namtu – Impact Zone 3 – Business sectors providing goods and services • Low sensitivity	Construction and operations	Medium (positive) magnitude • Low spatial extent • High severity • High duration	• Development and implementation of the Supply and Procurement Management Plan	Positive (low)	Business opportunities may lead to economic benefits in Namtu. Namtu has a reasonably diversified business sector and may have business opportunities available for those businesses that can provide goods and services to the mine over its lifetime.	Medium • Understanding of the current businesses that operate in Namtu is not well understood • Uncertainty regarding the magnitude of consequent impacts of businesses economic stimulus and the flow on effects to local and regional economies • Success of the proposed Community Development Plans is assumed

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
	Lashio – Impact Zone 6 – Business sectors providing goods and services • Low sensitivity		Medium (positive) magnitude • Low spatial extent • High severity • High duration		Positive (low)	Business opportunities may lead to regional economic benefits. Larger contracts may be source from businesses in Lashio, benefitting a small number of businesses that can provide goods and services to the project over tis lifetime.	Medium • Regional economic benefits will to a large degree depend on the location of successful contracting companies, which is not yet known.
Loss of access to land/resources for livelihood purposes	Bawdwin village communities – Impact Zone 1a – Access to productive agricultural land and scavenging sites • Low sensitivity		Medium magnitude • High spatial extent • Low severity • Medium duration	• Livelihood restoration and compensation measures in accordance with the Land Access and Resettlement Plan	Low	The majority of people will be affected due to resettlement associated with the project. This will result in loss of current land and the provision of access to alternative land in the resettlement location. Disruption to livelihoods as a result of loss of land will occur until the alternative land provides similar produce and livelihood security.	High • Given the stage of resettlement planning there is a high degree of uncertainty associated with livelihood restoration. • The assessment assumes that access to adequate cultivatable land is available at the relocation site for resettled communities.

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Loss of access to land/resources for livelihood purposes	Bawdwin farm communities – Impact Zone 1b – Access to productive agricultural land and scavenging sites • High sensitivity	Construction and operations	Medium magnitude • Very high spatial extent • Low severity • Medium duration	• Livelihood restoration and compensation measures in accordance with the Land Access and Resettlement Plan	High	All households will be affected due to resettlement associated with the project and the dependence on agriculture for livelihoods. This will result in loss of current land and the provision of access to alternative land in the resettlement location. Disruption to livelihoods as a result of loss of land will occur until the alternative land provides similar produce and livelihood security.	High • Given the stage of resettlement planning there is a high degree of uncertainty associated with livelihood restoration. • The assessment assumes that access to adequate cultivatable land is available at the relocation site for resettled communities.
	Loi Mi community – Impact Zone 1c – Access to productive agricultural land and scavenging sites	If resettled	Medium magnitude • Medium spatial extent • Medium severity • Medium duration	• Livelihood restoration and compensation measures in accordance with the Land Access and Resettlement Plan	High	The development of the project may impact on existing land use and potential for access constraints due to the project, such	High • There is a high degree of uncertainty regarding potential dust impacts from the project

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
	• High sensitivity	If not resettled	Medium magnitude • Medium spatial extent • Medium severity • High duration	• Livelihood restoration and compensation measures in accordance with the Land Access and Resettlement Plan	High	as from increased dust deposition. If receptors within the Bawdwin concession area are resettled this impact will be limited to 1 to 2 years prior to resettlement, however if not resettled, the impact may extend throughout the lifetime of the mine.	
Loss of access to land/resources for livelihood purposes	Nam Pangyun valley (permanent residents that live along the river with subsistence agricultural livelihoods) – Impact Zone 4a – Access to productive agricultural land and scavenging sites • High sensitivity	Construction and operations	Low magnitude • High spatial extent • Low severity • Low duration	• Livelihood restoration and compensation measures in accordance with the Land Access and Resettlement Plan	Moderate	Most households will be affected due to temporary loss of access to land associated with the project and their subsistence agriculture livelihoods. Disruption to livelihoods as a result of loss of access to land will probably be limited to during construction of the Namtu – Tiger Camp road.	High • There has not been detailed investigation and documentation regarding the details of inhabitants along the Nam Pangyun valley. Estimates regarding the number and location of residences has been based on analysis of satellite imagery.

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Loss of access to the Nam Pangyun river bed for fossicking for mineral waste	Nam Pangyun valley (temporary occupants that fossick within the Nam Pangyun river bed during the dry season) – Impact Zone 4b– Access to productive agricultural land and scavenging sites • High sensitivity	Construction and operations	Low magnitude • Medium spatial extent • Low severity • Low duration	• Livelihood restoration and compensation measures in accordance with the Land Access and Resettlement Plan	Moderate	A portion of residents will be affected due to temporary loss of access to the Nam Pangyun and subsequent inability to fossick and partake in artisanal mining activities. Disruption to livelihoods as a result of loss of access to land will probably be limited to during construction of the Namtu – Tiger Camp road.	High • There is a high degree of uncertainty regarding the livelihoods and land use of artisanal miners along the Nam Pangyun
Adverse physical living conditions as a result of project construction activities	Tiger Camp Village and surrounding rural farms prior to resettlement – Impact Zone 1 - Living conditions and infrastructure • High sensitivity	Construction and operations, prior to resettlement	Medium magnitude • Very high spatial extent • Medium severity • Medium duration	• Development and implementation of Community Development Plan, which is anticipated to include focus on improvement of infrastructure • Implementation of the Traffic Management Plan, Air Quality Management Plan and Noise and Vibration Management Plan	High	Most residents are expected to be impacted by increased dust, noise and traffic during construction. This will impact the existing amenity, convenience and liveability during this time.	Medium • Resettlement planning is at the early stages and a resettlement location has not been chosen

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Adverse physical living conditions as a result of project construction activities	Bawdwin Lower Village and surrounding farms prior to resettlement – Impact Zone 1 - Living conditions and infrastructure • Medium sensitivity	Construction and operations, prior to resettlement	High magnitude • Very high spatial extent • High severity • Medium duration	• Development and implementation of Community Development Plan, which is anticipated to include focus on improvement of infrastructure • Implementation of the Traffic Management Plan, Air Quality Management Plan and Noise and Vibration Management Plan	High	Most residents are expected to be impacted by increased dust, noise and traffic during construction and operations until resettled. This will have a high severity impact to the existing amenity, convenience and liveability during this time, as the village is located in close proximity to the mine.	Medium • Resettlement planning is at the early stages and a resettlement location has not been chosen
	Loi Mi village – Impact Zone 1c – Living conditions and infrastructure • Medium sensitivity	If resettled	Medium magnitude • Medium spatial extent • Low severity • Medium duration	• Implementation of the Traffic Management Plan, Air Quality Management Plan and Noise and Vibration Management Plan	Moderate	Some residents of Loi Mi may experience increased dust, noise and access constraints during construction and operation of the project, particularly related to TSF-B which is the closest project infrastructure. If receptors within the Bawdwin concession area are resettled, the impact will only occur for a limited period until this occurs.	High • Uncertainty whether this community will be exposed to project generated dust and what noise conditions will be like
		If not resettled	Medium magnitude • Medium spatial extent • Low severity • High duration		Moderate		

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Improved physical living conditions for resettled Bawdwin communities	Bawdwin villages (upper and lower), Tiger Camp village and surrounding farms including Nam La farms following resettlement – Impact Zone 1 - Living conditions and infrastructure • High sensitivity	All phases, following resettlement	High (positive) magnitude • Very high spatial extent • Medium severity • Very high duration	• Development and implementation of Community Development Plan, which is anticipated to include focus on improvement of infrastructure • Implementation of the Land Access and Resettlement Plan	Positive (major)	Once resettled, living conditions are expected to improve due to the resettlement commitments surrounding housing and improved essential services. The entire resettled population will benefit from improved living conditions, which will provide long term value.	High • A resettlement location has not been chosen. • Realised benefits will be heavily influenced by the success of constructive participation and engagement, planning and implementation of the resettlement program.
Adverse effects of traffic in terms of delays, access and amenity	Villages in tracts adjoining the Bawdwin concession area – Impact Zone 2 - Living conditions and infrastructure • Medium sensitivity	Construction	Low magnitude • Low spatial extent • Low severity • High duration	• Implementation of the Traffic Management Plan, Air Quality Management Plan and Noise and Vibration Management Plan	Low	Most of this receptor group will be impacted by adverse traffic changes for the life of the mine, however, this will have a limited effect on living conditions. There is likely to be some increased traffic during construction, particularly during construction of the process plant, as the Namtu-Manton Road will be diverted to enable this, which may result in increased truck traffic.	High • The level of use of the Namtu – Manton Road is uncertain. • There is some potential opportunity following the implementation of a Community Investment Plan and from broader regional economic stimulus as a result of the project has not been formally assessed due to the degree of uncertainty as to whether this benefit would be realised.

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Changes in physical living conditions for residents of Namtu due to changes in living conditions	Namtu town – Impact Zone 3 - Living conditions and infrastructure • Medium sensitivity	Construction and operations	Low magnitude • Medium spatial extent • Low severity • High duration	• Implementation of the Traffic Management Plan • Measures to limit the effects of in-migration	Low	Namtu may benefit from improved living conditions due to increased income and business opportunities associated with the project, however, may be affected over the life of the mine by increased project-related traffic and increased population due to resettlement and potential in-migration.	High • Resettlement planning is at the early stages and a resettlement location has not been chosen
Adverse effects of traffic in terms of delays, access and amenity	Nam Pangyun valley – Impact Zone 4 - Living conditions and infrastructure Medium sensitivity	Construction and operations	Medium magnitude • Medium spatial extent • Medium severity • High duration	• Implementation of the Traffic Management Plan, Air Quality Management Plan and Noise and Vibration Management Plan	Moderate	Residents immediately adjacent to the Namtu – Tiger Camp road will be impacted by its construction and use over the life of the mine. Amenity will be reduced by increased noise and exhaust emissions.	High • Due to access and security concerns at the time of the socio-economic field survey this area, there has not been detailed investigation and documentation regarding the details of inhabitants along the Nam Pangyun valley

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
	Export corridor – Impact Zone 5 - Living conditions and infrastructure Medium sensitivity	Operations	Medium magnitude • Low spatial extent • Medium severity • High duration	• Implementation of the Traffic Management Plan, Air Quality Management Plan and Noise and Vibration Management Plan	Moderate	Export of concentrate will result in an increase in truck traffic along the Namtu-Manton road between Namtu and the intersection with National Highway 3 during operations. This will affect residents close to the road in the villages along this route by causing an increase in noise and exhaust emissions.	Medium • There is an absence of air quality modelling and limited baseline data collection for this receptor
Reduced visual amenity through construction and operation of the project.	Bawdwin Lower Village, Tiger Camp Village and farms within the Bawdwin concession area prior to resettlement – Impact Zone 1 – Living conditions and infrastructure • Medium sensitivity	Construction and operations, prior to resettlement	Medium magnitude • High spatial extent • Medium severity • Medium duration	• Implementation of the Traffic Management Plan	Moderate	The project will result in large-scale, permanent modification of landforms, increased use of artificial lighting and increased numbers of heavy vehicles impacting visual amenity. The impact will affect the majority of residents until resettlement has occurred.	Medium • Perceptions of communities to visual changes of the Bawdwin concession area are not well understood.

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
	Villages in tracts adjoining the Bawdwin concession area (Namtu to Manton Road) – Impact Zone 2 – Living conditions and infrastructure • Medium sensitivity		Low magnitude • Low spatial extent • Very low severity • High duration	• Implementation of the Traffic Management Plan	Low	The project will result in large-scale, permanent modification of landforms, increased use of artificial lighting and increased numbers of heavy vehicles which may have an impact visual amenity. Permanent residents may be impacted by this change, but the impact to people using the road will only be impacted for a short period as they travel through.	Medium • Changes to the visual landscape as a result are well understood • The impacts of altered visual amenity on people or groups will vary due to the subjective nature of visual amenity.
Altered governance as a result of resettlement for the project	Bawdwin and Tiger Camp communities – Impact Zone 1 - Governance in the form of democratically elected leaders to represent communities • Medium sensitivity	All phases, following resettlement	Low magnitude • Medium spatial extent • Low severity • Very high duration	• Implementation of the Land Access and Resettlement Plan	Low	Some residents will be impacted by altered governance once resettled, and each individual is likely to be affected differently. Overall, while the impact will extend indefinitely, the impact is low as changes would be expected to be determined democratically	High • Resettlement planning is at the early stages and a resettlement location has not been chosen

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Altered social cohesion as a result of the project	Resettled Bawdwin and Tiger Camp communities – Impact Zone 1 - Social cohesion within and between communities • High sensitivity	All phases, following resettlement	Medium magnitude • Medium spatial extent • Medium severity • High duration	• Implementation of the Land Access and Resettlement Plan	High	A notable portion of the Bawdwin communities may be impacted by changes to social cohesion once resettled. Individuals will be affected differently, and hostility caused by changes to social cohesion are predicted to dissipate over time.	High • Resettlement planning is at the early stages and a resettlement location has not been chosen
Altered social cohesion as a result of the project and resettling of Bawdwin communities	Villages in tracts adjoining the Bawdwin concession area – Impact Zone 2 - Social cohesion within and between communities • Medium sensitivity	All phases, following resettlement	Low magnitude • Low spatial extent • Low severity • High duration	• Implementation of the Land Access and Resettlement Plan • Development and implementation of a local Community Development Plan that supports the presence of religious communities in proximity to the Bawdwin concession area	Low	The resettlement of Bawdwin communities and subsequent removal of social links to Bawdwin may cause changes to social cohesion that impacts some residents within the surrounding villages. Individuals will be affected differently, and hostility caused by changes to social cohesion are predicted to dissipate over time.	High • Resettlement planning is at the early stages and a resettlement location has not been chosen

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
	Namtu town – Impact Zone 3 - Social cohesion within and between communities • Medium sensitivity		Medium magnitude • Medium spatial extent • Medium severity • High duration	• Implementation of the Land Access and Resettlement Plan	Moderate	A notable portion of the Namtu community may be impacted by changes to social cohesion if Bawdwin communities are resettled in Namtu. Individuals will be affected differently, and hostility caused by changes to social cohesion are predicted to dissipate over time.	High • Resettlement planning is at the early stages and a resettlement location has not been chosen
Reduced personal and community wellbeing as a result of resettlement and in-migration generated by the project	Bawdwin and Tiger Camp communities – Impact Zone 1 – Social wellbeing • Medium sensitivity	All phases, following resettlement	Medium magnitude • Medium spatial extent • Medium severity • High duration	• Measures to limit the effects of in-migration • Implementation of a workers Code of Conduct	Moderate	A notable portion of the community will experience impaired social wellbeing throughout operations as a result of resettlement and in-migration. Individuals will be affected differently, and effects on social wellbeing are predicted to dissipate over time.	High • Resettlement planning is at the early stages and a resettlement location has not been chosen

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Reduced personal and community wellbeing as a result of resettlement and in-migration generated by the project	Villages in tracts adjoining the Bawdwin concession area – Impact Zone 2 – Social wellbeing • Medium sensitivity	Construction and operations, following resettlement	Low magnitude • Low spatial extent • Very low severity • High duration	• Measures to limit the effects of in-migration • Implementation of a workers Code of Conduct	Low	A small portion of the community may experience impaired social wellbeing throughout operations as a result of in-migration of people seeking work. This is likely to be minor as job-seekers are more likely to be attracted to Namtu where recruitment and training is likely to be based.	Medium • There is reasonable uncertainty regarding the extent of potential in-migration, as it is outside the control of WMM.
Reduced personal and community wellbeing due to in-migration and influx of mine workers	Namtu town – Impact Zone 3 – Social wellbeing • Medium sensitivity		Medium magnitude • Medium spatial extent • Low severity • High duration	• Measures to limit the effects of in-migration • Implementation of a workers Code of Conduct	Moderate	A small portion of the community may experience impaired social wellbeing throughout operations as a result of in-migration of people seeking work. This is likely to be minor as while job-seekers will be attracted to Namtu where recruitment and training is likely to be based, WMM will work with the GAD to manage administrative governance and a Code of Conduct will be implemented for workers.	Medium • There is reasonable uncertainty regarding the extent of potential in-migration, as it is outside the control of WMM.

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Reduced personal and community wellbeing of inhabitants as a result of in-migration generated by the project	Residents of Nam Pangyun valley – Impact Zone 4 – Social wellbeing • Medium sensitivity		Low magnitude • Low spatial extent • Very low severity • High duration	• Measures to limit the effects of in-migration	Low	A small portion of the community may experience impaired social wellbeing throughout operations as a result of in-migration of people seeking work in nearby communities.	High • There has not been detailed investigation and documentation regarding the details of inhabitants along the Nam Pangyun valley. • There is reasonable uncertainty regarding the extent of potential in-migration, as it is outside the control of WMM.
Loss or reduction of social identity as a result of resettlement	Bawdwin and Tiger Camp communities – Impact Zone 1 – Social identity • High sensitivity	All phases, following resettlement	Medium magnitude • Low spatial extent • Medium severity • High duration	• Establish a museum and cultural centre that promotes the history and culture of the Bawdwin operation (see Section 6.9 cultural heritage). • Interview and record the history of the Bawdwin mine from current Bawdwin residents. • Maximise local employment, which is likely to include employment that is linked to preservation and maintenance of cultural heritage relating to the mine	High	The social identity of some residents of Bawdwin and Tiger Camp may be impacted by the project due to resettlement that may cause a sense of loss, changes in the current form of the mine, and impacts to cultural sites. The impact can be partly remedied by the implementation of management measures.	High • Resettlement planning is at the early stages and a resettlement location has not been chosen.

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Negative effects on women and other vulnerable groups as a result of the project	Women and vulnerable groups in the Bawdwin and Tiger Camp communities – Impact Zone 1 – Social equality • Medium sensitivity	Construction. Operations, following resettlement	Medium magnitude • Medium spatial extent • Medium severity • High duration	• Implementation of a workers Code of Conduct • All job applications will be assessed equally, irrespective of the gender of the applicant	Moderate	Some women or vulnerable groups within the communities may experience impaired social and physical wellbeing over the mine life as a result of inequality and mining development.	Medium • The success of management measures has been assumed however WMM will have limited influence over employees in private residences, contractors and subcontractors
Impaired access to health services for villages surrounding the Bawdwin Concession due to resettling of Bawdwin communities	Villages in tracts adjoining the Bawdwin concession area – Impact Zone 2 – Access to medical and health facilities • Medium sensitivity	All phases, following resettlement	Medium magnitude • Low spatial extent • Medium severity • Very high duration	• Development and implementation of Community Development Plan, which is anticipated to include focus on improvement or expansion of health services	Moderate	These communities will be impacted by the removal of health services in Bawdwin, as there is a degree of dependence on Bawdwin for these services. While these facilities will be permanently removed and there is a lack of available facilities nearby, WMM plan to work with the district authority to implement a plan to minimise the severity of this impact.	High • Resettlement planning is at the early stages and a resettlement location has not been chosen. • There is some uncertainty regarding the project's investment priorities as the Community Investment Plan is yet to be developed and will require consultant with the relevant district administrations. The investment priorities are likely to include provision of health services however the nature, extent and responsibilities are yet to be defined.

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Impaired access to health services due to increased demand pressure from resettled populations	Namtu town – Impact Zone 3 – Access to medical and health facilities • Medium sensitivity	All phases, following resettlement	Low magnitude • Very low spatial extent • Low severity • High duration	• Development and implementation of Community Development Plan, which is anticipated to include focus on improvement or expansion of health services	Low	Once Bawdwin communities are resettled there may be increased pressure on health services is Namtu as a result of the increased population. This may be a long term impact to residents of Namtu , however may be offset by a greater proportion of the population being employed by the mine and being eligible for private healthcare.	High • Resettlement planning is at the early stages and a resettlement location has not been chosen. • There is some uncertainty regarding the project's investment priorities as the Community Investment Plan is yet to be developed and will require consultant with the relevant district administrations. The investment priorities are likely to include provision of health services however the nature, extent and responsibilities are yet to be defined.

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Impaired access to education facilities for villages in tracts adjoining the Bawdwin Concession due to resettling of Bawdwin communities	Villages in tracts adjoining the Bawdwin concession area – Impact Zone 2 – Access to schools and training facilities • Medium to high sensitivity	All phases, following resettlement	Low magnitude • Low spatial extent • Low severity • Very high duration	• Development and implementation of Community Development Plan, which is anticipated to include focus on improvement or expansion of education services	Moderate to low	The surrounding villages may be impacted by the removal of education facilities in Bawdwin and Tiger Camp, as around 20% of students in Bawdwin and Tiger Camp travel to attend the schools there from nearby villages. While these facilities will be permanently removed and there is a lack of available facilities nearby, WMM plan to work with the district authority to implement a plan to minimise the severity of this impact.	High • Resettlement planning and community development planning is at the early stages.

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Impaired access to religious support due to the relocation or rebuilding of places of worship in Bawdwin	Bawdwin communities – Impact Zone 1 - Access to places of worship and religious support • High sensitivity	Construction, during resettlement	Low magnitude • Very high spatial extent • Low severity • Medium duration	• Implementation of the Land Access and Resettlement Plan, including measures surrounding relocation of religious institutions • Development and implementation of a Community Development Plan	Moderate	As a result of the project, several religious institutions will need to be re-established during resettlement. Individuals in these communities may experience a sense of loss or anxiety associated with this process. While some effects will be restricted to the relocation phase, effects associated with separation may be longer-term and extend over at least one generation.	High • Resettlement planning is at the early stages and a resettlement location has not been chosen. • There is a degree of uncertainty surrounding where religious institutions will be relocated to. • Detailed procedures for relocation have not yet been developed.
Impaired access to religious institutions and support for residents villages in tracts adjoining the Bawdwin concession from closure of places of worship	Villages in tracts adjoining the Bawdwin concession area – Impact Zone 2 - Access to places of worship and religious support • Medium sensitivity	All phases, following resettlement	High magnitude • Very high spatial extent • Medium severity • Medium to very high duration	• Development and implementation of a local Community Development Plan that supports the presence of religious communities in proximity to the Bawdwin concession area	High	The surrounding villages may be impacted by the removal of religious institutions in Bawdwin and Tiger Camp, causing a sense of loss and anxiety. These facilities will be permanently relocated, and the impacts may be permanent depending on the location of the re-established institutions.	High • Resettlement planning is at the early stages and a resettlement location has not been chosen. • There is a degree of uncertainty surrounding where religious institutions will be relocated to. • Detailed procedures for relocation have not yet been developed.

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Impaired access to places of worship due to increased demand pressure from resettled populations	Namtu town – Impact Zone 3 - Access to places of worship and religious support • Medium sensitivity	After resettlement	Very low magnitude • Very low spatial extent • low severity • Medium to very high duration	• Development and implementation of a Community Development Plan	Very low	Once Bawdwin communities are resettled there may be increased pressure on religious institutions in Namtu as a result of the increased population. While some effects will be restricted to the relocation phase, effects associated with increased demand for existing institutions may be longer-term and extend over at least one generation.	High • Resettlement planning is at the early stages and a resettlement location has not been chosen. • There is a degree of uncertainty surrounding where religious institutions will be relocated to. • Detailed procedures for relocation have not yet been developed.
Improved access to commercial services from the relocation site for resettled Bawdwin communities	Bawdwin concession area villages – Impact Zone 1 - Access to commercial services • Medium sensitivity	After resettlement	Low (positive) magnitude • High spatial extent • Low severity • High duration	• Develop and implement a Business Development, Supply and Procurement Management Plan, which shall include aim to maximise local business contracts for goods and services • Development and implementation of Community Development Plan, which is anticipated to include focus on business development	Positive (low)	If the communities are resettled to near Namtu they will have improved access to commercial services.	High • Resettlement planning is at the early stages and a resettlement location has not been chosen.

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Impaired access to commercial services for villages in tracts adjoining the Bawdwin concession area due to resettling of Bawdwin communities	Villages in tracts adjoining the Bawdwin concession area – Impact Zone 2 - Access to commercial services • Medium sensitivity	All phases, following resettlement	Low magnitude • Very high spatial extent • Low severity • Medium duration	• Development and implementation of Community Development Plan, which is anticipated to include focus on business development	Low	The villages in tracts adjoining Bawdwin have limited access to alternative commercial services due to distance and expense. While most people will be impacted, it is expected that they will adjust to changes over a 1-2 year period, particularly considering the implementation of a regional Community Development Program.	Medium • Understanding of the current businesses that operate in these villages is not well understood.

6.10.5 Uncertainties and further work

This section outlines the key uncertainties associated with the impact assessment and outlines recommended further work to address uncertainties.

The key uncertainties are associated with:

- Resettlement planning is at the early stages and a location for resettlement has not been chosen. The Outline of the Land Access and Resettlement Plan (Appendix 4) has been prepared that will guide resettlement planning into the next stages. Potential relocations are currently being identified and assessed, which will then be presented for discussion with communities and Government agencies as part of further development of a Land Access and Resettlement Plan.
- Of the four study areas (Bawdwin, Namtu, regional villages, Shan State regional villages), only Bawdwin and Namtu communities participated in detailed socio-economic surveys. Consequently, there is a focus on these communities (also since they are in the highest zone of project influence) and details regarding the socio-economic environment of the artisanal miners and other inhabitants of Nam Pangyun Valley and regional villages (including those along the export route) have not been captured to the same extent.
- The extent of project-related regional economic stimulus, as it is largely dependent on the location of successful contracting companies which is not yet known.
- Perceptions of communities to visual changes of the Bawdwin concession area.
- The extent of potential in-migration, as it is outside the control of WMM.
- The limited influence WMM will have over employees' behaviour while offsite and in private residences, contractors and subcontractors.
- Which religious support venues and services will be re-established, detailed procedures for how the re-establishment is undertaken and where they will be relocated to.

Further work required to address these uncertainties is outlined in Table 6.247 and the relevant sections of the impact assessment (as indicated in Table 6.247).

Table 6.247 Uncertainties and further work in respect of social impacts

Uncertainty	Further work required	Purpose	Assumption
Resettlement planning is at the early stages and a location for resettlement has not been chosen. Given the current stage of resettlement planning there is a high degree of uncertainty associated with livelihood restoration	The Outline of the Land Access and Resettlement Plan (Appendix 4) has been prepared that will guide resettlement planning into the next stages. Potential relocations are currently being identified and assessed, which will then be presented for discussion with communities and Government agencies as part of further development of a Land Access and Resettlement Plan.	To identify resettlement locations. To determine whether the resettlement location will have access to adequate cultivatable land.	The assessment assumes the resettlement location will be near Namtu. The assessment assumes that access to adequate cultivatable land is available at the relocation site for resettled communities. The assessment assumes success of constructive participation and engagement, planning and implementation of the resettlement program.

Uncertainty	Further work required	Purpose	Assumption
Details regarding the socio-economic environment of the artisanal miners and other inhabitants of Nam Pangyun Valley and regional villages (including those along the export route) have not been captured to the same extent as other study areas (Bawdwin, Namtu, regional villages, Shan State regional villages).	WMM will commit to undertaking further socio-economic assessments during pre-construction planning. Detailed inventory and baseline surveys will be conducted as part of the resettlement program.	To develop of mitigation measures for any anticipated impacts from road construction and operations. To set the baseline on which monitoring can be based.	Estimates regarding the number and location of Nam Pangyun residences has been based on analysis of satellite imagery.
The extent of project-related regional economic stimulus, as it is largely dependent on the location of successful contracting companies and detailed procurement plan which is not yet known.	Develop the Business Development, Supply and Procurement Plan	To develop the plan which will seek to maximise the opportunities for local, state and national companies to contract to WMM, subject to meeting cost and quality considerations.	The success of the proposed Community Development Plans is assumed at this stage as the plans have not yet been developed.
Perceptions of communities to visual changes of the Bawdwin concession area.	WMM will commit to undertaking further socio-economic assessments during pre-construction planning	To develop mitigation measures for any anticipated impacts from road construction and operations.	The impact assessment assumes receptors are sensitive to changes in visual amenity and the degree of change.
The extent of potential in-migration, as it is outside the control of WMM.	Ongoing engagement with the GAD.	To manage administrative governance.	The impact assessment assumes in-migration will primarily be to Namtu as this is where WMM administration responsible for recruitment and training is likely to be based.
Which religious support venues and services will be re-established, detailed procedures for how the re-establishment is undertaken and where they will be relocated to is not yet known.	Development of a Land Access and Resettlement Plan and detailed Resettlement Action Plan(s). WMM will engage with relevant directly affected communities and other stakeholders, including township / district / state / national government and external parties	To identify community investment priorities as part of its community development planning process.	Re-establishment of religious institutions will be undertaken in consultation with relevant stakeholders and follow appropriate cultural practices and norms.
Concentrations and compositions of dust and gaseous emissions, and contaminants in dust and the level of dust deposition at receptors	Further work to address uncertainties regarding air quality impacts, as outlined in Table 6.119.	To quantify exposure to environmental hazards impact via air exposure pathways	Qualitative assessment adopting recommended separation distances
Level and distance of noise and vibrations emissions are not known	Further work to address uncertainties regarding noise impacts, as outlined in Table 6.145.	To quantify the sound levels at receptors	Noise emission levels were estimated based on literature values and the inverse square law.

6.10.6 Monitoring

WMM will establish procedures to monitor and measure the effectiveness of the environmental and social management plan, as well as compliance with any related legal and/or contractual obligations and regulatory requirements. The monitoring will be undertaken on a participatory basis with communities and in collaboration with government agencies. The monitoring program will be focussed on key social indicators, which are likely to include:

- General population and demographics.
- Social wellbeing, health and nutrition.
- School attendance.
- Economic and livelihood indicators such as employment, household income and business turnover.
- Physical housing conditions.
- Access to essential services.
- Worker and public grievances.

Monitoring specific to resettlement will be developed as part of the detailed Resettlement Action Plan(s). The monitoring program will cover all stages of resettlement, and will probably include:

- Process monitoring, such as tracking of resettlement program expenditure and resource use, number of people relocated and number of people receiving compensation and type of compensation.
- Impact monitoring to indicate whether implementation of the resettlement program is effective, unintended impacts have occurred or if corrective measures are required.

Completion audit to assess whether the objectives of the resettlement program have been met or if further work is required.

6.11 Health impact assessment

6.11.1 Approach to impact assessment

This chapter assesses the project impacts to community and occupational health values.

The health impact assessment method adopted in this chapter is a significance assessment. This approach assesses the potential significance of impacts by considering the sensitivity of community and occupational health values to change, and the magnitude of change that they are predicted to experience as a result of project-related activities.

The assessment is based on the framework in the IFC Good Practice publication, *Introduction to Health Impact Assessment* (IFC, 2009) which lists environmental health aspects for consideration, including:

- Exposure to potentially hazardous materials.
- Accidents and injuries (e.g., traffic accidents, injuries or fatalities from mine blasting operations).
- Soil- and water-sanitation–related diseases.
- Health services infrastructure and capacity.
- Respiratory and housing issues (including respiratory effects from housing and overcrowding).
- Food- and nutrition-related issues.
- Non-communicable diseases (e.g., hypertension, diabetes, stroke, heart disease, cancer and mental health).
- Sexually transmitted infections.
- Vector-related diseases (such as malaria, dengue fever and lymphatic filariasis).

- Social determinants of health.
- Veterinary medicine and zoonotic issues (i.e., diseases transmissible from animals to humans).
- Cultural health practices.

While veterinary medicine and zoonotic issues and cultural health practices were considered, such impact pathways from the project, either directly or indirectly, were not considered to be credible and therefore were not assessed.

The sensitivity of communities is based on:

- The importance of health to the community.
- The vulnerability of the community with consideration of baseline exposures and potentially sensitive sub-populations (e.g., children and women of childbearing age).
- How resilient the health of each population is if exposures to contaminants or hazards were to increase.

The magnitude of project related hazards is assessed on the proportion of the community likely to be impacted, the concentrations or levels of the hazard and its toxicity, and duration of their exposure.

The assessment of potential impacts has been completed on a qualitative basis and is based on specialist judgement and technical assessment supported by field data and scientific literature. The health baseline study (Appendix G) was informed by the socioeconomic baseline study (Appendix E) and environmental investigations described in Section 5.1 for soils and existing contamination, Section 5.2 groundwater, Section 5.3 surface water, Section 5.5 air quality and Section 5.6 noise. Particular emphasis has been placed on ensuring that the impact assessment describes the rationale, justification and any limitations and uncertainties of the assessment.

Further details on the significance assessment method are provided in Section 6.1.

Context for impact assessment

Community health was investigated in both Bawdwin and Namtu using publicly available health statistics, questionnaires and investigation of environmental conditions (see Section 5.9). A baseline investigation of blood lead levels in current workers at Bawdwin was also completed by WMM on behalf of WMM.

Overall, the populations of Bawdwin and Namtu seem to be in good health, with low incidence of chronic disease, infectious disease and vector-borne disease. The communities have adequate nutrition and housing, and possess positive health-related social determents including above average education and income. However, there are known health issues associated with the quality of potable water, poor sanitation, access to specialist medical services and supplies, and exposure pathways to known contaminants due to the historical operation of the mine, processing and smelting facilities. The hazardous environmental health exposure pathways that currently exist in Bawdwin and Namtu communities primarily relate to the inhalation, ingestion of or dermal contact with dust, metals (mainly lead) and bacteria (*E. coli).*

Contaminants such as particulate material and metals can cause toxic and other health effects in humans. Chronic exposures to certain metals can cause a number of long-term health effects. Metal toxicity is dependent on the route of exposure (primarily entering the body's system via inhalation or ingestion), the type of metal and what form it is in which will also influence its absorption into the body. Metals that are inhaled or ingested (via sources such as food or drink) have the potential to cause adverse health effects, depending on the dose and period of exposure.

In humans, exposure to lead can result in a wide range of biological effects depending upon the level and the duration of the exposure. Health effects range from inhibition of enzymes to the production of significant changes to body functions and death. Such changes occur over a broad range of doses. For neurological, metabolic and behavioural reasons, children are more vulnerable to the effects of lead than adults.

The occupational, safety and health blood lead level testing of both workforces and contractors that was undertaken by WMM on behalf of WMM found that all permanent workers who were tested exceeded at that time the 10 ug/dL threshold value for blood lead concentration, above which adverse health effects are expected (NHMRC, 2015). It is likely that most of the current Bawdwin workers experience adverse health effects, but symptoms and onset of lead poisoning may vary due to individual susceptibility. Many of the determinants of health are strongly influenced by individual factors, such as genetic, biological, lifestyle or behavioural factors, and specific personal circumstances. Examples of such circumstances include gender, age, diet, exercise, alcohol and tobacco use, educational attainment, and nature of employment.

Exposure pathways

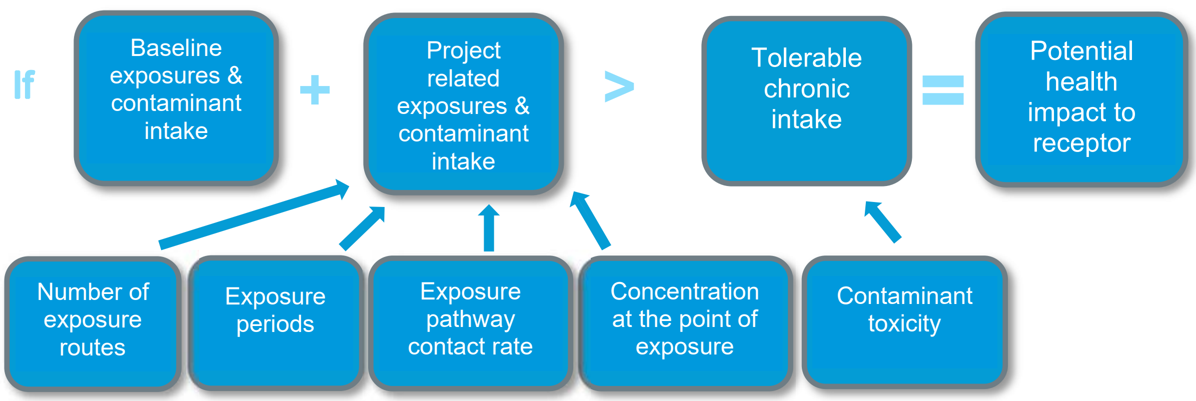
Identification of exposure pathways is a four-step process involving the identification of contaminant sources, how contaminants are transported to other media and locations, and which receptors may be exposed as a result. The process of identifying potentially complete exposure pathways in the context of the proposed project is illustrated in the following example:

- **Source**. Project mine area construction, operations, processing and related activities such as mined ore brought to the surface and stockpiled.
- **Transport pathways**. The fate and transport of contaminants once released from the source. This is usually via wind, water, sediments, soil, food etc. Examples include:
  - dust generated during the blasting of ore in the mine pit
  - dust generated by the filling of ore haul trucks in the mine and their subsequent movement on unsealed mine pit and access roads to the ROM
  - dust generated from stockpiled ore awaiting processing
  - dust generated from the loading of stockpiled ore into the primary crusher in the processing area.

  The dust then becomes airborne and may be transported to residential areas downwind of these activity areas. In addition, dust fallout and deposition can occur in waterways and water storage areas, on crops and gardens and in residential and community areas.
- **Receptors**. The point of exposure will depend on where the receptor is located. In this example, the receptors would include villager communities using the water for drinking or washing, swimming or consuming aquatic biota (such as fish) that resided in the impacted downstream region of the river.
- **Exposure route**. Once the source-pathway-receptor linkages have been identified, the potential direct and indirect routes of exposures can be determined. The route of exposure describes how a contaminant enters the body either via ingestion, inhalation or dermal contact.

Exposure assessment

Health impacts as a result of exposure to environmental hazards are dependent on a number of factors that will vary for each receptor, as generally described as follows:



Where:

- **Route/s of exposure**. How a contaminant enters the body and whether the contaminant enters the body by more than one route.
- **Exposure period**. Dependent on the time a receptor is exposed and range from acute (less than 24 hours or up to 2 weeks) to sub-chronic (2 weeks to 6 months) to chronic (greater than 6 months).
- **Contact rate**. For the ingestion pathway, this relates to the amount of impacted material consumed, for the inhalation pathway, how much is inhaled and the dermal contact pathway, how much skin comes into contact.
- **Concentration of a contaminant** at the point of exposure.
- **Toxicity of the contaminant**. A chemical's toxicity can differ depending on life stage of the receptor, residence time or storage in the body and the body systems it affects. The toxicity will also depend on whether the contaminant exhibits health effects at a level where the body is no longer able to metabolise or eliminate the chemical, and whether the contaminant is genotoxic and causes changes to the body's DNA which may result in cancer.
- **The impact of other hazards** such as noise or vibration.
- **Background exposures** to a contaminant from other sources. The intake from background sources can contribute a significant portion to the acceptable intake. In some instances, the background intakes can exceed to the acceptable intake which is the case for blood lead levels recorded in contract workers who had no history of working or living in Bawdwin or Namtu.
- **Tolerable chronic intake**. An estimate of intake (usually daily) of a substance that can occur over a lifetime without appreciable health risk. It is an established health limit below which lifetime exposure should not have any adverse health effects. It is usually expressed on a body weight basis. The US CDC considers blood lead levels to be elevated when above 5 µg/dL (https://wwwn.cdc.gov/nndss/conditions/lead-elevated-blood-levels/case-definition/2016/), with adverse effects when levels are above 10 µg/dL including increased blood pressure, and impacts to renal, reproductive and neurological functions (NHMRC 2015).

A qualitative assessment was undertaken to assess the nature and extent of potential impacts to environmental media at the point where receptors may be exposed. Where exposures to multiple contaminants is likely, the key contaminants of concern have been selected based on prevalence in media measured in baseline data, potential release to the environment during project activities and their toxicity and impact on sensitive populations within the receptor groups.

The key contaminants considered were lead, $PM_{2.5}$ and PM_{10} given the number of baseline exceedances in various media and or locations, and their toxicity. The sensitive populations to these contaminants are young children and pregnant women due to known health effects on the developing foetus.

6.11.2 Sources of potential impact

Project-related activities may directly, indirectly, and even cumulatively change community exposures to environment-based health risks, such as communicable diseases and exposure to hazardous materials or conditions. The project has the potential to affect a broad range of environmental and social determinants of health either positively or negatively.

Fundamental to the prediction of direct and indirect health impacts caused by the project is to understand the key sources of potential impact or drivers of change. Furthermore, the magnitude of predicted impacts will depend on the implementation of avoidance and management measures outlined in this EIA. Therefore, it is acknowledged that there is a degree of uncertainty in assessing predicted health impacts of the project.

Sources of potential impact that will occur as a result of the project include:

- Physical disturbance and displacement of communities.
- Occupational safety and health hazards (e.g., hazardous substances, blasting).
- Project related alteration to hydrology and water storages.
- Project emissions and discharges.
- Altered road traffic composition (increased proportion of heavy vehicles, traffic levels by time of day etc).
- Project workforce interactions.
- In-migration.

In the following section sources of potential health impact as a result of the project are described.

Physical disturbance and displacement

The proposed project with its large open pit, new mineral processing plant and mine waste storage facilities has a substantially larger footprint than the historical Bawdwin mining operation. The total footprint area of the future project will be approximately 470 ha. The existing Bawdwin villages and nearby scattered hamlets will have increased exposure to environmental and safety hazards (e.g., reduced air and water quality) as a result of the project. To minimise significant impacts to existing villages in the Bawdwin concession area during the operation of the project, resettlement is proposed.

The resettlement of all communities is the most effective method of reducing their exposures to lead, fine particulate matter, combustion gases and noise resulting from project construction and operation. It is noted the resettlement timing is highly dependent on required government approvals, project financing and reaching an agreeable outcome from the selected communities. As such, it is expected that only Bawdwin upper village will be resettled during construction, with Bawdwin lower village, Tiger Camp and the nearby scattered hamlets and farms being resettled during early operations. The timing of resettlement for each group with regard to project commencement and mining operations is presented in Table 6.85.. The other significant change as a result of resettlement will be the construction of an entirely new village or villages. If implemented well, this has the potential to improve the living conditions of people by providing new and improved housing and reliable access to modern essential services (e.g., water, electricity, sanitation) to support community wellbeing and health. Through the resettlement planning process, improvements in village planning, housing, and essential and supporting infrastructure can be agreed in consultation with the resettled communities.

Other impacts associated with resettlement which are not related to community health are described and assessed in Section 6.10.

Occupational safety and health hazards

The existing Bawdwin mine will be redeveloped into a larger, modern mining operation. Occupational safety and health hazards occur in all workplaces. Key hazards associated with open pit mining projects include exposure to hazardous substances (including chemicals and hydrocarbons and lead or other heavy metals in air, dust, water or soils), noise and vibration, use of explosives for blasting, fly rock, use of electrical systems and equipment, fatigue, work at height, slips, trips and falls, thermal stress, lifting and hoisting devices and moving machinery and vehicles. Given the proximity of Bawdwin lower village to open pit mining operations, industrial hazards such as blasting and fly rock have the potential to impact safety of nearby communities or damage private buildings or infrastructure.

Exposure of the project workforce to hazardous substances is addressed within this section of the EIA. Air quality and noise and vibration impacts are described and assessed in Section 6.5 and Section 6.7, respectively. The potential for occupational safety and health incidents (e.g., electrical, explosive, vehicle) and blasting and fly rock are addressed in Chapter 7.

Project related changes to hydrology and water storages

The project will involve construction of new or larger sources of standing water (e.g., new reservoirs, sediment dams and drainage lines) that may provide mosquito habitat. Key sources include construction of the Nam La water harvesting facility, Wallah waste dump sediment dams 1 to 3, TSF water reservoirs and diversion dams and expansion of the existing Nam Pangyun Reservoir. These sites with clean, slow-moving water are considered optimal habitats for mosquito egg-laying and breeding. Favourable conditions for mosquitos may increase the risk of vector-related diseases such as malaria, dengue and yellow fever in nearby communities. However, traditional household water storage containers such as metal drums and clay jars that are close to houses represent more common breeding sites for *Aedes aegypti*, a major vector of dengue fever and yellow fever, as opposed to large dams and reservoirs that are situated at distance from houses and people (Harrington et al., 2005).

Due to the elevation and climate of the project, the area is not considered to provide optimal conditions for the growth and spread of malaria locally. This is supported by results of the Bawdwin and Namtu household surveys in which vector borne disease was not commonly reported.

Emissions and discharges

Since the Bawdwin project will be occurring in a 'brownfield' environment that has had a long history of mining, mineral concentrating and smelting, high levels of metals are present in the existing environment. As a result, the communities of Bawdwin and Namtu have been and are currently being exposed to the impacts of environmental degradation.

The project will result in emissions and discharges to the environment. These include:

- Discharges of water generated through the mineral concentration process, surface water run-off, and seepage from the Wallah waste rock dump and TSFs. These discharges are described in detail in Section 6.3 and Section 6.4.
- Fly rock from blasting associated with open mining described in detail in Chapter 7.
- Emissions to air in the form of particulate matter (dust) and gases. These emissions are described in detail in Section 6.5.
- Generation of noise from fixed and mobile machinery and vehicles. Noise and vibration generated by the project described in detail in Section 6.7.
- Production of waste described in Chapter 4.

These have the potential to influence the health of communities in proximity to the mine and access roads. Contaminants such as particulate material and metals can cause toxic and other health effects in humans. Chronic exposures to certain metals can cause a number of long-term health effects. Metal toxicity is dependent on the route of exposure (primarily entering the body's system via inhalation or ingestion), the type of metal and what form it is in which will also influence its absorption into the body. Metals that are inhaled or ingested (via sources such as food or drink) have the potential to cause adverse health effects, depending on the dose and period of exposure. Metals such as arsenic, cadmium, copper, lead, mercury, selenium and zinc usually occur in soil at low concentrations as a result of natural processes such as weathering of rocks and minerals.

Particulates in airborne dust enter the body via inhalation. Very fine particulates are able to reach the lower parts of the lung where they may become lodged or enter the bloodstream. Laboratory and epidemiological studies have identified that these particles, if present in elevated levels, have the potential to cause adverse health impacts in susceptible people. However, it should be noted that very fine particulates typically represent a relatively small fraction by mass of the total dust that is inhaled.

People living near lead mining and processing operations (even ones currently not in production, such as the historical Bawdwin mine) may be exposed to lead (and other contaminants) by breathing dust particulates in air, drinking water, eating foods, or swallowing dust or dirt that contain lead. Fresh vegetables grown in lead containing soils may have lead dust particulates on the surface and hand-to-mouth contact may also occur after exposure to lead-containing soil or dust. In humans, exposure to lead can result in a wide range of biological effects depending upon the level and the duration of the exposure. Health effects range from inhibition of enzymes to the production of significant changes to body functions and death. Such changes occur over a broad range of doses.

The communities of Bawdwin and Namtu share many similarities; both have been and are currently being exposed to the impacts of environmental degradation brought about by a long history of mining and smelting in the local area. Currently the exposure to contaminant metals is higher at Bawdwin than in Namtu, due to the extent of historical disturbance, rural nature of the villages in the Bawdwin concession area and the local geology with high levels of natural as well as mine-derived contaminants. Contaminant exposures at Namtu are probably influenced by both historical and current (but separate from the Project) processing activities at Namtu.

The levels of lead measured in environmental media in Bawdwin indicates that residents are potentially exposed to elevated lead (and other metals) via multiple media (e.g., soil, water, air and food) and multiple exposure pathways (e.g., ingestion, inhalation, dermal contact). There is a significantly high potential these exposures may pose a serious health risk to the population in this study area.

The assessment of environmental exposure pathway was completed in the health baseline study (Appendix G), which was informed by the socioeconomic baseline study (Appendix E), as well as environmental investigations described in Section 5.1 for soils and existing contamination, Section 5.2 groundwater, Section 5.3 surface water, Section 5.5 air quality and Section 5.6 existing noise. A summary of health baseline conditions is presented in Section 5.9.

Investigations of air, water, and soil showed that a range of contaminants are present at elevated concentrations in the Bawdwin and Namtu study areas, but particularly the Bawdwin study area. To ensure the protection of human health, international agencies have derived health-based screening criteria for water, soil and air for contaminants of concern or pollutants that may cause ecological or human health impacts. Contaminants of concern recorded above these health screening criteria levels in the Bawdwin and Namtu study areas are presented in Table 6.248.

The number of exceedances in all of the media that were tested indicates the potential exposure pathways identified for the populations of interest in Bawdwin are complete (or confirmed). That is, the identified exposure pathways, the connections between the source and the receptor, are credible and have potential to expose populations to contaminants. Whilst there are strong indicators that a number of the exposure pathways occur for the populations in the Namtu study area, there is increased uncertainty due to the smaller dataset in this location, as the focus of this study is on the Bawdwin and Tiger Camp communities.

Community interviews on the subject of health indicators, together with anthropometric measurements and non-invasive clinical examinations, did not demonstrate any clear relationships between exposure to contaminants such as lead and chronic health conditions self-reported by surveyed community members at Bawdwin and Namtu, despite the fact that lead and other metals are known to be present in both study areas. However, the data must be treated with caution, as there are several limitations associated with the lack of primary health and public health data, and reliance on self-reporting of health conditions from members of the public who are not formally educated or trained in medical health.

Table 6.248 Confirmed contaminants of concern above recommended health screening criteria

<table>
<tr><th>Source</th><th>Exposure Pathway</th><th>Bawdwin</th><th>Namtu</th></tr>
<tr><td>Surface water</td><td rowspan="3">Ingestion of drinking water
Ingestion of water used in cooking.
Incidental ingestion of water during washing, cleaning, irrigation etc
Inhalation of aerosols
Dermal contact</td><td>Antimony, arsenic, cadmium, lead, nickel, and zinc.</td><td>Lead</td></tr>
<tr><td>Groundwater (springs)</td><td>Antimony, arsenic, cadmium, copper, lead, nickel, and zinc</td><td>No data available.</td></tr>
<tr><td>Drinking water</td><td>Bacteria (E. coli), arsenic, cadmium, lead, manganese</td><td>Lead and manganese</td></tr>
<tr><td>Soils (general)</td><td>Inhalation of particulates
Incidental ingestion
Dermal contact</td><td>Antimony, arsenic, cadmium, chromium, cobalt, lead, nickel, and zinc</td><td>Antimony, arsenic, cadmium, cobalt, lead, nickel, and zinc</td></tr>
</table>

Source	Exposure Pathway	Bawdwin	Namtu
Garden (gardens)	Ingestion of home grown produce/ animal products	Antimony, arsenic, cadmium, chromium, copper, cobalt, lead and selenium	No data available.
Food	Ingestion of food	Arsenic, cadmium, and lead	Arsenic, cadmium and lead
Ambient air	Inhalation of particulates Incidental ingestion Dermal contact	TSP, PM_{10}, chromium, and lead	TSP, PM_{10}, chromium, lead
Dust	Inhalation of particulates Incidental ingestion Dermal contact	Dust deposition and lead content	Dust deposition and lead content
Noise	Audible noise	Noise exceedances	Noise exceedances

Traffic

The project will generate additional heavy vehicle traffic. During steady state operations there will be between 60 and 93 additional 30-tonne trucks travelling on public roads between Lashio and Namtu per day. As many of these roads are narrow and winding, road travel will be restricted to daylight hours only for safety reasons. The interaction of local populations with project vehicular movements poses a safety risk, heightened by the volume of traffic during construction. This may lead to injury and trauma resulting from accidents. Safety risks associated with project-related traffic are assessed in Chapter 7.

Increased heavy traffic along the transport corridor may impact nearby villages due to increased air emissions (e.g., dust, vehicle emissions) and noise. Amenity impacts associated with project-related traffic are assessed in Section 6.5. Exposure of the project workforce to hazardous substances, including wheel generated dust and vehicle exhaust emissions, is addressed within this section of the EIA.

Project-related employment and in-migration

The project will require a large construction and operations workforce, predicted up to 2,285 people at its peak. Ongoing employment will be provided for around 1,100 people during operations. This will include roughly half WMM employees and half contractor employees, including mining, laboratory and accommodation camp personnel. WMM intends that the project will optimise the employment of locals and build the capacity and knowledge of the local workforce. WMM will also work with relevant authorities and organisations to stimulate indirect employment opportunities for local people in the provision of goods and services to the mining operation.

Projects have significant potential to increase community and household income, which can have a significant impact on a variety of health performance indicators for all populations in a community, including vulnerable groups (e.g. women, children and the elderly). Projects also have the potential to trigger inflation in nearby communities, impacting both food and housing availability.

While not directly caused by the project, a typical effect of large resource developments in the context of largely rural and developing economies is in-migration, whereby people are attracted to the site of the development in the hope of gaining employment or other benefits.

A large influx of new people to the area and interaction with the existing communities can facilitate the spread of communicable diseases including respiratory diseases, vector related diseases such as malaria, dengue and yellow fever and sexually transmitted infections.

Other social impacts associated with project related employment and in-migration are described and assessed in Section 6.10.

Summary of sources of potential impact

These project impacts may affect community health. Table 6.249 summarises potential impacts to health in each of the project phases. The sources of potential impact and impact magnitude during decommissioning and active closure are expected to align with construction phase impacts, with the exception of impacts related to the project workforce (i.e., communicable diseases and household income) given active closure will require a smaller workforce than construction.

Table 6.249 Summary of sources of potential impact during project construction, operations, closure and post-closure phases

Potential impacts	Construction Phase	Operations Phase	Decommissioning and Closure Phase	Post-Closure Phase
Reduced air quality due to increased airborne particulate matter	X	X	X	
Increased dust deposition	X	X	X	
Reduced air quality due to gaseous pollutants	X	X	X	
Reduced groundwater quality due to decreased flow and increased total and dissolved metals	X	X	X	X
Reduced surface water quality due to increased total and dissolved metals	X	X	X	X
Reduced groundwater quality due to increased hydrocarbons	X	X	X	
Reduced surface water quality due to increased hydrocarbons	X	X	X	
Increased noise and vibration levels	X	X	X	
Increased spread of communicable diseases	X	X		
Increased community and household income	X	X		

X = predicted to occur during this phase

6.11.3 Mitigation and management measures

Potential health impacts will be avoided through project design and resettlement of affected communities or minimised through developing and implementing a project Environmental Management Plan and Community Health, Safety and Security Management Plan. Proposed avoidance and management measures are outlined below.

Avoidance measures

The primary impact avoidance measure will be to physically remove residents from exposure to hazardous health conditions. This will be achieved by resettling the populations of the Bawdwin upper village, lower village and Tiger Camp areas, which would otherwise be located in proximity to the project area where the greatest potential impacts to health, including from exposure to contaminated dust, soils and runoff will occur.

Although resettlement will achieve the aim of removing residents from exposure to hazardous health conditions in the long term, the entire population will not be resettled prior to commencement of operations. The timing of resettlement is highly dependent on required government approvals, finding suitable resettlement locations, project financing and reaching agreement on resettlement plans with the affected communities. It is currently proposed that resettlement will be completed in three phases, based on the geographical layout of the various village clusters within the Bawdwin concession area, the locations of the proposed development areas and the proximity of villages. The resettlement locations have not been confirmed and further consultation with resettled communities is required to inform the decision.

Resettlement of Bawdwin upper village, Nam La farms and some farms near Tiger Camp will occur during construction, somewhere between 7 to 9 months after project commencement. It is planned to resettle Tiger Camp village before construction of the Wallah waste rock dump sediment dams starts and 8 months before WMM commences deposition of waste into the waste rock dump. Bawdwin lower village and associated farms, together with remaining farms near Tiger Camp are planned to be resettled between 30 and 32 months after commencement of mining operations. WMM does not propose to resettle the military base located on the Bawdwin concession area, although the Myanmar army may subsequently decide to do so. Populations located outside the Bawdwin concession area, including those along the primary access road in the Nam Pangyun valley and the residents of Namtu, will not be resettled.

Mitigation and management measures

Development and implementation of a project environmental management plan and community health, safety and security management plan will minimise potential health impacts of the project. Key management measures are provided in Attachment 4 and EIA sections 6.2, 6.4, 6.5, 6.7 and 6.10.

Environmental Management Plan

Key management measures to minimise adverse health impacts caused by environmental changes are outlined in the relevant sections of the EIA. This includes management measures associated with:

- Air emission and dust deposition (see Section 6.5).
- Runoff and seepage (see Section 6.4).
- Contaminated soils and erosion (see Section 6.2).
- Noise and vibration (see Section 6.7).

Community Health, Safety and Security

The objective of the Community Health, Safety and Security Management Plan is to establish measures to manage potential Project-related risks to community health, safety and security. The plan will apply to villages immediately surrounding the project area that are potentially subject to impact from project construction and operation.

The success of implementation of the Community Health, Safety and Security Management Plan will be influenced by relevant state and district level governments and therefore close engagement with key stakeholders regarding the content and implementation of the plan is required.

Community health measures will include:

- Implement a Health Awareness Program with government and non-government agencies in project-affected communities addressing key issues of:
  - Minimising exposure to metal contaminants i.e., lead.
  - Hygiene including waste disposal and sanitation.
  - Preventative health.
  - Lifestyle risk management and disease prevention.
  - Infectious disease management.
  - Vector-related disease management including mosquito management.
- Support the delivery of public health services to project-affected communities through engagement with government and service providers addressing key issues of:
  - Improve services (supplies, infrastructure, staff oversight).
  - Occupational safety and health.
  - Communicable disease management (malaria, TB, STIs, HIV etc).
  - Improve child mortality (immunisation, neonatal care, nutrition etc).
  - Improve maternal health (family planning, birthing, ante-natal care).
- Facilitate the improvement of water (reliability, quality, quantity) and sanitation facilities (hygienic disposal) at the resettlement village(s) in partnership with local-level government and other relevant agencies and organisations.

- Maintain the current standard of water (reliability, quality, quantity) and sanitation facilities (hygienic disposal) for residents remaining within the Bawdwin concession area.
- Community blood lead level monitoring program, with women of child-bearing age, pregnant women and children prioritised for testing.
- Monitoring project related water storages such as dams and reservoirs for mosquito breeding activity, with additional management controls implemented if required, such as provision of mosquito nets to communities at higher risk based on proximity to breeding grounds.

Community safety measures will include:

- Implement the Traffic Management Plan to minimise the potential for injuries to road users and minimise wheel-generated dust and vehicle emissions. The plan will include:
  - Ensure WMM (and contractor) drivers have the relevant level of competency for the vehicle they need to drive and carry relevant licences.
  - Establish and enforce speed limits on project roads and for project vehicles.
  - Conduct regular vehicle inspections.
- Notify relevant communities as required about significant changes in traffic conditions (e.g., high project traffic periods or road/ river diversions/ blockages) and the associated hazards with these changes.
- Deliver an education and awareness program to project-affected communities, including schools in project-affected communities, to raise awareness of risks to safety posed by project activities and personal behaviours which can reduce risk and improve safety.
- Implement a Project-wide induction process that covers, as a minimum: ethics; health; environment; safety; alcohol and drug use; workforce diversity; harassment; and cultural and social sensitivities of workers and communities.
- Develop, implement and monitor compliance with a workforce code of conduct that governs internal workforce interaction and interaction between the workforce and project-affected communities.

Measures to limit the effects of in-migration will include:

- Communicate potential impacts of in-migration to local communities to assist them to devise strategies to manage in-migration.
- Engage with the state, township and village-level government representatives to assist them to devise strategies to prepare for and discourage in-migration.
- Select workers in accordance with the geographic priorities determined by the project.
- Establish multiple points of hire that provide access to affected communities and do not encourage people to move to project sites.
- Communicate to the community the recruitment process that requires applicants' place of origin to be identified.
- Do not allow public access to services (such as health and transportation services) provided to project employees.

Occupational Safety and Health Management Plan

The Occupational Safety and Health Management Plan will be implemented by WMM to protect the health, safety and wellbeing of the project workforce. The plan will identify safety, health and hygiene hazards in the project area and operations and will determine appropriate controls in accordance with the level of risk. Lead exposure risks associated with both the existing contamination at site from historical mining practices and the future operations will be addressed by a separate Lead Management Plan. Other occupational safety and health issues common to open pit mining operations, such as fatigue management, fitness for work, working at height, working in confined spaces and operation of electrical equipment will also be addressed within the plan.

Strategies to manage blood lead levels in workers include:

- Equip enclosed workplaces with air management equipment to minimise ambient dust and metals in the air.
- Overarching principle of separating 'dirty' areas from 'clean' ones (e.g., quarantine area where all contaminated clothing is removed, including boots).
- Provide change room facilities with clean water to shower and the ability to remove contaminated clothing before a shower and clean locker room to change into street clothes. Coveralls will be laundered before re-use on the next shift.
- Provide appropriate PPE to workers. Workers will be issued with clean coveralls, clean respirator/dust mask and clean gloves before starting each shift. The potential requirement for respirators will be based on results of personal exposure monitoring and the nature of the work being undertaken and the work environment. Disposable coveralls will be issued whilst washing and quarantine facilities are being established.
- Keep offices, accommodation and meal areas dust free, including floors and all surfaces. Wet mopping and wet dusting are preferable over vacuuming.
- Implement education programs regarding hygiene measures (i.e., hand and face washing, protocols for eating, no smoking) and healthy diet.
- Consult and provide counselling for workers with elevated exposures.
- Periodically monitor blood lead levels of all workers using onsite testing equipment, and selection of blood samples to undergo laboratory analysis for heavy metals. The monitoring program will be continuous to detect any change in blood lead levels.
- Monitor the exposure of workers using personal dust inhalation samplers and personal aerosol monitors
- Monitor of ambient air quality conditions in workplaces, with particular emphasis on the process plant
- Monitor dust in the project area in real time.

Blasting and Explosives Management Plan

WMM will develop and implement a blasting and explosives management plan which will include site and project-specific measures to manage blasting and blasting-related impacts associated with mining operations. The objective of the blasting and explosives management plan is to protect the amenity and safety of the project workforce and also residents of Bawdwin lower village and Tiger Camp prior to resettlement, and to prevent damage to infrastructure and cultural heritage features due to open pit mining operations.

The blasting and explosives management plan will include the following:

- Quantify the baseline noise and vibration levels in the project area and nearby villages, including Bawdwin lower village and Tiger Camp.
- Comply with relevant statutory requirements regarding explosives transport and storage, blasting and blasting-related impacts.
- Measure performance indicators and criteria, such as air blast overpressure and ground vibration criteria, that the project will comply with.

- Describe management measures that will be implemented to comply with the defined criteria, such as limiting the frequency and duration of blasts where practicable and maximising design and quality control on blasts within 500 m of Bawdwin lower village residences. These management measures will be aligned with current good practice in the international mining industry.
- Implement a blast monitoring program to monitor vibration and air blast overpressure at Bawdwin lower village, and other potential locations relevant to the project workforce and sensitive receptors in other directions.
- Communicate procedures regarding notification of scheduled blasting, and process for receiving and responding to complaints or grievances regarding blasting to residents within the Bawdwin concession area.
- Implement an incident response procedure, including relevant authorities and/or stakeholders to be notified.
- Develop and implement a process for review of the blast management plan and stipulated criteria in the event that blasting impacts are observed, as well as periodic review of the plan.

Mine Closure Plan

The Mine Closure Plan will define a set of closure objectives, addressing physical, biological and socio-economic aspects. Linked to these objectives, WMM will define conceptual post-closure land uses that can feasibly achieve the closure objectives, as well as closure completion criteria, which allow WMM and stakeholders to measure and assess whether closure objectives have been achieved.

At this stage, the closure plan is conceptual and WMM has identified preliminary closure objectives and land uses (Attachment 4). Under Myanmar law, WMM is required to update the conceptual closure plan to a detailed plan within 3 years of physically commencing the Bawdwin project. Consultation will be carried out during that process to identify and agree suitable closure objectives, post-closure land uses and closure completion criteria.

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

Health impacts associated with dust emissions will be managed at major residual sources (e.g., TSF and Wallah waste rock dump) via capping. However, clean cap is unlikely to extend over the whole area where dust has been deposited given the significant volumes required.

6.11.4 Residual impact assessment

Despite the management measures that are to be implemented, there will be a number of impacts to community health. These impacts may be caused by a number of activities or effects as described in Section 6.11.2, which are often inter-related and can be cumulative.

This section assesses the potential impacts identified in Section 6.11.2 after implementation of the management measures outlined in Section 6.11.3. The magnitude of each residual impact is assessed based on the impact's geographic extent, severity and duration, taking into consideration the existing conditions of the features and their importance, vulnerability and resilience. Table 6.250 presents the criteria used to determine the magnitude of impact. The severity descriptors depend on the nature of the impact. For example, concentrations / levels of the hazard are only relevant to impacts arising from exposure to environmental hazards. An overall magnitude rating was produced based on subjective weighting of spatial extent, severity and duration.

Table 6.250 Criteria used to determine the magnitude of impacts related to exposure to hazardous materials

Factor	Magnitude Ratings				
	Very low	**Low**	**Medium**	**High**	**Very high**
Spatial extent	Local scale impacts that affect a small number of people (<5%) within the defined impact area	Mostly local scale impacts that affect some people (5 – 15%) within the defined impact area	Intermediate scale impacts that affect a notable proportion of people (15 – 50%) within the defined impact area	Far reaching impacts that affect the majority (i.e. 50 – 75%) of people within the defined impact area	Far reaching impacts that affect the almost all people (>75%) within the defined impact area
Severity	These health impacts impose limited costs on community. Impact will probably recover on its own or require minimal management. Hazardous material has very low or undetectable concentrations / levels of the hazard.[1]	Impact can be straightforwardly remedied or managed using standard management measures. Hazardous material has low concentrations / levels of the hazard.[1]	Health impacts impose moderate costs on community. Impact can be partly remedied or managed by implementing management measures. Concentrations will be readily detectable at levels posing an exceedance when combined with existing effects.[1]	High social disruption to affected community. Impact is very difficult to mitigate despite implementation of management measures. Elevated levels / concentrations above acceptable levels.[1]	Very high disruption to affected community. Impact cannot be avoided despite implementation of management measures. High elevated levels / concentrations well above acceptable levels.[1]
Duration	Impact is very short in duration (i.e., days). Exposure to hazardous material is very short in duration (i.e., less than 24 hours) and very infrequent.[2]	Impact is short term (i.e., months or less). Exposure to hazardous material is short term (i.e., less than 2 weeks).[2]	Impact is medium term (1 to 2 years). Exposure to hazardous material is medium term (i.e., less than 6 months).[2]	Impact is long term (3 to 15 years). Exposure to hazardous material is long term (i.e., 1 to 2 years) and is frequently occurring.[2]	Impact is greater than 15 years or permanent. Exposure to hazardous material and/or hazard is greater than 2 years and is either frequent or continuous during such time.[2]
Positive	Some limited value to the community.	Impacts some value to community.	Impacts can provide substantial social value to community.	Impacts can provide high value to communities.	Impacts can provide very high value to communities.

1. *Based on the level and toxicity of expected contaminant/hazard at the point of exposure*
2. *Very acute exposures: <24 hours, acute: 24hours – 2 weeks, sub-chronic: 2 weeks – 6 months, chronic < 6 months*

Receptor groups

The potential receptor groups have been identified based on their location within or in the vicinity of the Bawdwin concession area or their proximity to downstream waterways or proposed transport routes. The receptors relevant to the health impact assessment include:

- Villages in the Bawdwin concession area (Figure 6.20):
  - Bawdwin upper village.
  - Bawdwin lower village.
  - Bawdwin lower village farms.
  - Tiger Camp village.
  - Tiger Camp farms.
  - Nam La farms.
  - Loi Mi village and farms.
- Project workforce.
- Villages in tracts adjoining the Bawdwin concession area (Figure 6.21).
- Namtu Town (Figure 6.20 and 6.21).
- Residents of Nam Pangyun valley (Figure 6.20).
- Residents along the export route (road between Namtu and the intersection with National Highway 3 (Oriental highway) near Lashio) (Figure 6.22).

Table 6.85 provides a summary of the receptors, proposed resettlement and timing and concurrent project activities for the construction, operations, decommissioning and closure.

Exposure to environmental hazards

The key contaminants considered were lead and general dust of $PM_{2.5}$ and PM_{10} fractions, based on the number of baseline exceedances in various media and or locations, and their toxicity. The sensitive populations to these contaminants are young children and pregnant women due to known health effects on the developing foetus. Other environmental hazards include airborne particulate matter (i.e., dust).

Villages in the Bawdwin concession area

The villages within the Bawdwin concession area are currently located in areas where significant historical mining activities took place and hence they are currently exposed to elevated levels of contaminants in air, soil, drinking water sourced from groundwater and noise that exceed the adopted health screening levels. Resettlement of these communities will remove residents from their current exposure to elevated lead (and other metals).

As a result of the existing contamination, the sensitivity of these communities to changes in community health from exposure to environmental hazards is high for all residents living within the Bawdwin concession area, with the exception of Nam La farms and Loi Mi farms which are assessed as medium sensitivity due to the lesser extent of contamination of air, soil and water in these areas (see Section 5.9.10).

During project construction and operations the exposure of villages in the Bawdwin concession area to environmental hazards will temporarily increase as a result of project disturbance, emissions and discharges, prior to their resettlement. Inhalation, incidental ingestion and, to a lesser extent, dermal contact of contaminants (such as lead) in airborne particulate matter, water or soil will add additional exposures and will increase existing body burdens of lead. Any further exposures will increase the potential incidence of adverse health effects. WMM will implement a range of management measures to minimise emissions of dust and contaminated water and soil. Key measures include water carts for dust suppression, erosion and sediment controls such as sediment dams and capture and treatment of seepage from the TSFs and waste rock dump prior to discharge. In addition, WMM will implement a Health Awareness Program as part of the Community Health, Safety and Security Plan to education communities on how to identify signs and symptoms of lead poisoning, availability of appropriate medical resources, healthy diet to help decrease lead absorption (e.g., milk products, green leafy vegetables and calcium fortified foods), hygiene practices such as hand and face washing and protocols for eating.

Bawdwin upper village will be resettled approximately 7 to 9 months after commencement of construction and will be exposed to dust from construction of the process plant, power station, mine services area and haul road. These areas are largely outside the identified areas with existing elevated metals concentrations in soil from historic mining, except for the southern portion of the haul road as it approaches the existing open pit (Section 5.1.4). The key areas where project ground disturbance will encounter soils containing high metals concentrations are around the existing open pit and ER valley, the Tiger Tunnel area and Tiger Camp village. Wind data collected between January and May 2020 at Bawdwin showed prevailing regional winds to be south-southwesterly. This indicates that for at least some of the year, much of the dust generated during the project activities would be transported / deposited to uninhabited mountainous terrain areas north of the Bawdwin concession area. It should be noted that the wind trends described here are based on very limited data (single season only with no repeat data).

Prior to resettlement, the residual impact of temporarily increased exposure to environmental hazards from existing conditions on community health of Bawdwin upper village is rated of **high significance**, based on the **medium magnitude** of impact and the **high sensitivity** of this community to changes in health (Table 6.251).

The residual impact of reduced exposure to environmental hazards on community health of Bawdwin upper village following resettlement is rated of **positive (major) significance**, based on the **positive (high) magnitude** of impact and the **high sensitivity** of this community to changes in health (Table 6.251).

Table 6.251 Residual impact significance summary – construction and operations phases – exposure to environmental hazards - affecting Bawdwin upper village

Value	**Sensitivity of value**			
Bawdwin upper village – community health	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Health is highly valued by the community	**High** Highly vulnerable, due to the existing exposure to environmental hazards from historical mining (soil, dust, water and food), the community's proximity to the project, use of groundwater fed springs for drinking water and presence of sensitive receptors (children or women of childbearing age).	**Low** The key contaminants of concern (lead, $PM_{2.5}$ and PM_{10}) have a cumulative effect. Existing exposures are assumed to be high based on baseline environmental results. Communities have low resilience to changes with limited capacity and/or resources to absorb, adapt to, and recover from changes to the value or health effects.	**High**
Impact	**Magnitude of impact**			
Bawdwin upper village exposure to environmental hazards (contaminated dust and water) as a result of the project	**Prior to resettlement**			
	Spatial extent	***Severity***	***Duration***	***Magnitude***
	Very High Almost all people (>75%) within Bawdwin upper village are expected to be impacted given the proximity to dust generating activities (construction of haul road, mine services area, process plant and power station)	**Medium** Residents are in close proximity to dust generating activities (within 500 m of the haul road and 1 km of the process plant and power station). Inhalation of very fine airborne particulate matter has the potential to cause adverse health impacts in susceptible people.	**Medium** Exposure to environmental hazards is medium term (7 to 9 months) during construction and prior to resettlement	**Medium**
			Residual impact significance	**High**
	Following resettlement			
	Spatial extent	***Severity***	***Duration***	***Magnitude***
	Very High All residents of Bawdwin upper village are proposed to be resettled	**High** Reduced exposure to environmental hazards can provide substantial social value to community	**Very High** Reduced exposure to environmental hazards will be for greater than 2 years and is continuous during such time	**Positive (high)**
	Residual impact significance			**Positive (major)**
	Assessment of uncertainty			
	High There is an absence of air quality modelling and limited meteorological baseline. The resettlement sites have not yet been selected. However, one of the requirements of the site is that they are safe for habitation and will not have harmful levels of contamination.			

Bawdwin lower village is located in proximity to the open pit and haul road and will be resettled 30 to 32 months after the commencement of mining operations. Pre-stripping of the open pit and construction of the haul road will result in a temporary increase in emissions of dust with potentially elevated metals concentrations. During mining operations, it is expected that Bawdwin lower village will be exposed to highly elevated dust emissions from open pit mining and haulage.

Prior to resettlement during the operations phase, the residual impact of temporarily increased exposure to environmental hazards from existing conditions on community health of Bawdwin lower village is rated of **major significance**, based on the **very high magnitude** of impact and the **high sensitivity** of this community to changes in health (Table 6.252).

Following resettlement, the residual impact of reduced exposure to environmental hazards on community health of Bawdwin lower village is rated of **positive (major) significance**, based on the **positive (high) impact magnitude** and the **high sensitivity** of this community to changes in health (Table 6.252).

Table 6.252 Residual impact significance summary – construction and operations phases – exposure to environmental hazards – affecting Bawdwin lower village

Value	Sensitivity of value			
Bawdwin lower village – community health	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Health is highly valued by the community	**High** Highly vulnerable, due to the existing exposure to environmental hazards from historical mining (soil, dust, water and food), the community's proximity to the project, use of groundwater fed springs for drinking water and presence of sensitive receptors (children or women of childbearing age).	**Low** The key contaminants of concern (lead, $PM_{2.5}$ and PM_{10}) have a cumulative effect. Existing exposures are assumed to be high based on baseline environmental results. Communities have low resilience to changes with limited capacity and/or resources to absorb, adapt to, and recover from changes to the value or health effects.	**High**
Impact	**Magnitude of impact (prior to resettlement)**			
Bawdwin lower village exposure to environmental hazards (contaminated dust and water) as a result of the project	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Prior to resettlement			
	Very High Almost all people (>75%) within Bawdwin lower village are expected to be impacted due to the proximity to sources of contaminants, including dust generating sources (<100 m from the open pit), and use of groundwater and surface water resources	**High** Residents are in close proximity (<100 m) to the open pit and haul road. Inhalation, incidental ingestion or dermal contact of contaminants (such as lead) in airborne particulate matter, water or soil will add additional exposures and increase the existing body burdens of lead.	**Very High** Exposure to environmental hazards is greater than 2 years and is frequent during such time	**Very High**
	Residual impact significance			**Major**
	Following resettlement			
	Very High All residents of within Bawdwin lower village are proposed to be resettled	**Medium** Resettlement will avoid the existing environmental exposures resulting from historic mining activities	**Very High** Reduced exposure to environmental hazards will be for greater than 2 years and is continuous during such time	**Positive (high)**
	Residual impact significance			**Positive (major)**
	Assessment of uncertainty			
	High There is an absence of air quality modelling and limited meteorological baseline. The resettlement sites have not yet been selected. However, one of the requirements of the site is that they are safe for habitation and will not have harmful levels of contamination.			

Tiger Camp village is located in proximity to a temporary access road connecting to the Namtu-Tiger Camp access road, and Wallah waste rock dump. Some existing contamination may be present along the access road due to the proximity to areas of high existing contamination (i.e., Tiger Tunnel portal and Tiger Camp village) and use of the existing railway corridor during historic mining activities. Two samples from this area (approximately 800 m east of Tiger Camp village along the access road) returned concentrations of lead above the adopted health screening criteria (300 mg/kg) (NEPM, 2013) (Section 5.1.4). Other contaminants including zinc, copper, nickel and arsenic were found to be below the adopted screening criteria (NEPM, 2013) within the sampled soils. However, the majority of the Namtu-Tiger Camp access road has not been sampled for soils and therefore predicted metals concentrations in dust emissions are not known. Construction of the sections of the Namtu-Tiger Camp access road in proximity to the village may result in a temporary increase in emissions of dust with potentially elevated metals concentrations and run off from construction sites containing elevated suspended sediments. Residents of Tiger Camp village will be resettled prior to construction of the Wallah waste rock dump sediment dams and deposition of waste rock to the dump.

Prior to resettlement during the construction phase, the residual impact of temporarily increased exposure to environmental hazards from existing conditions on community health of Tiger Camp village is rated of **high significance**, based on the **medium impact magnitude** and the **high sensitivity** of this community to changes in health (Table 6.253).

Following resettlement, the residual impact of reduced exposure environmental hazards on community health of Tiger Camp village is rated of **positive (major) significance**, based on the **positive (high) impact magnitude** and the **high sensitivity** of this community to changes in health (Table 6.253).

Table 6.253 Residual impact significance summary – construction phase – exposure to environmental hazards – affecting Tiger Camp village

Value	**Sensitivity of value**			
Tiger Camp village – community health	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Health is highly valued by the community	**High** Highly vulnerable, due to the existing exposure to environmental hazards from historical mining (soil, dust, water and food), the community's proximity to the project, being located in a valley with minimal dispersal of particulates, dust and noise, use of groundwater fed springs for drinking water and presence of sensitive receptors (children or women of childbearing age).	**Low** The key contaminants of concern (lead, $PM_{2.5}$ and PM_{10}) have a cumulative effect. Existing exposures are assumed to be high based on baseline environmental results. Communities have low resilience to changes with limited capacity and/or resources to absorb, adapt to, and recover from changes to the value or health effects.	**High**
Impact	**Magnitude of impact (prior to resettlement)**			
Tiger Camp village exposure to environmental hazards (contaminated dust and water) as a result of the project	**Spatial extent**	**Severity**	**Duration**	**Magnitude**
	Prior to resettlement			
	High Majority of people (50 to 75%) within Tiger Camp village are expected to be impacted due to the proximity to sources of contaminants, including dust generating sources (construction of a temporary access road), and use of groundwater and surface water resources	**Medium** Residents are adjacent to a temporary access road connecting to the Namtu-Tiger Camp access road. Inhalation of very fine airborne particulate matter from access road construction has the potential to cause adverse health impacts in susceptible people. Existing metals concentrations in soil along the existing railway corridor are not expected to be high.	**Medium** Exposure to environmental hazards is medium term (i.e., less than 6 months during construction of the access road)	**Medium**
	Residual impact significance			**High**
	Following resettlement			
	Very High All residents of within this subgroup are proposed to be resettled	**Medium** Resettlement will avoid the existing environmental exposures resulting from historic mining activities	**Very High** Reduced exposure to environmental hazards will be for greater than 2 years and is continuous during such time	**Positive (high)**
	Residual impact significance			**Positive (major)**
	Assessment of uncertainty			
	High There is an absence of air quality modelling and limited meteorological baseline. The resettlement sites have not yet been selected. However, one of the requirements of the site is that they are safe for habitation and will not have harmful levels of contamination.			

The Bawdwin lower village farms are likely to experience lesser dust impacts as they are about 2 km from the open pit and are outside the recommended separation distance of 500 m.

Prior to resettlement during the construction phase, the residual impact of temporarily increased exposure to environmental hazards from existing conditions on community health of Bawdwin lower village farms is rated of **moderate significance**, based on the **low impact magnitude** and the **high sensitivity** of this community to changes in health (Table 6.254).

Following resettlement, the residual impact of reduced exposure to environmental hazards on community health of Bawdwin lower village farms is rated of **positive (high) significance**, based on the **positive (medium) impact magnitude** and the **high sensitivity** of this community to changes in health (Table 6.254).

Table 6.254 Residual impact significance summary – construction phase –exposure to environmental hazards – affecting Bawdwin lower village farms

Value	**Sensitivity of value**			
Bawdwin lower village farms – community health	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Health is highly valued by the community	**High** Due to some areas being likely to be contaminated from historical mining (soil, dust, water) to a lesser degree than Bawdwin villages, the farms use of groundwater fed springs for drinking water and presence of sensitive receptors (children or women of childbearing age).	**Low** The key contaminants of concern (lead, $PM_{2.5}$ and PM_{10}) have a cumulative effect and are not readily eliminated from the body following chronic exposure periods. Current levels of exposure are likely to be less than Bawdwin villages due to separation from current mine footprint. Community health strongly reliant on facilities/services at Bawdwin.	**High**
Impact	**Magnitude of impact (prior to resettlement)**			
Bawdwin lower village farms exposure to environmental hazards (contaminated dust and water) as a result of the project	**Spatial extent**	**Severity**	**Duration**	**Magnitude**
	Prior to resettlement			
	Very Low Impacts are expected to affect a very small proportion of the receptor given most of the individual residences will be over 2 km from access roads and open pit. It is assumed residents use groundwater fed springs for drinking water.	**Low** Residents are at a distance from the Namtu-Tiger Camp access road and open pit (over 2 km). Inhalation, incidental ingestion or dermal contact of contaminants (such as lead) in airborne particulate matter, water or soil will add additional exposures and increase the existing body burdens of lead.	**Very High** Exposure to environmental hazards is greater than 2 years and is frequent (e.g. dust emissions) during such time	**Low**
	Residual impact significance			**Moderate**
	Following resettlement			
	Very High All residents within this subgroup are proposed to be resettled	**Low** Resettlement will avoid the existing environmental exposures resulting from historic mining activities	**Very High** Reduced exposure to environmental hazards will be for greater than 2 years and continuous during this time	**Positive (medium)**
	Residual impact significance			**Positive (high)**
	Assessment of uncertainty			
	High There is an absence of air quality modelling and limited baseline data collection for this receptor. The resettlement sites have not yet been selected. However, one of the requirements of the site is that they are safe for habitation and will not have harmful levels of contamination.			

Tiger Camp farms are likely to experience high levels of particulate matter from construction of the Namtu-Tiger Camp access road and plant road and construction of the Wallah waste rock dump sediment dams. Farms immediately along the plant access road will be resettled prior to road construction and will therefore not be impacted by construction activities. The remaining farms will be resettled during the operations phase (29 to 32 months after operations commence).

Prior to resettlement during the operations phase, the residual impact of temporarily increased exposure to environmental hazards from existing conditions on community health of Tiger Camp farms is rated of **high significance**, based on the **medium impact magnitude** and the **high sensitivity** of this community to changes in health (Table 6.255).

Following resettlement, the residual impact of reduced exposure to environmental hazards on community health of Tiger Camp farms is rated of **positive (medium) significance**, based on the **positive (high) impact magnitude** and the **high sensitivity** of this community to changes in health (Table 6.255).

Table 6.255 Residual impact significance summary – construction and operations phases – exposure to environmental hazards – affecting Tiger Camp farms (not located along plant access road)

Value	**Sensitivity of value**			
Tiger Camp farms (not located along plant access road) – community health	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Health is highly valued by the community	**High** Due to some areas being likely to be contaminated from historical mining (soil, dust, water) to a lesser degree than Tiger Camp village, their proximity to the project, use of groundwater fed springs for drinking water and presence of sensitive receptors (children or women of childbearing age).	**Low** The key contaminants of concern (lead, $PM_{2.5}$ and PM_{10}) have a cumulative effect and are not readily eliminated from the body following chronic exposure periods. Communities have low resilience to changes with limited capacity and/or resources to absorb, adapt to, and recover from changes to the value or health effects.	**High**
Impact	**Magnitude of impact (prior to resettlement)**			
Tiger Camp farms (not located along plant access road) exposure to environmenta l hazards (contaminated dust and water) as a result of the project	**Spatial extent**	**Severity**	**Duration**	**Magnitude**
	Prior to resettlement			
	High Impact is expected to affect a high proportion of the receptor, taking into account the proximity to sources of contaminants (several farms are within 500 m of the Namtu-Tiger Camp access road, plant access road or waste rock dump and sediment dams) and use of groundwater and surface water resources	**Low** Residents are at a distance from dust generating construction activities. The nearest farms to the Wallah waste rock dump sediment dams that are not being resettled prior to access road construction are approximately 1 km from the sediment dams. Inhalation, incidental ingestion or dermal contact of contaminants (such as lead) in airborne particulate matter, water or soil will add additional exposures and increase the existing body burdens of lead.	**Medium** Exposure to environmental hazards (dust potentially containing elevated metals) is medium term during construction of Wallah waste rock dump sediment dams (approximately 6 months) and construction of the access roads and is frequent (e.g., dust emissions) during such time.	**Medium**
	Residual impact significance			**High**
	Following resettlement			
	Very High All residents of Tiger Camp are proposed to be resettled	**Low** Resettlement will avoid the existing environmental exposures resulting from historic mining activities	**Very High** Reduced exposure to environmental hazards will be long term	**Positive (medium)**
	Residual impact significance			**Positive (high)**
	Assessment of uncertainty			
	High There is an absence of air quality modelling and limited baseline data collection for this receptor. The resettlement sites have not yet been selected. However, one of the requirements of the site is that they are safe for habitation and will not have harmful levels of contamination.			

Nam La farms will be exposed to particulate matter during construction of the northern access road, from site earthworks at the process plant and power station. Soil testing results indicated concentrations of metals (lead, arsenic and zinc) were largely below adopted health screening criteria (NEPM, 2013) in these areas, with the exception of four samples which returned exceedances of adopted lead criteria (Section 5.1.4)

This receptor will be resettled 7 to 9 months after commencement of construction and will therefore not experience increased exposures during operations.

Prior to resettlement during the construction phase, the residual impact of temporarily increased exposure to environmental hazards from existing conditions on community health of Nam La farms is rated of **moderate significance**, based on the **medium impact magnitude** and the **medium sensitivity** of this community to changes in health (Table 6.256).

If Nam La farms are resettled, the residual impact of reduced exposure to environmental hazards on community health of Nam La farms is rated of **positive (high) significance**, based on the **positive (medium) impact magnitude** and the **medium sensitivity** of this community to changes in health (Table 6.256).

Table 6.256 Residual impact significance summary – construction phase – exposure to environmental hazards – affecting Nam La farms

Value	**Sensitivity of value**			
Nam La farms – community health	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Health is highly valued by the community	**Medium** There may be some contamination of air, soil, water, however, though to a lesser degree than villages closer to historic mining operations. The community health of the farms may be vulnerable due to some existing contamination, the farms proximity to the project, use of groundwater fed springs for drinking water and presence of sensitive receptors (children or women of childbearing age)	**Medium** The key contaminants of concern (lead, $PM_{2.5}$ and PM_{10}) have a cumulative effect. Existing exposures are assumed to be moderate based on baseline environmental results. Communities have low resilience to changes with limited capacity and/or resources to absorb, adapt to, and recover from changes to the value or health effects.	**Medium**
Impact	**Magnitude of impact**			
Nam La farms exposure to environmental hazards (contaminated dust and water) as a result of the project	**Spatial extent**	**Severity**	**Duration**	**Magnitude**
	Prior to resettlement			
	Medium Impact will affect a moderate proportion of the receptor (those individual residences near the northern access road and Nam La water harvesting facility), and use of groundwater and surface water resources	**Medium** Residents are adjacent to sections of the northern access road (<100 m) and some farms around 500 m from the power plant or Nam La water harvesting facility. Whilst metals concentrations in soils in the area were largely below adopted health screening criteria, inhalation, incidental ingestion or dermal contact of contaminants (such as lead) in airborne particulate matter, water or soil will add additional exposures and may increase the existing body burdens of lead.	**Medium** Exposure to environmental hazards is medium term (7 to 9 months) during construction and prior to resettlement.	**Medium**
	Residual impact significance			**Moderate**
	Following resettlement			
	Very High All residents within this subgroup are proposed to be resettled	**Low** Resettlement will avoid the existing environmental exposures resulting from historic mining activities	**Very High** Reduced exposure to environmental hazards will be long term	**Positive (medium)**
	Residual impact significance			**Positive (high)**
	Assessment of uncertainty			
	High There is an absence of air quality modelling and limited baseline data collection for this receptor. The resettlement sites have not yet been selected. However, one of the requirements of the site is that they are safe for habitation and will not have harmful levels of contamination.			

Loi Mi village and associated farms will be exposed to particulate matter during construction and operation of the TSFs, as well as blasting, mining and haulage. This receptor may be resettled. However this will depend on the outcomes of engagement and further investigation of environmental impacts.

If Loi Mi village and associated farms are not resettled, the residual impact of temporarily increased exposure to environmental hazards from existing conditions during the construction and operations phases on community health is rated of **low significance**, based on the **low impact magnitude** and the **medium sensitivity** of this community to changes in health (Table 6.257).

If Loi Mi village and associated farms are resettled, the residual impact of reduced exposure to environmental hazards on community health is rated of **positive (moderate) significance**, based on the **positive (medium) impact magnitude** and the **medium sensitivity** of this community to changes in health (Table 6.257).

Table 6.257 Residual impact significance summary – construction and operations phases – exposure to environmental hazards – affecting Loi Mi farms

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Loi Mi farms – community health</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>High
Health is highly valued by the community</td><td>Medium
There may be some contamination of air, soil, water, though to a lesser degree than villages closer to historic mining operations. The community health of the farms may be vulnerable due to some existing contamination, their proximity to the project, use of groundwater fed springs for drinking water and presence of sensitive receptors (children or women of childbearing age).</td><td>Medium
The key contaminants of concern (lead, $PM_{2.5}$ and PM_{10}) have a cumulative effect. Existing exposures are assumed to be moderate based on baseline environmental results.
Communities have low resilience to changes with limited capacity and/or resources to absorb, adapt to, and recover from changes to the value or health effects.</td><td>Medium</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact</th></tr>
<tr><td rowspan="10">Loi Mi exposure to environmental hazards (contaminated dust and water) as a result of the project</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td colspan="4">IF NOT RESETTLED</td></tr>
<tr><td>Low
Impact is expected to affect a small proportion of this receptor (those farms and residents within the Bawdwin concession area), given the proximity to contaminants, including dust generating sources (i.e., TSF-B).</td><td>Low
The closest project dust source is the TSF B embankment about 500 m away from individual Loi Mi farms. However, most farms are further than 500 m away. Inhalation, incidental ingestion or dermal contact of contaminants (such as lead) in airborne particulate matter, water or soil will add additional exposures and increase the existing body burdens of lead.</td><td>High
Exposure to environmental hazards is medium term during TSF-B embankment construction.</td><td>Low</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Low</td></tr>
<tr><td colspan="4">IF RESETTLED (those receptors within the concession)</td></tr>
<tr><td>Very High
If resettled, all affected residents of within this subgroup will be resettled</td><td>Low
Resettlement will avoid the existing environmental exposures resulting from historic mining activities</td><td>Very High
Reduced exposure to environmental hazards will be for greater than 2 years and is continuous during such time</td><td>Positive (medium)</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>Positive (moderate)</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">High
There is an absence of air quality modelling and limited baseline data collection for this receptor.
The resettlement sites have not yet been selected. However, one of the requirements of the site is that they are safe for habitation and will not have harmful levels of contamination.</td></tr>
</table>

During construction, the Bawdwin military base will experience dust emissions from construction of the process plant, power station, haul road and TSF embankments. During operations, the military base will experience reduced air quality due to gaseous pollutants during operation of the power station. This receptor will not be resettled as part of the project and may remain throughout operations. If it remains in its current location, the significance of increased dust and gaseous pollutants to the military base during construction and operations is considered to be of **major significance,** based on the **high magnitude** of impact and the **high sensitivity** of this community to changes in health (Table 6.258).

Table 6.258 Residual impact significance summary – construction and operations phases – exposure to environmental hazards – affecting Bawdwin military base

Value	**Sensitivity of value**			
Military base – health	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Health is highly valued by people residing within the military base	**High** Due to the existing exposure to environmental hazards and their proximity to the project.	**Low** The key contaminants of concern (lead, $PM_{2.5}$ and PM_{10}) have a cumulative effect. Existing exposures are assumed to be high based on baseline environmental results.	**High**
Impact	**Magnitude of impact**			
Military base exposure to environmental hazards (contaminated dust and water) as a result of the project	**Spatial extent**	**Severity**	**Duration**	**Magnitude**
	Very high Impact is expected to affect the entire receptor given the proximity to the dust generating activities and the power plant (approximately 400 m).	**High** There is predicted to be a notable increase in dust given the receptor's proximity to a range of construction activities (approximately 400 m of the power station and process plant), which are likely to result in a cumulative contribution of dust. Inhalation, incidental ingestion or dermal contact of contaminants (such as lead) in airborne particulate matter, water or soil will add additional exposures and increase the existing body burdens of lead.	**Very high** Exposure to environmental hazards (hazardous materials) is greater than 2 years	**High**
	Residual impact significance			**Major**
	Assessment of uncertainty			
	High There is an absence of air quality modelling and limited baseline data collection for this receptor. The source of drinking water for the military base is not known.			

Project workforce

An accommodation camp for approximately 1,400 people will be used during construction and operation of the project. It is expected that the local workforce will reside in their homes and be transported to site daily. As such, the project workforce will be exposed to the existing contamination at Bawdwin mine and project-induced exposures from disturbance, emissions and discharges.

As mentioned in the previous section, WMM will implement a range of management measures to minimise emissions of dust and contaminated water and soil. In addition, WMM will develop and implement an Occupational Safety and Health Management Plan and Lead Management Plan which will include strategies to manage blood lead levels in the project workforce, including providing washing facilities for contaminated clothes, segregating 'clean' and 'dirty' areas and eating areas, education awareness on good hygiene, monitoring personal exposures and blood lead level testing.

The residual impact of increased exposure to environmental hazards during the construction and operations phases on occupational health of the project workforce is rated of **high significance**, based on the **medium impact magnitude** and **high sensitivity** of this receptor to changes in health (Table 6.259).

Table 6.259 Residual impact significance summary – construction and operations phases – exposure to environmental hazards – affecting project workforce

Value	**Sensitivity of value**			
Project workforce –occupational health	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Health is highly valued by the project workforce and it is important that WMM provide and maintain a health and safe workplace.	**High** Blood lead concentration testing indicated all permanent Bawdwin workers and 48% of contractors working at Bawdwin who were tested in 2020 had elevated blood lead levels. The existing conditions/health levels of the future workforce are unknown at this stage.	**Medium** The key contaminants of concern (lead, $PM_{2.5}$ and PM_{10}) have a cumulative effect. Workers have some capacity and/or resources to absorb, adapt to, and recover from changes to the value or health effects (i.e. WMM operated health facilities).	**High**
Impact	**Magnitude of impact**			
Project workforce exposure to environmental hazards (contaminated dust and water) as a result of the project	**Spatial extent**	**Severity**	**Duration**	**Magnitude**
	Very high Impact is expected to affect the entire receptor given the proximity to the dust generating activities and the power plant. Personnel with primarily indoor roles may be less affected than those who are outdoors during their shift.	**Low** The workforce will be introduced to exposure pathways to environmental hazards, however with the application of the project's Occupational, Safety and Health Management and the Lead Management plans these impacts are predicted to be manageable.	**Very high** Exposure to environmental hazards (hazardous materials) is greater than 2 years	**Medium**
	Residual impact significance			**High**
	Assessment of uncertainty			
	Medium Other modern mining operations have successfully applied similar management and mitigation measures to occupational health exposures associated with lead mining.			

Surrounding villages

The sensitivity of communities located in the regional area surrounding the Bawdwin concession area varies depending on their location in relation to the historical mining activities, proximity to the Namtu-Manton Road, the prevailing wind direction, use of downstream waterways for drinking water and food, and reliance on groundwater fed springs.

Periods of increased dust emissions are expected during construction of TSF embankment, Nam La water harvesting facility and other infrastructure components such as plant road, haul road and access roads. Similar impacts (nature and scale) are expected during decommissioning and active closure works. The primary exposure pathway identified for communities in tracts adjoining the Bawdwin concession area is inhalation of airborne particulate matter.

The residual impact of increased dust emissions during all phases on community health of villages and hamlets in tracts adjoining the Bawdwin concession area is rated of **low significance**, based on the **low impact magnitude** and the **medium sensitivity** of this community to changes in health (Table 6.260).

Table 6.260 Impact significance summary – all phases – exposure to environmental hazards - affecting villages and hamlets in tracts adjoining the Bawdwin concession area

Value	Sensitivity of value			
Villages and hamlets in tracts adjoining the Bawdwin concession area – community health	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Health is highly valued by the community	**Medium** Vulnerability of villages and hamlets in tracts adjoining the Bawdwin concession area is considered moderate. The influence of historic contamination from the site is expected to be low.	**Medium** The key contaminants of concern (lead, $PM_{2.5}$ and PM_{10}) have a cumulative effect. Existing exposures are assumed to be low based on distance from historic operations. Communities have low resilience to changes with limited capacity and/or resources to absorb, adapt to, and recover from changes to the value or health effects.	**Medium**
Impact	**Magnitude of impact**			
Villages and hamlets in tracts adjoining Bawdwin exposure to environmental hazards (contaminated dust and water) as a result of the project	**Spatial extent**	**Severity**	**Duration**	**Magnitude**
	Low The impact is limited to those who use surface water resources in proximity to or downstream of the project, groundwater resources in the impacted catchments or those in proximity to dust generating sources (probably only Ho Chet village)	**Low** Periods of increased dust emissions during construction of the TSF embankment, Nam La water harvesting facility and other infrastructure components may result in inhalation of airborne fine particulate matter.	**Very High** Exposure to environmental hazards is greater than 2 years and is frequent (e.g., dust emissions) during such time	**Low**
	Residual impact significance			**Low**
	Assessment of uncertainty			
	High There is an absence of air quality modelling, limited meteorological baseline, and limited baseline data collection for this group.			

Namtu

Namtu wards and villages evaluated in the baseline health assessment were generally observed to have potentially high exposures to gases, metals (particularly lead), fine particulate matter and noise. Minor changes to the current conditions in Namtu are expected due to the distance from project construction and decommissioning activities. The primary source of exposure related to the project for these communities is vehicle transport during construction of the Namtu-Tiger Camp access road and ongoing use as a transport corridor during operations.

Contamination of groundwater in the saprolite and fractured rock aquifers due to seepage from the TSFs has the potential to discharge to Nam La, which is a major source of drinking water for the township of Namtu downstream. WMM will implement an underdrainage system to capture seepage, however some seepage into the underlying aquifer is expected to occur and may result in discharges to the Nam La catchment. The impacts to the aquifers are discussed further in Section 6.4.4. Construction of the Nam La raw water harvesting facility and earthworks associated with the processing plant site are expected to result in some minor and temporary increases in sediment reporting to the Nam La. After closure, runoff from the capped TSF A will be released to the Nam La via a spillway. Geochemical modelling has not been completed and the quality of water released via the spillway has not been predicted, but may include concentrations of sediment and metals above background conditions in the Nam La. Further modelling work of potential impacts to the Nam La will be undertaken to address uncertainty on downstream water quality see Section 6.4.6. See Table 6.16 for further assessment on potential water quality impacts to Nam La drinking water source for Namtu wards and villages as a result of the project.

The residual impact of increased exposure to environmental hazards during all phases on community health of Namtu wards and villages is rated of **moderate significance**, based on the **low impact magnitude** and the **high sensitivity** of this community to changes in health (Table 6.261).

Table 6.261 Residual impact significance summary – all phases – exposure to environmental hazards – affecting Namtu

Value	**Sensitivity of value**			
Namtu villages and wards – community health	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Health is highly valued by the community	**High** Potentially high existing exposures to gases, metals (particularly lead), fine particulate matter and noise, reliance on the Nam La for drinking water which may be impacted by the project and presence of sensitive receptors (children or women of childbearing age).	**Low** The key contaminants of concern (lead, $PM_{2.5}$ and PM_{10}) have a cumulative effect. Existing exposures are assumed to be high based on baseline environmental results. Communities have low resilience to changes with limited capacity and/or resources to absorb, adapt to, and recover from changes to the value or health effects.	**High**
Impact	**Magnitude of impact**			
Namtu wards and villages exposure to environmental hazards (contaminated dust and water) as a result of the project	**Spatial extent**	**Severity**	**Duration**	**Magnitude**
	Very Low Local scale impacts that effect some people (<5%) within Namtu living along the project vehicle transport route	**Low** An increase in emissions of particulate matter (potentially with elevated metals) from construction and operation of the Namtu-Tiger Camp access road. Incidental ingestion or dermal contact with dust, water or dust deposited in soil.	**Very High** Exposure to environmental hazards is greater than 2 years and is frequent during such time. Peak periods and traffic volumes across the construction and operations phases will be variable.	**Low**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	Medium There is an absence of air quality modelling and limited meteorological baseline.			

Nam Pangyun valley

The mid and lower catchments of the Nam Pangyun are considered to be highly degraded at the present time. The artisanal miners operating in this valley are likely to have been historically exposed to metal and particulate contaminants due to their location and frequent use of the lower Nam Pangyun for mining and possibly other uses.

The baseline soil investigation analysed soil samples from a small portion (approximately 800 m) of the existing railway corridor closest to Tiger Camp village (Section 5.1.4). Two samples from this area returned concentrations of lead above the adopted health screening criteria (300 mg/kg). The Namtu - Tiger Camp access road has not been sampled and therefore soil quality and predicted metals concentration of dust emissions is not known. Some existing contamination may be present as a result of use of the existing railway corridor during historic mining activities, however the extent is expected to be limited given the increasing distance from the areas of high existing contamination at Tiger Tunnel portal and Tiger Camp village. Construction of the Namtu-Tiger Camp access road will result in a temporary increase in emissions of dust and run off from construction sites containing elevated suspended sediments. Exposure to fine particulate matter and gaseous emissions from project vehicles will be ongoing during operations.

Groundwater in the Nam Pangyun catchment may be impacted by seepage from the TSF complex (discussed further in Section 6.4.4). Seepage beneath the TSFs will be collected by an underdrainage system, however some seepage to the surrounding groundwater may still occur, adversely impacting groundwater quality, resulting in increased concentrations of dissolved and total metals, sulphate and cyanide. Modelling is required to confirm the degree of impact to water quality expected as a result of seepage from the TSF and Wallah waste rock dump (see Section 6.3 and Section 6.4).

The residual impact of increased exposure to environmental hazards during all phases from existing conditions on community health of residents of the Nam Pangyun valley is rated of **high significance**, based on the **medium impact magnitude** and the **high sensitivity** of this community to changes in health (Table 6.262).

Table 6.262 Residual impact significance summary – all phases – exposure to environmental hazards – affecting Nam Pangyun valley farms and artisanal miners

<table>
<tr><th>Value</th><th colspan="4">Sensitivity of value</th></tr>
<tr><td rowspan="2">Residents of the Nam Pangyun valley – community health</td><td>Importance</td><td>Vulnerability</td><td>Resilience</td><td>Sensitivity</td></tr>
<tr><td>High
Health is highly valued by the community</td><td>High
Due to some areas being in proximity to expected contamination in the Nam Pangyun riverbed from historical mining, and uncertainty regarding current source of drinking water.</td><td>Medium
The key contaminants of concern (lead, $PM_{2.5}$ and PM_{10}) have a cumulative effect. Existing exposures are assumed to be high based on baseline environmental results.
The artisanal mining community is transient and has some resilience to change due to this. However, in general the community is assessed to have low resilience to changes with limited capacity and/or resources to absorb, adapt to, and recover from changes to the value or health effects.</td><td>High</td></tr>
<tr><th>Impact</th><th colspan="4">Magnitude of impact</th></tr>
<tr><td rowspan="6">Residents of Nam Pangyun valley exposure to environmental hazards (contaminated dust and water) as a result of the project</td><td>Spatial extent</td><td>Severity</td><td>Duration</td><td>Magnitude</td></tr>
<tr><td>Medium
Impact will affect a moderate proportion of the receptor (i.e., those individual receptors adjacent to the road).</td><td>Low to Medium
An increase in emissions of dust is predicted from construction of the Namtu-Tiger Camp access road (medium severity), and then ongoing exposure of fine particulate matter and gaseous emissions from project vehicles during operations (low severity). Several residences are located <200 m from the access road.
Inhalation of very fine airborne particulate matter has the potential to cause adverse health impacts in susceptible people.</td><td>Medium to Very High
Exposure to increased dust is medium term (i.e., approximately 7 months) during construction of the Namtu-Tiger Camp access road and is frequent during such time.
Exposure to exhaust emissions is long term during operations (i.e., greater than two years) and is frequent during such time. Peak periods and traffic volumes across the construction and operations phases will be variable.</td><td>Medium</td></tr>
<tr><td colspan="3">Residual impact significance</td><td>High</td></tr>
<tr><td colspan="4">Assessment of uncertainty</td></tr>
<tr><td colspan="4">High
There is an absence of air quality modelling and baseline data collection for this group.
There is limited baseline stream flow data and lack of quantitative predictions of downstream water quality chemistry. To reduce uncertainty and allow for understanding of changes to water quality in relation to existing concentrations in ambient waters and international water quality guidelines, geochemical modelling of runoff contaminant concentrations and predicted changes to water quality will be necessary.</td></tr>
</table>

Export corridor

The residents located along the proposed export transport corridor beyond Namtu are considered to have existing exposures commensurate with living near a major road with elevated levels of particulates, dust, gases and noise. The residents will experience increased gaseous emissions from project vehicles during construction and operation of the project. During the peak export traffic period, up to threefold increase in truck numbers is predicted on sections of the export corridor roads. The road is sealed and will not be a source of wheel generated dust. Furthermore, vehicles used to export concentrate will be enclosed and are not expected to be a source of dust with elevated concentration of lead. The residual impact of increased gaseous emissions during the construction and operations phases on community health of villages along the export corridor between Namtu and Highway 3 is rated of **moderate significance**, based on the **medium impact magnitude** and the **medium sensitivity** of this community to changes in health (Table 6.263).

Table 6.263 Residual impact significance summary – construction and operations phases – exposure to environmental hazards – villages along the export route

Value	**Sensitivity of value**			
Villages along the export route – community health	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Health is highly valued by the community	**Medium** Existing exposures commensurate with living near a major road with elevated levels of particulates, dust, gases and noise, and presence of sensitive receptors (children or women of childbearing age). The vulnerability to change is assessed to be moderate.	**Medium** The key contaminants of concern (lead, $PM_{2.5}$ and PM_{10}) have a cumulative effect. Existing exposures to lead are assumed to be low based on distance from historic operations. However exposures relating to road use are expected to be high. Communities have low resilience to changes with limited capacity and/or resources to absorb, adapt to, and recover from changes to the value or health effects.	**Medium**
Impact	**Magnitude of impact**			
Villages along the export route exposure to particulates, dust, gas and noise) and noise as a result of the project	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Low Impacts would probably only be noticed by receptors in close proximity to the road. Some receptors will be affected more-so than others depending on proximity to the road.	**Low** Exhaust emissions increases are unlikely to exceed emission criteria, or cause exceedance of air quality criteria. Inhalation of gases associated with vehicles.	**Very High** Exposure to environmental hazards is greater than 2 years and is frequent during such time. Peak periods and traffic volumes across the construction and operations phases will be variable.	**Low**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	High There is an absence of baseline data and modelling. Gaseous emissions from project vehicles in comparison to background levels, and overall cumulative impact, have not been quantified by modelling.			

Occupational and community safety

Several mining industrial hazards and risks are related to the design or operation of the Project. These include events which may be induced by extreme natural events. Earthquakes or extreme rainfall events with magnitudes above design allowances have the potential to result in failure of the TSFs, Wallah waste rock dump, water storage dams and pit wall. Pipeline breaks, chemical spills or leaks, fire and explosion, electrical failures or buildings failures may result from degradation, malfunction, operator error, accidental or deliberate interference, landslides or earthquakes. These unplanned events have the potential to impact occupational and community health and safety through injuries or fatalities, or contamination of drinking water supplies.

The sudden influx of cash from direct or indirect employment associated with the project (usually predominantly of men) can result in adverse social and health impacts for women and other vulnerable community members, including an increase in alcohol related abuse and gender-based violence. This can lead to decreased security for women and children and an increase in inter-personal violence. Most of the local workforce will be transported to site each day and will not be accommodated in the project accommodation camp. There may also be violence and other forms of inappropriate behaviour by project workers or security personnel.

Given these are unplanned events (i.e., hazards) and not planned project events, the risk of accidents and injuries is assessed in Chapter 7 and a residual assessment of impacts is not completed here.

Water and sanitation

Sanitation is known to directly influence community health, particularly availability and type of toilets and waste disposal practices, and also access to clean, non-contaminated water.

Currently the sanitation situation and waste facilities are more developed in Namtu than in Bawdwin. Sewage disposal in villages within the Bawdwin concession area is currently limited to direct disposal to the Nam Pangyun or its tributaries. Sewage disposal by Namtu residents is primarily into pit toilets or septic tanks.

Most households in both communities have ready access to piped water, although these sources may be substituted during periods of rain due to consequent turbidity. Microbiological testing of water samples in Bawdwin showed that most of the drinking water sources sampled (24 of the 29 samples) contained total coliforms and/or *E. coli*. The presence of coliforms and/or E. coli in drinking water indicates potential for recent contamination with soil or faeces and disease-causing organisms (pathogens) in the water system, which can lead to diarrhoeal disease and associated poor health outcomes. During community surveys 55% of survey respondents in Bawdwin stated that they treat their drinking water by either boiling, ultraviolet irradiation or chlorination, as they believe it to be of poor quality.

The baseline health study (Appendix G) recorded a high prevalence of gastritis in Bawdwin and Namtu, which can probably be attributed to *H. pylori*, which has a prevalence (i.e., proportion of people in a population that are infected by *H.pylori*) of 50% to 90% in Asian countries. This bacterium can be transmitted between people and by water, particularly in areas where water quality is poor and rates of *H. pylori* are high (Brown, 2000).

As noted by IFC (2013), a significant portion of the underlying community burden of disease in poor or rural communities (for example, diarrheal-related) is often effectively addressed by engineering strategies such as housing design, water access and supply. Design of a robust water supply system to ensure reliable and non-contaminated water supply system to the resettlement village will be a key design feature. Similarly, a modern community sanitation system will be designed and constructed.

With resettlement of the villages in the Bawdwin concession area and the construction of a new village(s) with essential services including clean water and modern sanitation systems, the project is expected to have a positive effect on the gastrointestinal conditions related to water and sanitation for the resettled populations.

Villages within the Bawdwin concession area

Drinking water for the Bawdwin upper and lower villages is currently sourced from the spring-fed settling pond which is located to the northwest of the mine area, supplemented by inflows from various springs in the area. Drinking water is either sourced directly from the smaller springs when located within walking distance of a ward, or via an extensive piped network that distributes the spring or pond water to other wards. Some residents in the upper Nam Pangyun catchment may possibly use water from the Nam Pangyun for drinking water, domestic and recreational purposes, although this is not confirmed. The mid and lower Nam Pangyun segments are not used by these populations as the water is known to be polluted with historical mine runoff and sewerage.

A screening assessment of the quality of surface waters in Namtu and Bawdwin against drinking water criteria was completed. This assessment demonstrated that existing (baseline) water quality exceeds several of the water quality criteria. The average concentrations of lead exceed adopted guidelines in all surface waters with the exception of the Myitnge River as it flows through Namtu, before the convergence with the Nam Pangyun stream. The average concentrations of arsenic, cadmium, nickel and zinc exceed the health screening criteria in the Nam Pangyun stream. The maximum concentrations of antimony, arsenic, cadmium, nickel and zinc exceed the health screening criteria in the Nam Pangyun stream.

Surveys of Loi Mi farms identified the use of springs as a water source. The springs are outside and up-gradient of mineralised zones and areas of historic mining disturbance. Several springs that emerge towards the base of the Wallah Gorge are used for potable water (see surface water baseline report, Appendix C), by Tiger Camp village. The waste rock dump will be constructed over the spring during operation, thereby removing it as a potential potable water source. However, regardless of its current use by Tiger Camp village the water quality of one of these springs (SWPS01) is poor (see Section 6.3) and is therefore not an ideal drinking water source. At least four springs around the general lower Bawdwin region (see Figure 6.5) are potable water supplies (see surface water baseline report, Appendix C), which may be used by Bawdwin lower village and farms. Tiger Camp farms use different springs to Tiger Camp village, which are located in proximity to the farms at higher elevation. The nature of groundwater use by Nam La farms is unknown.

Most construction activity will take place within the Nam Pangyun catchment around the headwaters north of Bawdwin, at Bawdwin and Tiger Camp and in the Wallah Valley. Construction of a new access road will also extend through the lower catchment from Namtu to Tiger Camp. Construction activities will have increased risk of sediment laden and potentially contaminated runoff entering the Nam Pangyun and to a less extent the Nam La. Construction of the processing plant north of Bawdwin will take place on the catchment divide between the Nam Pangyun and Nam La. Similar water quality risks may exist for the Nam La catchment during construction.

Tiger Camp village and associated farms, Bawdwin upper village, Bawdwin lower village and associated farms and Nam La farms will be resettled during operations. Loi Mi village and associated farms may be resettled during operations, but this will only be confirmed following discussion with the villagers and further investigation of impacts. Communities residing within the Bawdwin concession area will be present during some or all of the project construction program and may experience a temporary reduction of water quality from upstream construction activities. As a result, the communities may ingest contaminants in groundwater, spring water or surface water used for drinking water. An assessment of water quality impacts as a result of the project is provided in Section 6.4.

WMM will avoid locating infrastructure close to drainages or watercourses, where practicable, and will implement erosion and sediment mitigation measures such as conducting earthworks preferentially during the dry season and installing downstream sediment dams to facilitate the settlement of suspended sediment from runoff. WMM has committed to providing clean alternative water sources if the existing water supply is compromised during construction or early operations. As a result of this mitigation measure the impact pathway is not complete and has not been assessed further.

The new village(s) at the resettlement location will provide access to clean, non-contaminated water and improved sanitation facilities. The residual impact of improved water and sanitation at the resettlement village(s) on community health of villages within the Bawdwin concession area is rated of **positive (moderate to high) significance,** based on the **positive (medium) impact magnitude** and the **medium to high sensitivity** of this community to changes in health (Table 6.264).

Table 6.264 Residual impact significance summary – construction phase onwards – changes in sanitation and access to clean, non-contaminated water – affecting villages in the Bawdwin concession area

Value	**Sensitivity of value**			
Villages in the Bawdwin concession area– community health	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Health is highly valued by the community	**Medium to High** Due to the occurrence of, or potential for, existing exposure to environmental hazards from historic mining (soil, dust, water and food), proximity to the project, use of groundwater fed	**Low to Medium** The key contaminants of concern (lead, $PM_{2.5}$ and PM_{10}) have a cumulative effect. Communities have low to medium resilience to	**Medium to High**

Value	Sensitivity of value			
		springs for drinking water and presence of sensitive receptors (children or women of childbearing age)	changes with limited to some capacity and/or resources to absorb, adapt to, and recover from changes to health, dependent on the level of existing exposure.	
Impact	**Magnitude of impact (prior to resettlement)**			
Changes in sanitation and access to clean, non-contaminated water for residents within the concession area	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Prior to resettlement			
	No impact is expected as WMM has committed to providing clean alternative water sources if the existing water supply is compromised during construction or early operations.			
	Following resettlement			
	Very High As the majority of residents living within the Bawdwin concession area will be resettled	**Medium** Resettlement will avoid the existing environmental exposures resulting from historic mining activities	**Very High** Impact is greater than 15 years and is continuous during such time	**Positive (medium)**
	Residual impact significance			**Positive (moderate to high)**
	Assessment of uncertainty			
	High The resettlement sites have not yet been selected. However, one of the requirements of the site is that they are safe for habitation and will not have harmful levels of contamination.			

Villages in tracts adjoining the Bawdwin concession area

It is assumed that residents of villages in tracts adjoining the Bawdwin concession area use similar types of drinking water sources as those living within the concession area, namely groundwater-fed springs. No impact is expected as WMM has committed to providing clean alternative water sources if the existing water supply is compromised during construction or early operations.

Nam Pangyun valley

No impacts to downstream users of the Nam Pangyun are predicted given the mid and lower Nam Pangyun segments is known to be polluted with historical mine runoff and sewerage. It is assumed this waterway is not relied on as a source of drinking water however will require confirmation through additional baseline data collection and community engagement regarding resource use.

Namtu

Residents of some wards of Namtu are known to use water from the Nam La stream, as well as the Kho Mo water source (a natural pond) which is used by all the Tha Ta La wards located south of the Myitnge (Namtu) River. The Kho Mo source has been noted to be insufficient during the summer period with a corresponding decrease in water quality. As outlined in the previous section, the Nam La catchment may be impacted by sedimentation and erosion from project disturbance during construction. Initial impact may be minimal due to distance from source and dilution before the point of exposure at Namtu. In addition, there is potential for water quality of the Nam La stream to be affected by poor quality groundwater discharge from the TSF and Wallah waste rock dump during operations, closure and post closure. However this impact is not expected to occur due to implementation of management measures by WMM. Further modelling work of potential impacts to the Nam La will be undertaken to address uncertainty on downstream water quality see Section 6.4.6.

Project impacts to surface water features will be reduced due to a combination of avoidance (i.e., by designing the project in a way that removes the impact pathway) and management (i.e., by implementing controls to minimise the effects on the environment). Refer to Section 6.4 for proposed surface water management measures to be implemented by WMM.

The residual impact of reduced quality of Nam La drinking water during all phases on Namtu wards and villages is rated of **moderate significance,** based on the **low impact magnitude** and the **high sensitivity** of this community to changes in health (Table 6.265).

Table 6.265 Residual impact significance summary – all phases - reduced quality of drinking water source – affecting Namtu

Value	**Sensitivity of value**			
Namtu villages and wards – community health	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Health is highly valued by the community	**High** Potentially high existing exposures to gases, metals (particularly lead), fine particulate matter and noise, reliance on the Nam La for drinking water which may be impacted by the project and presence of sensitive receptors (children or women of childbearing age)	**Low** The key contaminants of concern (lead, $PM_{2.5}$ and PM_{10}) have a cumulative effect. Existing exposures are assumed to be high based on baseline environmental results. Communities have low resilience to changes with limited capacity and/or resources to absorb, adapt to, and recover from changes to the value or health effects.	**High**
Impact	**Magnitude of impact**			
Reduced quality of Nam La drinking water source for Namtu wards and villages as a result of the project	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Medium The Nam La River supplies the area north of Myitnge (Namtu) River. The Kho Mo water source (a natural pond) is the main water supply for all the Tha Ta La wards located south of the Myitnge (Namtu) River.	**Very Low** The impact will be minimal as it can be managed through standard mitigation. Initial impact may be minimal due to distance from source and dilution before the point of exposure at Namtu.	**Medium** Impact is medium term during construction disturbance in the Nam La catchment (i.e., 1 to 2 years). The frequency of impact is not known due to the lack of surface water modelling.	**Low**
	Residual impact significance			**Moderate**
	Assessment of uncertainty			
	Medium There is an absence of surface water modelling and limited baseline.			

There is opportunity for improved water and sanitation in surrounding villages as a result of project investment in line with the Community Development Plan to be developed and implemented by WMM. This plan will comply with the amended Mining Laws that require all mining companies to put a percentage of profits into a fund that will contribute to Community and Social Responsibility initiatives. WMM will continue to develop its knowledge of community conditions and needs through a formal process of community engagement and will use this knowledge to progressively refine the Community Development Plan. It is anticipated that investment priorities are likely to focus on infrastructure to support essential services, including water and sanitation. As the community investment priorities have not yet been decided this potential positive impact has not been assessed further.

Respiratory and housing issues

Overcrowding and poor ventilation are widely recognised as important factors for health, particularly the prevalence of respiratory infections such as pneumonia.

Based on survey observations, housing is generally basic in Bawdwin and Namtu. As discussed in Section 5.9.12, most residents appear to be long-term, both in the community and in a particular house. The average household size in both Bawdwin and Namtu is six people, often with extended family living together in the same dwelling. The majority of homes are less than 50 m^2 in total floor area with generally larger dwellings in Namtu compared to Bawdwin. As such, the majority of Bawdwin and Namtu communities were not assessed to be particularly overcrowded.

The air quality experienced by the surveyed householders depends not just on natural ventilation but also on whether the family cooks inside and what type of fuel is used. As discussed in Section 5.9.9, food was generally cooked with electricity or wood and electricity, and coal/charcoal was generally regarded as a back-up fuel for when electricity was not available. Few houses (less than 3% in Bawdwin and 17% in Namtu) were considered to be poorly ventilated and most householders did not cook inside the house. As such, the majority of Bawdwin and Namtu communities were not assessed to be particularly susceptible to respiratory issues from indoor smoke inhalation.

A higher population density (driven by in-migration indirectly cause by the project) has the potential to contribute to overcrowding, which in turn could lead to increased physical contact and heighten the risk of spreading communicable diseases, including tuberculosis. WMM will implement measures to limit the effects of in-migration to be developed and detailed in the Community Health, Safety and Security Plan such as selecting workers in accordance with the geographic priorities determined by the project and establishing multiple points of hire that do not encourage people to move to the project site. The development of management measures will involve engaging state, township and village-level government representatives to assist them to devise strategies to prepare for in-migration. At the resettlement location, key requirements for the new village(s) will be housing design with appropriate floor space, ventilation and cooking facilities.

Respiratory health may be indirectly influenced by the project potentially through increased prevalence of smoking. It is well known that smoking damages the respiratory system and increases the risk for respiratory infections or diseases such as tuberculosis, chronic obstructive pulmonary disease, asthma and lung cancer (US DHHS, 2014). The Noncommunicable Disease Risk Factor Survey by WHO (2011) reported that in Myanmar in 2009, of those surveyed, 22.0% were current smokers, with 75.8% of smokers smoking daily. The baseline health survey reported that a person who smoked lived in 37% of households in Bawdwin and 49% of households in Namtu.

The project has the potential to indirectly influence the rates of smoking through higher disposable incomes and thereby reduce respiratory health. However, high disposable incomes may also increase other aspects of living standards (e.g., housing with improved ventilation) and access to health services and medicine. With the implementation of a Health Awareness Program by WMM which will focus on lifestyle risk management and disease prevention the magnitude of impact is assessed to be very low.

Villages in the Bawdwin concession area

Following implementation of management measures to limit in-migration and promote health awareness, the project was assessed to be unlikely to directly influence overcrowding and associated respiratory conditions pre-resettlement. Following resettlement during the construction and operations phases, the residual impact of improved housing at the resettlement village(s) and potential indirect effect of increase smoking rates on community health of the villages in the Bawdwin concession area is rated of **positive (low to moderate) significance,** based on the **positive (low) impact magnitude** and the **medium to high sensitivity** of this community to changes in health (Table 6.266).

Table 6.266 Residual impact significance summary – all phases – reduced respiratory and housing issues following resettlement – affecting villages in the Bawdwin concession area

Value	**Sensitivity of value**			
Villages in the Bawdwin concession area – community health	***Importance***	***Vulnerability***	***Resilience***	***Sensitivity***
	High Health is highly valued by the community	**Medium to High** Due to the occurrence of, or potential for, existing exposure to environmental hazards from historic mining (soil, dust, water and food), proximity to the project, use of groundwater fed springs for drinking water and presence of sensitive receptors (children or women of childbearing age)	**Low to Medium** The key contaminants of concern ($PM_{2.5}$ and PM_{10}) have a cumulative effect. Communities have low to medium resilience to changes with limited to some capacity and/or resources to absorb, adapt to, and recover from changes to health, dependent on the level of existing exposure.	**High**
Impact	**Magnitude of impact (following resettlement)**			
Reduced respiratory and housing issues following resettlement of villages in the Bawdwin concession area	***Spatial extent***	***Severity***	***Duration***	***Magnitude***
	Very High As the majority of residents living within the Bawdwin concession area will be resettled	**Low** Bawdwin houses are not particularly overcrowded or susceptible to respiratory issues from indoor smoke inhalation however the design of the new village(s) will be improved. Smoking rates may indirectly increase as a result of higher disposable incomes of the project workforce, however the Health Awareness Program will mitigate this impact by educating the workforce on lifestyle disease management.	**Very High** Impact is greater than 15 years and is continuous during such time	**Positive (low)**
	Residual impact significance			**Positive (low to moderate)**
	Assessment of uncertainty			
	High The resettlement sites have not yet been selected. However, one of the requirements of the site is that they are safe for habitation and will not have harmful levels of contamination.			

Food and nutrition

Food and nutrition play a vital role influencing health. Depending on individuals' choices, the project may indirectly exacerbate nutritional issues. The project is likely to increase income levels and therefore result in greater disposable income (see Section 6.11.2). While increased incomes can provide improved access to a diversity of foods and therefore better nutrition, it has more frequently been shown to encourage some people to rely more on store-bought foods potentially of lower nutritional value. Aside from increasing purchasing power, employment may reduce the time available to undertake subsistence activities, further encouraging reliance on store-bought foods. This impact would affect people who find employment as a result of the project.

To mitigate the potential for reliance on store-bought foods of lower nutritional value WMM will provide the project workforce with access to a good diversity of food in the kitchen / dry mess that is comparable to their current diets.

As a result of increased demand on local goods and services from the project there is also the potential for increased local inflation. MCRB (2018) reported that during field investigations of the potential impacts of mining in Myanmar, community members reported higher food prices linked to the increase of the population due to mining activities. Furthermore, poorly planned or implemented resettlement program can result in food insecurity, often due to loss of subsistence agriculture. The assessment assumes that access to adequate cultivatable land is available at the relocation site for resettled communities. This will be further investigated as resettlement planning progresses.

The annualised food consumption frequency results indicated the household diets in all of the wards/villages studied contained a good diversity of food, with remarkable similarities between the Bawdwin and Namtu communities. Rice was a primary carbohydrate source in all households. Bananas, pumpkins and potatoes were also significant carbohydrate sources as was bread and biscuits while sweets and snacks were minor sources. The consumption of protein-rich food is dominated by fish and chicken, with pork, lamb, mutton, tinned meats, prawns and shellfish or beef also common protein sources. Eggs were also frequently consumed. Legumes and beans added to the diverse sources of proteins.

Consumption of green vegetables was high at all the community wards/villages with mean consumption varying between 4 to 6 times a week and daily. The consumption of fresh fruit at an average of two to three times a week, was significant. To some degree, this result may be a consequence of the timing of the survey (May 2019), but direct observation would indicate there was widespread availability of garden produce at all times during the year. This is supported by the results of the survey of seasonal availability.

Laboratory analysis of foods indicated the potential ingestion of lead and other metal contaminants in or on locally grown foods, or foods grown and transported from local areas. This was particularly the case for villages in the Bawdwin concession area where more than three quarters of sampled food exceeded the recommended metal concentration of at least one element (typically lead). Food sampled in Namtu was only marginally better with more than one third exceeding the recommended metal concentration of at least one element.

Prior to resettlement, villages in the Bawdwin concession area will experience increased exposure to hazardous materials as a result of project disturbance, emissions and discharges through ingestion of home grown produce or animal products (see Table 6.205 to Table 6.257). WMM will implement a range of management measures to minimise emissions of dust and contaminated water and soil. Key measures include water carts for dust suppression, erosion and sediment controls such as sediment dams and capture and treatment of seepage from the TSFs and waste rock dump prior to discharge.

Many factors can influence the absorption of lead including nutritional status, the form of lead and the route of exposure. Implementation of a Health Awareness Program with government and non-government agencies in project-affected communities will assist in educating communities with methods to minimise exposure to metal contaminants (i.e., lead). Examples include following good hygiene practices such as thoroughly washing hands and rinsing garden produce prior to eating, keeping eating areas clean and free of dust, and maintaining a diverse diet inclusive of milk products, green leafy vegetables and calcium-fortified foods such as orange juice, soy milk and tofu.

Local expenditure by the project will provide business opportunity to local providers of goods and services and may result in economic stimulus and a redistribution of wealth. A potential negative impact associated with a stimulated local economy is the potential for local inflation of the price of goods and services, such as store-bought food. While a potential positive impact for providers of goods and services, people whose incomes do not increase proportionally to inflation may be negatively impacted and not able to access store-bought foods.

Overall, with the implementation of management measures including providing the project workforce with access to a good diversity of food, and supporting public health services through engagement with government and services providers during implementation of the Community Health, Safety and Security Plan no direct material change in nutritional levels is expected. As a result, food and nutrition related issues have not been assessed further.

Non-communicable diseases

In 2016, 68% of deaths in Myanmar were estimated to be due to non-communicable diseases. The majority of these were cardiovascular disease (25%), cancers (13%), chronic respiratory disease (8%), digestive disease (8%) and diabetes (4%) (WHO, 2018). Risk factors for the most prevalent non-communicable diseases include behaviour-based factors (physical activity, fruit and vegetable consumption, tobacco use and alcohol use) and physical factors (obesity and hypertension) (WHO, 2011).

There is an established association between non-communicable diseases and increased income, particularly in developing countries (Di Cesare et al., 2013; Habib and Saha, 2010; Pi et al., 2018). The risk of non-communicable diseases (such as heart disease, high blood pressure and cancer) may be exacerbated by lifestyle choices (e.g., diet, tobacco, marijuana, alcohol). Consumption of unhealthy food and harmful substances may be driven by increased income – which makes unhealthy store-bought foods and harmful substances (such as tobacco and alcohol) more affordable.

The health baseline study found that cardiovascular accidents were the leading cause of mortality in Namtu township in 2017 and 2018. The incidence of diabetes is low, consistent with the dietary habits and lack of obesity in the population.

The measured waist circumferences of all surveyed adults indicated that for approximately 23% all the surveyed adult males were at elevated risk of cardiovascular disease. The corresponding value for all surveyed adult females was about 39%. Despite this, the blood pressure measurements reported only 15% of males and 15% of females were hypertensive indicating an overall healthy lifestyle in both communities.

Whilst there may be an indirect effect on prevalence of non-communicable diseases as a result of increased income from project employment, there are also a range of benefits. This includes being able to afford travelling further for education, health and commercial services such as stores and markets, access to more advanced levels of education, access to better and/or more frequent healthcare and purchasing more and greater range of food from stores and markets. WMM will support delivery of public health services through engagement with government and service providers and will implement a Health Awareness program to address key issues of lifestyle risk management and disease prevention.

Overall, with the implementation of management measures, project-induced increase in non-communicable diseases in the project workforce or other communities effected by economic stimulus of the project is considered unlikely, noting the uncertainty regarding individuals spending habits.

Communicable diseases

The report of the Commission on AIDS in Asia stated that Asia’s epidemics depend to a considerable extent on incomes and mobility of workers outside their family settings (UNAIDS, 2008). The report stated that “men who have disposable income, and who travel or migrate to work opportunities, provide most of the demand for commercial sex” (UNAIDS, 2008). Experiences around resource developments has shown that higher incomes (from employment) and greater mobility can lead to unsafe sexual practices. The number of people living with HIV in Myanmar was 240,000 in 2019 according to UNAIDS, with a high level of transmission through injecting drug users and prostitution (Avert, 2020). The prevalence of HIV in Myanmar is second highest in Southeast Asia (Avert, 2020). The World Health Organisation (WHO) estimated that 2.1% of deaths in Myanmar in 2016 could be attributed to sexually transmitted diseases (WHO, 2020).

The health baseline survey reported zero incidences of HIV/AIDS in the previous 12 months in Namtu and Bawdwin. There is the potential that the project to indirectly increase the prevalence of HIV/AIDS and other STDs through increased income and mobility.

Myanmar has one of the highest tuberculosis rates in the world; WHO estimated a TB prevalence of 473 per 100,000 population in 2013 (MOH, 2014), and a rate of 53 deaths per 100,000 people in 2014. The United Nations Development Programme (UNDP) reports that the Myanmar TB incidence rate has been in decline since 1997. During the health baseline survey, one respondent in Bawdwin reported having tuberculosis in the previous 12 months, indicating a very low prevalence of tuberculosis.

Many health issues can be resolved with the application of well-established, simple, and cost-effective public health interventions, such as treated bed nets, immunizations, and information, education, and communication programs. WMM will develop a Health Awareness Program as part of the Community Health, Safety and Security Plan to address key issues influencing communicable disease transmission such as hygiene, preventative health and infectious disease management. The awareness program will provide education to communities on communicable diseases, such as tuberculosis and STDs, and provide advice regarding seeking medical treatment.

The ICMM good practice guidance on HIV/AIDS, tuberculosis and malaria (2008) includes a range of practical measures for the mining industry regarding management of communicable diseases. Other guidance documents include the IFC HIV/AIDS guide for the mining sector (Golder, 2004), which was developed for mining communities in South African however contains relevant learnings applicable to other geographical areas. With implementation of management measures to raise awareness on communicable diseases and to limit the potential for in-migration, project-induced spread of communicable diseases is considered unlikely. Increase in communicable disease is an unplanned event (i.e., hazard) and not planned project events. As such, a residual assessment of impacts is not completed here.

Vector-related diseases

Malaria is prevalent in Myanmar. The disease is endemic in 86% of townships in Myanmar and about 70% of the national population lives in malaria-endemic areas. As of 2013, morbidity and mortality rates were 6.44 per 1000 people and 0.48 per 100,000 people, respectively (MOH, 2014). Malaria is primarily spread by mosquitos as the vector.

Vector borne disease was not commonly reported during the Bawdwin and Namtu household surveys. Most households reported the use of mosquito bed-nets and/or the use of repellents, as well as attention to control of mosquito breeding areas. Mosquito control methods were practiced in the majority of homes but were not universal. The use of repellents was common to about 50% of households although almost no households used insect screens. Most households were aware of the risks of standing water for mosquito breeding and most used mosquito nets, although almost no households re-treated nets with insecticide to optimise their effectiveness.

Of the 230 people surveyed in Bawdwin and 190 people surveyed in Namtu as part of the health baseline study, six respondents in Bawdwin and four respondents in Namtu reported having malaria in the previous 12 months. One respondent in Bawdwin and no respondents in Namtu surveyed in the health baseline study reported having filariasis (a parasitic disease caused by roundworms and their larvae), a vector-borne parasitic disease in the previous 12 months.

Currently the transmission risk of malaria and other vector-related diseases around the project area is assessed to be low, based on the low reported incidences. The project may increase the risk of mosquito-borne diseases through the construction of new or larger sources of standing water (e.g., new reservoirs, sediment dams and drainage lines) that may provide mosquito habitat. Mosquitoes have an average maximum flight distance of between 50 m and 50 km, depending on the species (Verdonschot & Besse-Lototskaya, 2014). Other influential factors include local environmental conditions (e.g., landscape, topography, and meteorological conditions, including prevailing wind direction), the mosquito population density and the presence, and position and density of potential hosts (Verdonschot & Besse-Lototskaya, 2014). In a metadata analysis study by Verdonschot & Besse-Lototskaya (2014) the average flight distance of malaria carrying mosquitos (i.e., genus *Anopheles*) ranged between 24 m (*A. Subpictus*) and 1.25 km (*A. Minimus*), dependent on the species.

The impact to Bawdwin upper village will be largely avoided as residents will be resettled during construction. Receptors at higher risk of communicable diseases spread by mosquitos during the pre-resettlement period include Tiger Camp, Tiger Camp farms and Bawdwin lower village farms near the Wallah waste dump sediment dams, and Nam La farms near the Nam La water harvesting facility. Resettlement of Loi Mi and Loi Mi farms near the TSF water reservoirs is dependent on the outcomes of further consultation. If these communities remain in their current location they would also fall within the higher risk category (i.e., within 1.25 km of project-related water storages). WMM will monitor project reservoirs and dams for mosquito breeding activity. If a high level of breeding activity is observed or if health monitoring results indicate an increase in the prevalence of vector-related diseases WMM will explore additional controls. This may include pesticide control and/or provision of mosquito nets, treated or untreated, to surrounding villages.

The nearest project water storage to the accommodation camp is the existing Nam Pangyun Reservoir. Whilst this facility will be expanded to greater water storage capacity it is not considered to pose an increased risk of vector-related disease from mosquitos. The accommodation camp will be sealed and may be regularly fumigated if additional controls are required to manage mosquitos. The workforce will be provided with PPE including long sleeved coveralls and long pants and insect repellent.

Due to the elevation and climate of the project, the area is not considered to provide optimal conditions for the growth and spread of malaria locally. Additionally, with the planned resettlement many of the communities that may be at an increased risk of exposure will be resettled.

WMM will support the delivery of public health services to project-affected communities through engagement with government and service providers to address vector-related diseases.

Summary of residual impacts

Table 6.267 provides a summary of the residual impacts and their significance.

Table 6.267 Summary of assessment of residual health impacts

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Exposure to environmental hazards (contaminated dust and water) as a result of the project	Bawdwin upper village – community health • High sensitivity	Construction (prior to resettlement)	Medium • Very high spatial extent • Medium severity • Medium duration	• Resettlement • Measures to minimise emissions of dust, and contaminated water and soil • Dust suppression measures • Erosion and sediment control measures • Implementation of a Health Awareness Program	High	Community health in Bawdwin upper village is highly sensitive, and exposure to contaminants is expected to impact 75% of people due to the proximity of dust generating activities. Once resettled, reduced exposure to environmental hazards are expected to benefit community health	High • Absence of air quality modelling and limited meteorological baseline • Resettlement sites have not been selected
		Operations, closure (following resettlement)	Positive (high) • Very high spatial extent • High severity • Very high duration		Positive (major)		
	Bawdwin lower village – community health • High sensitivity	Construction and operations (prior to resettlement)	Very high • Very high spatial extent • High severity • Very high duration	• Resettlement • Measures to minimise emissions of dust, and contaminated water and soil • Dust suppression measures • Erosion and sediment control measures • Implementation of a Health Awareness Program	Major	Community health in Bawdwin lower village is highly sensitive, and exposure to contaminants is expected to impact 75% of people due to the proximity of dust generating activities and use of groundwater and surface water. Once resettled, reduced exposure to environmental hazards are expected to benefit community health	High • Absence of air quality modelling and limited meteorological baseline • Resettlement sites have not been selected
		Operations, closure (following resettlement)	Positive (high) • Very high spatial extent • Medium severity • Very high duration		Positive (major)		
	Tiger Camp village – community health • High sensitivity	Construction and operations (prior to resettlement)	Medium • High spatial extent • Medium severity • Medium duration	• Resettlement • Measures to minimise emissions of dust, and contaminated water and soil • Dust suppression measures • Erosion and sediment control measures • Implementation of a Health Awareness Program	High	Community health in Tiger Camp is highly sensitive, and exposure to contaminants is expected to impact the majority of people due to the proximity of dust generating activities and use of groundwater and surface water. Once resettled, reduced exposure to environmental hazards are expected to benefit community health	High • Absence of air quality modelling and limited meteorological baseline • Resettlement sites have not been selected
		Operations and closure (following resettlement)	Positive (high) • Very high spatial extent • Medium severity • Very high duration		Positive (major)		

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Exposure to environmental hazards (contaminated dust and water) as a result of the project	Bawdwin lower village farms – community health • High sensitivity	Construction and operations (prior to resettlement)	Low • Very low spatial extent • Low severity • Very high duration	• Resettlement • Measures to minimise emissions of dust, and contaminated water and soil • Dust suppression measures • Erosion and sediment control measures • Implementation of a Health Awareness Program	Moderate	Community health in Bawdwin lower village farms is highly sensitive, and exposure to contaminants is expected to impact a small proportion of people due to the distance from dust generating activities. Once resettled, reduced exposure to environmental hazards are expected to benefit community health	High • Absence of air quality modelling and limited baseline data collection • Resettlement sites have not been selected
		Operations and closure (following resettlement)	Positive (medium) • Very high spatial extent • Low severity • Very high duration		Positive (high)		
	Tiger Camp farms (not located along plant access road) – community health • High sensitivity	Construction and operations (prior to resettlement)	Medium • High spatial extent • Low severity • Medium duration	• Resettlement • Measures to minimise emissions of dust, and contaminated water and soil • Dust suppression measures • Erosion and sediment control measures • Implementation of a Health Awareness Program	High	Community health in Tiger Camp farms is highly sensitive, and exposure to contaminants is expected to an impact a high proportion of people due to the proximity of dust generating activities and use of groundwater and surface water. Once resettled, reduced exposure to environmental hazards are expected to benefit community health	High • Absence of air quality modelling and limited baseline data collection • Resettlement sites have not been selected
		Operations and closure (following resettlement)	Positive (medium) • Very high spatial extent • Low severity • Very high duration		Positive (high)		
	Nam La farms – community health • Medium sensitivity	Construction and operations (prior to resettlement)	Medium • Medium spatial extent • Medium severity • Medium duration	• Resettlement • Measures to minimise emissions of dust, and contaminated water and soil • Dust suppression measures • Erosion and sediment control measures • Implementation of a Health Awareness Program	Moderate	Community health in Nam La farms is highly valued but less vulnerable to changes than other villages due to their distance from the mine. Exposure to contaminants is expected to impact residences near the northern access road and Nam La water harvesting facility (where dust generating activities will occur). Once resettled, reduced exposure to environmental hazards are expected to benefit community health	High • Absence of air quality modelling and limited baseline data collection • Resettlement sites have not been selected
		Operations and closure (following resettlement)	Positive (medium) • Very high spatial extent • Low severity • Very high duration		Positive (high)		

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Exposure to environmental hazards (contaminated dust and water) as a result of the project	Loi Mi farms – community health • Medium sensitivity	If not resettled	Medium • Low spatial extent • Low severity • High duration	• Resettlement • Measures to minimise emissions of dust, and contaminated water and soil • Dust suppression measures • Erosion and sediment control measures • Implementation of a Health Awareness Program	Low	If Loi Mi village and associated farms are not resettled, the effect of temporarily increased exposure to environmental hazards from existing conditions on community health will be greater than if they are resettled. Community health of this receptor group is somewhat vulnerable due to existing contamination and use of groundwater, and part of this receptor group is close to dust generating sources (TSF-B).	High • Absence of air quality modelling and limited baseline data collection • Resettlement sites have not been selected
		If resettled	Positive (medium) • Very high spatial extent • Low severity • Very high duration		Positive (moderate)		
	Bawdwin military base • High sensitivity	Construction and operations	High • Very high spatial extent • High severity • Very high duration	• Measures to minimise emissions of dust, and contaminated water and soil • Dust suppression measures • Erosion and sediment control measures	Major	The military base is exposed to existing environmental hazards and is located in proximity to dust generating activities (approximately 400 m from the power station and process plant)	High • Absence of air quality modelling and limited baseline data collection • Source of drinking water is unknown
	Project workforce • Medium sensitivity	Construction and operations	Medium • Very high spatial extent • Low severity • Very high duration	• Implementation of the Occupational Safety and Health Management Plan • Measures to minimise emissions of dust, and contaminated water and soil • Dust suppression measures • Erosion and sediment control measures	Moderate	The project workforce highly value occupational health and will be exposed to environmental hazards, however the impact will be managed by implementing the Occupational Safety and Health Management Plan.	Medium • Other modern mining operations have successfully applied similar management and mitigation measures

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Exposure to environmental hazards (contaminated dust and water) as a result of the project	Villages and hamlets in tracts adjoining the Bawdwin concession area – community health • Medium sensitivity	Construction and operations	Low • Low spatial extent • Low severity • Very high duration	• Measures to minimise emissions of dust, and contaminated water and soil • Dust suppression measures • Erosion and sediment control measures	Low	The villages and hamlets in tracts adjoining the Bawdwin concession area may be impacted by changes to surface water and groundwater and increased dust emissions, however this is only expected to have a low severity impact to a limited proportion of the receptor group.	High • Absence of air quality modelling, limited meteorological baseline and limited baseline data collection
	Namtu villages and wards – community health • High sensitivity	Construction and operations	Low • Very low spatial extent • Low severity • Very high duration	• Measures to minimise emissions of dust, and contaminated water and soil • Dust suppression measures	Moderate	Impact to Namtu will be localised to those living along the transport route, and may experience an increase in emission over construction and operations.	Medium • Absence of air quality modelling and limited meteorological baseline
	Residents of the Nam Pangyun valley – community health • High sensitivity	Construction and operations	Medium • Medium spatial extent • Low to medium severity • Medium to very high	• Measures to minimise emissions of dust, and contaminated water and soil • Dust suppression measures • Erosion and sediment control measures	High	Receptors close to the road may be impacted by increased dust during construction and from project vehicles during operations. Receptors dependent on the Nam Pangyun water may experience changes to contaminant concentrations in the water.	High • Absence of air quality modelling and baseline data collection • Limited baseline stream flow data and lack of qualitative predictions of downstream water quality
	Villages along the export route – community health • Medium sensitivity	Construction and operations	Low • Low spatial extent • Low severity • Very high duration	• Measures to minimise emissions of dust, and contaminated water and soil • Dust suppression measures	Moderate	Receptors closest to the road are expected to be affected, and emission criteria are unlikely to exceed emission criteria or air quality criteria	High • Absence of baseline data and modelling

Impact	Value impacted and sensitivity	Impact phase	Impact magnitude	Key management measure(s)	Impact significance	Justification for impact significance	Uncertainty
Changes in sanitation and access to clean, non-contaminated water	Communities within the Bawdwin concession area – community health • Medium to High sensitivity	Construction, operations, closure (following resettlement)	Positive (medium) Very high spatial extent Medium severity Very high duration	• Facilitate the improvement of water and sanitation facilities at resettlement village(s) • Manage the current standard of water and sanitation facilities	Positive (moderate to high)	Residents within the Bawdwin concession area will be provided clean drinking water prior to resettlement if the existing supply is compromised. After resettlement the existing environmental exposure will be avoided.	High • Resettlement sites have not been selected
Reduced quality of Nam La drinking water source for Namtu wards and villages as a result of the project	Namtu villages and wards – community health • High sensitivity	Construction	Low • Medium spatial extent • Very low severity • Medium duration	• Measures to minimise emissions of dust, and contaminated water and soil • Erosion and sediment control measures	Moderate	Community health of Namtu is highly sensitive and may be impacted by reduced drinking water quality throughout construction, however this can be managed with standard mitigation measures.	Medium • Absence of surface water modelling and limited baseline
Reduced respiratory and housing issues following resettlement of villages in the Bawdwin concession area	Villages within the Bawdwin concession area – community health • Medium to High sensitivity	Construction, operations and closure (following resettlement)	Positive (low) • Very high spatial extent • Low severity • Very high duration	• Measures to limit the effects of in-migration • Implementation of a Health Awareness Program	Positive (low to moderate)	The community health of villages within the Bawdwin concession area is highly sensitive, and once resettled there are expected to be reduced respiratory and housing issues due to limited in-migration and appropriate housing at the new resettlement locations.	High • Resettlement sites have not been selected

6.11.5 Uncertainties and further work

This section outlines the key uncertainties associated with the impact assessment and outlines recommended further work to address uncertainties.

The key uncertainties are associated with:

- Baseline blood lead levels for all receptor groups (there is only data for a portion of the current Bawdwin workforce blood lead levels).
- The project schedule indicates all Group 1 receptor groups will be present during construction and Group 1B, 1C and 1D will be present for the first year of open mine pit operations.
- The effectiveness of design measures to minimise the release of dust, gases, runoff, drainage or release/seepage of contaminated water to groundwater and surface waters is uncertain and detailed design and modelling work has not yet been conducted.

Further work required to address these uncertainties is outlined in Table 6-22 and the relevant sections of the impact assessment (as indicated in Table 6.268).

Table 6.268 Uncertainties and further work in respect of health impacts

Uncertainty	Further work required	Purpose	Assumption
Lack of data regarding community blood lead levels	Blood lead analysis of young children and adults in all receptor groups	Establish a baseline in order to assess future project impacts	Baseline blood lead levels for all receptors have been assumed to be at or above the recommended levels
Lack of environmental baseline data for farms within the Bawdwin concession area, Loi Mi and villages in tracts adjoining the Bawdwin concession area, residents of the Nam Pangyun valley and residents along the export route beyond Namtu	Collect baseline environmental data for at these locations, including: • Socio-economic data • Health data • Air quality data	Establish a baseline in order to assess future project impacts	Contamination from historic mine activities is concentrated near mine
Baseline contaminant exposure levels in the resettlement location are not known	Collect baseline environmental data at the resettlement locations, including: • Socio-economic data • Health data • Air quality data	Establish a baseline in order to assess future project impacts	The resettlement location is assumed to be safe for habitation and to not have harmful levels of contamination.
Resettlement location and the resettlement period in relation to the project schedule	Identify and secure appropriate resettlement location and confirm timing of resettlement for each receptor	Validate key assumptions of impact assessment	The resettlement location is assumed to be safe for habitation and to not have harmful levels of contamination. Refer to Table 6.85 for assumed timing of resettlement.
Effectiveness of design measures and dust suppression measures	Refer to Section 6.11.6.	Validate key assumptions of impact assessment	Design and management measures are assumed to be effective in mitigating impacts
Concentrations and compositions of dust and gaseous emissions, and contaminants in dust and the	Further work to address uncertainties regarding air quality impacts, as outlined in Table 6.31.	To quantify exposure to environmental hazards impact via air exposure pathways	Qualitative assessment adopting recommended separation distances

Uncertainty	Further work required	Purpose	Assumption
level of dust deposition at receptors			
Level and distance of noise and vibrations emissions are not known	Further work to address uncertainties regarding noise impacts, as outlined in Table 6.145.	To quantify the sound levels at receptors	Noise emission levels were estimated based on literature values and the inverse square law.
Lack of quantitative predictions of downstream water quality (total and dissolved metals, pH) during construction, operations and post-closure.	Further work to address uncertainties regarding surface water impacts, as outlined in Table 6.82.	To quantify the severity and spatial extent of water quality impacts on downstream water users	Qualitative assessment
Quality of groundwater at the points of discharge as a result of changes to flow rate, direction, drawdown, seepage from TSFs, Wallah waste rock dump and mine pit are not known.	Further work to address uncertainties regarding groundwater impacts, as outlined in Table 6.49.	To quantify the severity and spatial extent of groundwater quality impacts on groundwater users	Qualitative assessment
Significant volume of topsoil is required for capping of landforms at closure. The extent, thickness and adequacy are not known.	Further work to address uncertainties regarding soil impacts, as outlined in Table 6.22.	To validate key assumptions of impact assessment	Assumed sufficient volume of capping material is available

6.11.6 Monitoring

Environmental monitoring, inspecting and auditing commitments for landform and soils, surface water and groundwater, air quality and noise are outlined in sections 6.2 to 6.5 and 6.7.

Air quality, noise and blast monitoring programs will be established at Bawdwin lower village and Tiger Camp during operations given their proximity to open pit mining activities.

Ongoing regular monitoring of human health aspects, including blood lead levels, for all receptor groups and workers is planned throughout the life of mine in order to detect emerging issues early. Exposure of Bawdwin workers will be monitored using personal dust inhalation samplers, personal aerosol monitors and real time monitoring of dust in the project area.

WMM will establish procedures to monitor and measure the effectiveness of the environmental and social management plan as well as compliance with any related legal and/or contractual obligations and regulatory requirements. The monitoring will be undertaken on a participatory basis with communities and in collaboration with government agencies. A community grievances register will be maintained and regularly reviewed with any issues followed up with local communities.

Appendix A - Greenhouse gas impact assessment calculations

Appendix A - Greenhouse gas impact assessment calculations

Introduction

This report briefly outlines the calculation methodology used to determine the greenhouse gas emissions generated by source for the Bawdwin project and the carbon dioxide equivalent (CO_2-e) for each emission source for various project stages.

Emissions from land clearance of primarily grasslands (where carbon storage is minimal) are considered negligible.

Operation

It was assumed that the operation period would last for 13 years. The method used to calculate the emissions are presented in Section 0 to Section 0.

Fuel consumption in trucks moving materials to and from mine area

Average daily fuel consumption was calculated to be 5,804 L for the transport of materials to and from the mine area. This was calculated based on the following assumptions:

- 63.09 trucks/day (WMM 2020)
- 37.7 L/100 km (ICCT 2017):
  - 30 tonne capacity trucks
  - N3 Rigid vehicles
  - 8x4 axle configuration
  - 60 km/h
  - Consumption at upper weight limit
- Distance from Bawdwin to Muse of 244 km

The CO_2-e was calculated using the following equation (DEE 2018):

$$E_{ij} = \frac{Q_i \times EC_i \times EF_{ijoxec}}{1000}$$

where:

- E_{ij} is the emissions of gas type (j), (carbon dioxide, methane or nitrous oxide), from fuel type (i) (CO2-e tonnes).
- Q_i is the quantity of fuel type (i) (kilolitres) combusted for stationary energy purposes.
- EC_i the energy content factor of fuel type (i) (gigajoules per kilolitre) for stationary energy purposes.
  - $EC_{Diesel\ oil} = 38.6\ GJ/kL$
- EF_{ijoxec} the emission factor for each gas type (j)
  - $EF_{i(CO2)} = 69.9\ kgCO_{2-e}/GJ$
  - $EF_{i(CH4)} = 0.1\ kgCO_{2-e}/GJ$
  - $EF_{i(N2O)} = 0.5\ kgCO_{2-e}/GJ$

Fuel consumption in mine operation fleet

Average daily fuel consumption for the mine operation fleet was assumed to be 48,168 L per day (WMM 2020).

The CO_2-e was calculated using the following equation (DEE 2018):

$$E_{ij} = \frac{Q_i \times EC_i \times EF_{ijoxec}}{1000}$$

Diesel consumption in power station for mine infrastructure during operation

Average daily fuel consumption of the power station on site was taken to be to be 106,552 L (WMM 2020).

The CO_2-e was calculated using the following equation (DEE 2018):

$$E_{ij} = \frac{Q_i \times EC_i \times EF_{ijoxec}}{1000}$$

Explosive use during mine operation

The total explosives used in the project operation phase was based on the total amount of mineral mined in bulk cubic meters (BCM). The total amount mined year was assumed to be 6,268,422 BCM (WMM 2020), with 0.52 kg of explosives used per BCM.

The CO_2-e was calculated using 0.17 CO_2-e per tonne of explosive (DCC 2008).

Waste production during mine operation

Both the amount of waste produced by the project and the CO_2-e were based on a mining project of similar size.

Construction

It was assumed that the construction period would last for two years.

For all emissions sources during the construction period, a value of 40% of the operational value was taken (WMM 2020). The emissions sources for the construction period comprised of:

- Fuel consumption in trucks moving materials to and from mine area.
- Fuel consumption in mine construction fleet.
- Diesel consumption in power generation during construction.
- Explosive use during mine construction.
- Waste production during mine construction.

Decommissioning

It was assumed that the decommissioning period would last for two years. Emissions associated with the closure monitoring and maintenance period were excluded as these would be negligible compared to the construction, operation and decommissioning periods.

For all emissions sources during the decommissioning period, a value of 20% of the operational value was taken (WMM 2020). The emissions sources for the construction period comprised of:

- Fuel consumption in mine decommissioning fleet.
- Power generation.

Summary

Table A1 presents the greenhouse gas emissions generated by each project source and the equivalent tonnes of CO_2 per annum (t CO_2-e / annum).

Table A1 Activity data and emissions for each GHG emission source

Project source emissions	Emission value	Units	GHG emissions (t CO_2-e / annum)
Construction (2 years)			
Fuel consumption in trucks moving materials to mine area	847	kL/annum	2,306
Fuel consumption in mine construction fleet	7,033	kL/annum	18,994
Diesel consumption in power generation for mine infrastructure during construction	15,557	kL/annum	42,154
Explosive use during mine construction	1,304	tonnes/annum	221
Waste production during mine construction	513	tonnes/annum	111
Total			**63,787**
Operation (13 years)			
Fuel consumption in trucks moving materials to and from mine area	2,118	kL/annum	5,764
Fuel consumption in mine operation fleet	17,581	kL/annum	47,486
Diesel consumption in power generation for mine infrastructure during operation	38,891	kL/annum	105,385
Explosive use during mine operation	3,260	tonnes/annum	554
Waste production during mine operation	644	tonnes/annum	693
Total			**159,883**
Closure (2 years)			
Fuel consumption in mine decommissioning fleet	3,940	kL/annum	10,650
Power generation	7,778	kL/annum	21,077
Total			**31,727**

Bawdwin Project

Environmental Impact Assessment
Chapter 7 – Assessment of hazard and risk

October 2023

Bawdwin Project

Prepared for

Win Myint Mo Industries Company Limited

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7 Assessment of hazard and risk

7.1 Background

In addition to the potential impacts caused by the planned or known events associated with the project (identified in Chapter 6), there is the potential for impacts to occur due to unplanned events. These unplanned events include natural hazards and disasters and industrial mining hazards. The unplanned events can have consequences that may impact the success of the project and/or increase the magnitude of project impact on the surrounding environment. These are considered unplanned events as they are not expected to occur as a result of the project's normal operating conditions. However, they have the potential to result in significant consequences if they do occur.

There are key differences between undertaking a risk assessment of unplanned events and completing an impact assessment of known events associated with a project. The impact assessment in Chapter 6, assesses, quantifies and describes impacts that will occur if the project is constructed, operated and closed in accordance with its scope and design, albeit with varying levels of significance. While only credible impacts from the project are assessed in Chapter 6, a range of other hazards exist that are unlikely or very unlikely to occur such as extreme natural events (including earthquakes, landslides, flooding, storms and droughts) or significant industrial mining hazards. However, if these were to occur they would have serious consequences and therefore it is important that they are considered, and measures put in place to reduce the likelihood of them occurring or their consequences. Technical codes and relevant legislation have been considered when designing aspects of the project, including infrastructure, in order to prevent potential incidents and their subsequent consequences from eventuating.

The focus of this section is on the risk associated with natural hazards that may affect the project, and mining industrial hazards associated with project activities that may impact human health or lives or have environmental impacts. This includes discharges of hazardous and non-hazardous materials that occur as a result of these events that would not normally occur, or not occur to the same degree as during normal project activities.

7.2 Assessment approach

Hazards and unplanned events relating to the project have been identified based on the location and nature of the project. The hazards and events presented are those that may cause high or extreme consequences such as adverse off-site impacts on the natural environment, acute or chronic human health issues, and injuries or fatalities. The hazard and risk assessment is structured by presenting different groups of hazards or unplanned events and within each group outlining the nature of the hazard or unplanned event and:

- **Consequences**: Description of the consequences associated with the unplanned event.
- **Management measures and design controls**: Identification of design controls and mitigation measures to reduce the likelihood and/or minimise consequences of the event.
- **Assessment of risk**: The overall risk is determined as a function of the consequences of the event, and the likelihood of it occurring. As per the risk assessment framework summarised below.

Risk assessment framework

Risks have been assessed qualitatively in accordance with the risk assessment process outlined in AS/ISO 31000:2018 Risk management – guidelines, and handbook HB 203:2012 Managing environment-related risk.

The environmental risk assessment method adopted involved the following steps:

- **Hazard and risk identification**: Description of the hazard, potential unplanned event, pathway between hazard and receptor, and potential consequences.
- **Risk analysis**: Assessment of the consequences associated with the event, should it occur and assessment of the likelihood of the consequence occurring, taking existing controls and management measures into account.
- **Risk evaluation:** Qualitative determination of the overall risk as a function of the consequences of the event and likelihood of the consequences occurring. Risk is assessed as being very low, low, moderate, high or major.

The definitions for consequence and likelihood are provided in Table 7.1 and Table 7.2 respectively. Assessment of consequences associated with the event and likelihood of those consequences occurring, following the implementation of design controls and management measures.

Table 7.1 Definitions for consequence

Receptors	Consequences				
	Negligible	**Minor**	**Severe**	**Major**	**Extreme**
People	Minimal impact on health. Minimal impact to community.	Injuries requiring first aid treatment. Minor impact to community.	Injury or illness requiring hospital treatment. Moderately impacting the community.	Few fatalities or several people with life threatening injuries. Major impacts to the community.	Multiple fatalities. Significant impacts to wider community.
Environment	No effect or minor on site effects rectified immediately with negligible residual effect.	Effect very localised (<0.1 ha) and short term (weeks), minimal rectification required.	Localised (<1 ha) and medium term (<2 years) effects, easily rectified.	Major off-site impact or long-term severe effects or rectification difficult.	Effects widespread, viability of ecosystem or species affected, permanent major changes.
Project activities (in the context of employment and socioeconomic benefits)	Negligible interruption to project activities.	Minor interruption to project activities.	Interruption to project activities, with the potential for delays or short-term mine closure.	Major interruption to project activities, with the potential for temporary mine closure.	Severe interruption to project activities, with the potential for permanent mine closure.

Table 7.2 Definitions for likelihood

	Likelihood Categories				
	Rare	**Remote**	**Unlikely**	**Probable**	**Frequent**
Frequency	Theoretically possible but has never occurred in the past	Not anticipated to occur.	Unlikely to occur but possible	Will probably occur during the project life.	Expected to occur during the project life

The risk was determined by applying consequence and likelihood in the matrix presented in Table 7.3.

Table 7.3 Risk matrix

		Likelihood				
		Rare	**Remote**	**Unlikely**	**Probable**	**Frequent**
Consequences	**Negligible**	Very low	Very low	Very low	Low	Moderate
	Minor	Very low	Low	Low	Moderate	Moderate
	Severe	Low	Low	Moderate	High	High
	Major	Low	Moderate	High	Major	Major
	Extreme	Moderate	High	Major	Major	Major

7.3 Natural hazards and disaster risk

Extreme natural events may affect the project and have associated social and/or environmental consequences. These include earthquakes, landslides, storms, flooding and drought. Natural events may cause an environmental or safety incident at the mine such as infrastructure failure, which in turn can have environmental and social impacts. This section discusses the potential for extreme natural events to occur in the project area and Section 7.4 discusses the project incidents that may eventuate as a result of these extreme natural events.

7.3.1 Climate change

Climate change has the potential to exacerbate certain natural hazards, including storms, flooding and droughts. Myanmar has been the second most affected country by extreme weather events between 1999 and 2018 (Germanwatch, 2020). Future climate change is expected to impact Myanmar, with changes in precipitation and temperature anticipated. The project is located within the Eastern Hilly Region of Myanmar, which receives the lowest annual precipitation in Myanmar, and the lowest wet-season and hot-season precipitation (Horton et al., 2017). Precipitation is predicted to increase annually and in the wet seasons in the 2011 to 2041 period compared to baseline rates (Table 7.4). In the same period, there is a possibility precipitation may either increase or decrease from baseline rates in the hot season and cool season with the magnitude of increases greater than predicted decreases. Temperature is predicted to increase annually and in all seasons in the 2011 to 2041 period compared to baseline temperatures (Table 7.4).

Table 7.4 Projected changes in precipitation and temperature in the Eastern Hilly Region in the 2011 to 2040 period compared to average precipitation and temperature between 1980 and 2005

	Annual		Hot Season (March to May)		Wet Season (June to October)		Cool Season (November to February)	
	Low	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**
Precipitation (% change from baseline)	0	+10	-11	+11	+2	+12	-2	+9
Temperature (°C change from baseline)	+0.7	+1.2	+0.9	+1.4	+0.6	+1.2	+0.7	+1.3

Source: Horton et al. (2017)

7.3.2 Earthquakes and landslides

The project lies within an area of moderate seismic activity, with several major faults nearby, such as the Sagaing Fault, which is 150 km to the west. The project is located in the Bawdwin Fault Zone, with minor faults mapped within the vicinity of the mine. Knight Piésold (2020b; Appendix A) carried out a seismic analysis for the project, as input to the design of open pit slopes, TSFs and the Wallah waste rock dump. Their assessment indicates that the nearby Kyaukme Fault and Lashio Fault typically experience earthquakes lower than magnitude 4.5. The region could expect to experience a maximum seismically-induced peak ground acceleration (PGA) of approximately 0.15 g to 0.2 g units of gravity) with a recurrence interval of 50 years (WMM, 2019). The means the maximum acceleration of the ground during an earthquake that occurs on average once every 50 years is 15% to 20% of the average acceleration of earth due to gravity. Seismic hazard modelling has indicated the maximum credible earthquake (MCE) which could feasibly occur in Bawdwin has a peak ground acceleration of 0.35 g (Knight Piesold, 2020b). The MCE represents the maximum possible ground acceleration during an earthquake based on available seismic and tectonic information.

Landslides may occur as a result of sustained heavy rainfall, earthquakes and slope instability. Landslides caused by floods have been known to occur in the Eastern Hilly Region of Myanmar (Horton et al., 2017). There is little evidence of large slips in the Nam Pangyun, ER and Wallah valleys; however, large landslides may obstruct watercourses, reducing surface water flows should they occur. Landslides have occurred in the Thabeikkyin area, approximately 140 km west of Bawdwin, in 1991 and the Shwebo area, approximately 175 km southwest of Bawdwin, in 2012 as a result of earthquakes on the nearby Sagaing Fault (Knight Piésold, 2020b).

The steep terrain and high rainfall frequently induce landslips along the Namtu-Manton Road (Valentis 2020). This road will be used to a limited extent during construction. The landslip risk varies along the main route between Bawdwin mine and Lashio that will be used for the transport of materials, consumables, equipment and personnel to site and export of concentrate to National Highway 3 in accordance with different terrain. Some sections are in steeper terrain and may be susceptible to slips whilst others are in gentle or rolling terrain and are therefore at lower risk.

Earthquakes and landslides have the potential to cause the following project related events:

- Damage to project facilities, including failure of the tailings storage facilities (TSFs), Wallah waste rock dump, water storage dams, open pit wall and pipelines. Such an event was observed in August 2020 when a landslide on the valley flank supporting Namtu-Manton Road damaged the head of the Nam La flume and the weir head. The flume has since been repaired.
- Damage to project facilities, vehicles or equipment, resulting in uncontrolled release of contaminated materials, hazardous materials or product concentrate into the environment, posing a risk to the environment and human health.

The risk of these events occurring are assessed in Section 7.4.

7.3.3 Storms and flooding

Whilst projected changes in cyclone severity and frequency remain uncertain, flooding is known to occur in the Eastern Hilly Region (Horton et al. 2017) and specifically in the Myitnge River basin due to heavy rainfall associated with low pressure waves from monsoons moving across the country (DOMH, 2019). There is little evidence of major flooding occurring in Namtu, with flooding in the Myitnge River at the monitoring station near Hsipaw recorded every 1 in 50 years (2%). This is likely due to the deeply incised valley restricting flooding extent. However, high water levels were observed in Myitnge River in August 2020 with some localised flooding north of Namtu. Contrastingly, flooding has been recorded in the Myitnge River in 78% of years between 1972 and 2016 at the monitoring station closer to central Myanmar (DOMH, 2019). In 2015, unusually heavy rainfall during the monsoon season followed by Cyclone Komen caused severe flooding and associated landslides across Myanmar, affecting 12 states and regions, including Shan State (Kawasaki et al., 2017; DOMH, 2019).

Anecdotal evidence suggests high rainfall has the potential to damage infrastructure located on or near watercourses, with the Nam La weir controller indicating the Nam La flow rate and level rises rapidly during storm events with high rainfall. This has historically resulted in damage to the Nam La flume and a bridge of the Namtu to Tiger Camp railway. The intensity of the storm is evidenced by the movement of large boulders down the watercourse.

The probable maximum precipitation (PMP) storm event for Bawdwin has been modelled as 485 mm per 24 hours, representing the theoretical maximum amount of precipitation that could be expected in a 24-hour period under modern meteorological conditions (Knight Piésold, 2020c).

Storms and flooding have the potential to cause the following project related events:

- Damage to project facilities, including failure of the TSFs, WRD, water storage dams and open pit wall.
- Damage to project facilities resulting in uncontrolled release of contaminated materials into the environment, posing a risk to the environment and human health.

The risk of these events occurring are assessed in Section 7.4.

7.3.4 Drought

Droughts or extended periods of lower than normal rainfall may occur and impact the project. Parts of Myanmar have experienced droughts recently, with a significant drought in 2010 causing water shortages in several parts of Myanmar (Yi et al., 2014). Increases in drought frequency may be associated with increases in temperature due to climate change, however droughts may not always be accompanied by decreased precipitation (Horton et al., 2017).

Droughts may reduce the availability of water for the project, which requires 150.9 m^3/hr or 2.8 M m^3 at steady state operations (WMM, 2020). These large amounts of water will be collected during the wet season, stored in dams and used year-round. Abnormally dry wet seasons may not provide sufficient water to be drawn down over the dry season.

Average annual rainfall was calculated by Knight Piésold as 1,568 mm, with a 1 in 100 dry average recurrence interval (ARI) as 1,065 mm and 1 in 100 wet ARI as 2,066 mm. Water balance modelling indicates the Nam La water storage dam capacity of 1.13 M m^3 will be adequate to prevent water shortfalls under 1 in 100 ARI dry conditions. Should 1 in 100 ARI dry conditions occur in any year between Years 5 and 10, make-up water will be supplied to the process plant from the Nam La water harvest dam at rates of between 35,000 m^3 and 141,000 m^3 per year. Downstream of the abstraction point and dam, communities in Namtu source potable water from the Nam La. Abstraction of water from the Nam La to the Nam La water harvest dam during unanticipated dry conditions may result in reduced flows in the Nam La, thus reducing the amount of water available for communities.

Consequences

The potential consequences of this hazard include:

- Reduced water supply, potentially putting pressure on water resources, including limited drinking water supply for local communities in Namtu, and raw water for project activities.

Management measures and design controls

Management measures and design controls implemented to reduce the consequences of droughts and likelihood of consequences are to:

- Conduct scenario planning for drought circumstances to consider during detailed design phase.
- Design the project with multiple water sources.
- Conduct further work to estimate the baseline flows of the Nam La to quantitatively assess impacts to existing water supply to Namtu and potential ecological effects of reduced stream flow. Investigate options to supplement Namtu water supply if predicted to have impact under possible scenarios due to the project.

Assessment of risk

The risk of droughts has been assessed considering the consequences and likelihood of the consequences occurring. The consequences are considered severe, and are unlikely to occur, resulting in an overall risk that is assessed to be **moderate** (Table 7.5).

Table 7.5 Risk assessment of droughts

Hazard	Consequences	Likelihood	Overall Risk
Drought	**Severe** Potential temporary impacts to the Namtu community due to reduced water supply	**Unlikely** Unlikely to occur but possible	**Moderate**

7.4 Mining industrial hazards

Mining industrial hazards and risks are related to the design or operation of the project. This includes events which may be induced by the extreme natural events outlined above. An earthquake or extreme rainfall event with magnitudes above design allowances (MCE and PMP, respectively) have the potential to result in failure of infrastructure, including the TSFs and dams.

7.4.1 Vehicle accident

In Myanmar there has been a dramatic increase in the number of road fatalities and injuries, more than doubling between 2008 to 2016 with the number expected to double again by 2020 (noting that these are likely under estimates do to under-reporting). Key factors underpinning the rapid increase in road fatalities and injuries includes the rapid increase in motorization being experienced, the large proportion of motorbikes, bicycles and pedestrians using roads, and the poor condition of roads (Wegman et al., 2017; ADB, 2016).

The road infrastructure is particularly unsafe for pedestrians and those travelling on motorbikes. There is little in the way of pedestrian facilities; footpaths are often non-existent along high-speed sections of road and pedestrian crossings are considered inadequate. Signage for drivers, alerting to the presence of pedestrians, is also lacking, with no appropriate advanced signage, no signage at pedestrian crossings and no lighting. Driver behaviour also contributes to the unsafe roads, as there is little emphasis on safety in the country. Speeding and not giving way to pedestrians is common, as is driving while under the influence of alcohol. Many motorcyclists often do not wear helmets (ADB, 2016).

The project requires the use of heavy and light vehicles, including 25 light vehicles/buses, and truck fleets for transporting supplies and concentrate. The route between Bawdwin and Lashio primarily comprises public roads and will be utilised during project activities for the transport of materials, consumables, equipment and personnel to site and export of concentrate from the site. Project activities will increase the traffic on these roads and add additional pressure to existing roading infrastructure, consequently increasing the risk of vehicle accidents.

Vehicle accidents on roads within the mine concession area may have consequences for mining personnel, equipment and infrastructure. Vehicle accidents on public roads may have implications for the general public and infrastructure and buildings unrelated to the project.

Vehicle accidents on public roads may have implications for the general public and infrastructure and buildings unrelated to the project. These trucks may transport hazardous materials, including concentrate, fuel and reagents required during the operation phase of the project. Over the mine life there is expected to be an additional 20 (year 1) to 93 (year 12) trucks per day associated with the project. Compared to the baseline traffic report (Valentis, 2020), this represents up to a 69% increase the number of trucks passing through Namtu on weekdays, and up to a 190% increase in the number of trucks passing through the Man Sam western junction on weekdays.

Consequences

The potential consequences of accidents involving project-related vehicles include:

- Potential injuries or fatalities to project and non-project related people.
- Damage to project and non-project related infrastructure and property.
- Social tension between affected parties and mining personnel/authorities (see Section 7.6).

- Environmental contamination, if the accident results in spills of hazardous materials.

Management measures and design controls

Management measures and design controls implemented to reduce the likelihood and consequences of vehicle accidents are to:

- Implement the Traffic and Transport Management Plan and Hazardous Materials Plan when hazardous materials are involved.
- Use only competent and licenced WMM (and contractor) drivers.
- Establish and enforce speed limits on project roads and for project vehicles on public roads.
- Conducting regular vehicle inspections.
- Deliver a program to project-affected communities including schools in project-affected communities to raise awareness of road and traffic risks to safety, and personal behaviours which can reduce risk and improve safety.
- Operate a grievance mechanism that all project-affected communities have access to.
- Conduct a hazard and operability study (HAZOPS), which is a structured and systematic examination of a complex planned or existing process or operation, in order to identify and evaluate hazards that may represent risks to personnel, equipment or the environment.
- Design and construct haul roads and access roads to international standards.
- Equip special purpose vehicles such as fuel trucks with equipment necessary to respond to an accident that may result in a spill.
- Maintain project roads to a suitable and safe standard.
- Install signage to advise road users of safe operating speeds and conditions.
- Develop a risk-based spill prevention and response plan to reduce risks to as low as reasonably practical.
- Create an Emergency Response Team and include spill response in the team's responsibilities. Specifically:
  - Equip the team with reference material, spill response and decontamination equipment (including PPE), using a risk-based approach that is appropriate to the nature of hazardous materials on site
  - Train the team in spill response techniques and implement regular practice of those techniques
- Establish arrangements to mobilise additional resources for responding to larger spills and strategies for deployment.

Assessment of risk

The risk of vehicle accidents has been assessed taking into consideration the consequences and likelihood of the consequences occurring (Table 7.6). The high risk of vehicle accidents is common across the mining industry and will be managed through implementation of good industry practice, as outlined above.

Table 7.6 Risk assessment of vehicle accidents

Hazard	Consequences	Likelihood	Overall Risk
Vehicle accident	**Major** Potential fatalities and/or severe injuries	**Unlikely** Unlikely to occur but possible	**High**
	Minor	**Unlikely**	**Low**

Hazard	Consequences	Likelihood	Overall Risk
	Minor impacts to community with respect to damage to infrastructure and property, and associated social tension	Unlikely to occur but possible	
	Minor Accidents resulting in spills and leaks causing localised environmental contamination which are easily remedied	**Probable** May occur during the project life	**Moderate**

7.4.2 Tailings storage facility failure

Tailings will be stored in three interconnecting tailings storage facilities (TSFs). TSF A and B have capacity to store up to 8.2 Mt and 9.1 Mt of tailings, respectively. TSF C has capacity to store 7.9 Mt of tailings and 7.3 Mt of waste rock (including up to 1.5 Mt of PAF waste rock).

Tailings are not expected to be net acid forming, however are expected to have high concentrations of metals and metalloids. Geochemical analysis of tailings by Knight Piesold (2020a) indicates the enrichment of several metals, including concentrations of arsenic, cadmium, lead and nickel that exceed the health standards adopted by Knight Piésold, and concentrations of antimony, arsenic, cadmium, chromium, cobalt, copper, nickel, silver, zinc, sulfur and sulfate that exceed the ecological soil standards adopted by Knight Piésold.

Failure of the TSFs may occur as a result of seismic events which are greater than accounted for in the design criteria, geotechnical failure of the embankments, failure of the underdrains and decant return, or landslides.

The TSF seismic design parameters recommended by Knight Piésold follow ANCOLD guidelines and consider an operating basis earthquake (OBE) for normal operations, a safety evaluation earthquake (SEE) for extreme (dam safety) conditions during operations, and a maximum credible earthquake (MCE) for post-closure stability (Knight Piésold, 2020b). These parameters are outlined in Table 7.7.

Table 7.7 Recommended seismic design criteria (Knight Piésold, 2020b)

Design earthquake	Annual exceedance probability	Distance from site (km)	Magnitude	Peak ground acceleration (g)
OBE	1 in 1,000	15	7.1	0.25
SEE	1 in 5,000	10	8.2	0.50
MCE	Same as SEE (1 in 10,000)	10	8.2	0.50
Structural design	2,500	10	7.5	0.34

The TSF design was informed by seismic hazard assessment (Knight Piésold, 2020b) and assessing the consequence of dam failure as per ANCOLD guidelines for Dam Failure Consequence Category and Environmental Spill Consequence Category (Knight Piésold, 2020c). The overall severity of TSF failure was deemed major by Knight Piésold based on medium impacts to other infrastructure, public health, a medium affected area and duration; major impacts to business; and minor impacts to the natural environment. The ANCOLD Consequence Category is a 'High B' considering the overall severity level and population of less than 10 to 100 at risk. The severity of a tailings dam spill (from each TSF) was considered minor, based on the minor impacts to infrastructure, business, public health, and natural environment, and minor area and duration. The ANCOLD Consequence category is a 'High C' considering the overall severity level and population of less than 10 to 100 at risk. This risk assessment allows the design criteria to manage the identified risks.

The TSFs are be designed to withstand a probable maximum flood (PMF) event of a 1:1,000 72 hr flood (or PMP before spillway is built) (Knight Piésold, 2020). Blockage or failure of the TSF spillway may reduce the ability of the TSF to withstand a PMF event and may lead to more significant failure of the dam.

As the tailings embankment dams are adjacent and connected, failure of TSF A and B could subsequently lead to the failure of TSF C (Knight Piésold, 2020c). Failure could result in tailings (and PAF waste rock in the case of TSF C) entering the open pit and/or Nam Pangyun catchment.

Consequences

The potential consequences of TSF failure include:

- Potential injuries or fatalities to project and non-project related people.
- Damage to mine pit and subsequent temporary or permanent mine closure.
- Damage to project and non-project related infrastructure, equipment and buildings.
- Damage to terrestrial/aquatic habitat by tailings causing smothering or introduction of elevated levels of contaminants to waterways/soils.
- Contamination of drinking water supplies for local communities.

Management measures and design controls

Management measures and design controls that will be implemented to reduce the likelihood and consequences of TSF failure are to:

- Resettlement of Bawdwin concession communities to remove these communities from the physical impacts and risks associated with the project in the long term.
- WMM will comply with the Global Industry Standard on Tailings Management (ICMM et al., 2020) in relation to design, construction, operation, monitoring, management, governance, emergency response and community consultation of the TSF facilities, including associated water quality treatment plant. This will include implementation of Construction vs Design Intent Verification (CDIV), which will ensure that design intent is implemented and continues to be met in the case that site conditions vary from design assumptions. It will also involve preparation and implementation of an Operations, Maintenance and Surveillance (OMS) Manual that outlines critical controls for safe TSF operations and allows tracking.
- Design the dimensions, embankments, benches, and sediment dams associated with the TSFs and waste rock dump based on detailed assessment of site conditions and in line with relevant Australian guidelines and design principles outlined in the Global Industry Standard on Tailings Management (ICMM et al., 2020) and with sufficient factors of safety (see Chapter 4 Project Description). This will involve developing a design that considers the technical, social, environmental and local economic context, the results of risk analysis for TSF failure scenarios, site conditions, water management, mine operations, construction issues and requirements for safe closure.
- Incorporate geotechnical earthquake and slope stability studies and analysis, including drilling and the seismic hazard assessment, into the TSF design.
- Design TSFs to include a spillway to prevent accumulation of water, allowing rainfall runoff from a 24-hour duration PMP storm (485 mm in 24 hours) to safely pass.
- Design the embankment crest height in stages 1 and 2 to take into account the supernatant pond under 1 in 100 year ARI wet conditions, along with probably maximum precipitation (PMP inflow) and allow an extra metre of height as a contingency (Knight Piésold, 2020c).
- Design the embankment crest height in stage 3 to take into account the 1 in 100 year ARI wet conditions, 1 in 100 ARI 72 hour inflow, 1 metre of contingency freeboard, PMP spillway depth, and 1 metre dry freeboard (Knight Piésold, 2020c).

- Ensure the TSF geotechnical design and hydraulic design criteria are aligned with ANCOLD guidelines for large dams.
- Incorporate a factor of safety (FoS) into the design for the Bawdwin TSF embankments (Chapter 4) that is greater than the minimum values for tailings facilities recommended by ANCOLD guidelines. This has been adopted in the Tailings and Waste Rock Management DFS Design Report (Knight Piésold, 2020c) and stability modelling confirms that the desired FoS is effective.
- Monitor the TSFs with a series of inclinometers to monitor settlement and internal movements within the foundations and embankments fill.
- Monitor groundwater levels and quality with two pairs of monitoring bores at the downstream toe of each TSF embankment.
- Develop a comprehensive TSF monitoring plan, including deformation, saturation levels, pore pressures, groundwater level and quality, internal deformation and settlement (Knight Piésold, 2020c).
- Select the TSF sites considering the required height of facilities into account, contributing to the decision to construct three adjacent facilities.
- Implement measures to manage vibration as outlined in Section 6.7.

Assessment of risk

The risk of TSF failure has been assessed considering the consequences and likelihood of the consequences occurring (Table 7.8). The high risk of TSF failure is common across the mining industry and will be managed through implementation of good industry practice, as outlined above.

Table 7.8 Risk assessment of tailings storage facility failure

Hazard	Consequences	Likelihood	Overall Risk
TSF failure	**Minor** According to ANCOLD severity level assessment (Knight Piésold, 2020c) degraded land would be affected and would likely be able to be remediated	**Remote** Not anticipated to occur	**Moderate**
	Extreme Multiple injuries and/or fatalities	**Remote** Not anticipated to occur	**High**
	Major Long-term damage to terrestrial and/or aquatic habitats	**Remote** Not anticipated to occur	**Moderate**
	Minor Contamination of drinking water supplies impacting local communities	**Remote** Not anticipated to occur	**Low**
	Severe Moderate impacts to the community through mine closure or damage to infrastructure and property	**Remote** Not anticipated to occur	**Low**

7.4.3 Wallah waste rock dump failure

The project is expected to produce 163.9 Mt of waste rock, the majority of which will be stored in the Wallah waste rock dump. The waste rock dump design incorporates benches, batters and ramps (see Section 4.7.2 Waste dump design). Modelling by Knight Piésold (2020c) indicated that most likely form of failure of the Wallah waste rock dump would be localised landslips associated with individual benches. Geochemical characterisation of waste rock by Knight Piésold determined sample waste material was highly enriched in silver, arsenic, lead and antimony, and significantly enriched in bismuth (Knight Piésold, 2020d). At present it is proposed that PAF waste rock will be stored under water in TSF C (Section 7.4.2). However, WMM will continue to assess the possibility of storing PAF waste rock within encapsulated cell(s) within the waste rock dump.

Failure of the Wallah waste rock dump could occur during a seismic event exceeding the design criteria. Additionally, flows from rainfall greater than a 1 in 1,000 ARI 24-hour storm event may result in the erosion of waste which the sediment dams cannot contain, resulting in additional metal enriched sediments entering the Nam Pangyun. Stability criteria and FoS were determined based on the consequence of failure and low confidence level in input parameters. The consequence of failure was deemed low during operations and high after closure (Knight Piésold, 2020c). Stability assessments to determine the waste dump stability acceptance criteria indicated the FoS of the waste rock dump are greater than the minimum FoS criteria (Table 7.9).

Table 7.9 Waste rock dump stability assessment results and minimum FoS values

	Modelled drained FoS	Minimum drained FoS	Modelled undrained FoS	Minimum undrained FoS	Modelled post-seismic FoS	Minimum post-seismic FoS
Operation	1.77	1.3	1.46	1.1	1.36	1.05
Closure		1.5		1.5		1.15

Failure caused by instability is unlikely to occur during project operations as minor failures or instabilities that are detected are able to be remediated prior to significant failure. After closure, it is more likely that developing instabilities will not be remediated, increasing the risk of failure and resulting in waste material entering the Nam Pangyun catchment (Knight Piésold, 2020c). Additionally, after the mine is closed, further development and changes in land use in the Nam Pangyun valley downstream of the waste rock dump may occur.

Consequences

The potential consequences of failure of the Wallah waste rock dump include:

- Damage to downstream infrastructure after mine closure may occur if local residents utilise the surrounding area after closure.
- Downstream contamination (total suspended solids, particulate and dissolved metals) in the Nam Pangyun catchment which may cause environmental degradation (including harm to aquatic habitat and ecosystems), and deterioration of the quality of potable water.
- Contamination of land and potential harm to terrestrial habitat and ecosystems.
- Potential injuries or fatalities to project and non-project related people.

Management measures and design controls

Management measures and design controls implemented to reduce the likelihood and consequences of failure of the Wallah waste rock dump are to:

- Resettlement of Bawdwin concession communities to remove these communities from most of the physical impacts and risks associated with the project in the long term.
- Install a series of inclinometers to monitor settlement and internal movements within the waste rock dump, foundations and embankments fill.
- Design the waste rock dump so surface drains can safely pass flows generated from a 1 in 1,000 year ARI 24-hour storm event (187.5 mm, note that the PMP is 485 mm (Knight Piésold, 2020c) and maximum daily recorded rainfall between 2000 and 2018 in Bawdwin was 108.7 mm (Coffey, 2020)).
- Design waste rock dump sediment dams as a cascade system, to reduce the likelihood of downstream flash flooding occurring during periods of heavy rainfall.
- Design the waste rock dump in accordance with appropriate guidelines (Knight Piésold, 2020c).
- Construct and operate Wallah waste rock dump in accordance with detailed designs and operating manual.
- Progressively revegetate inactive areas of the waste rock dump and conduct final rehabilitation of the site after mine closure.
- Cover the front face of the dump with a 25 m wide external surface layer of fresh waste to improve geotechnical stability and reduce the long-term erosion potential.

Assessment of risk

The risk of failure of the Wallah waste rock dump has been assessed considering the consequences and likelihood of consequences occurring (Table 7.10).

Table 7.10 Risk assessment of the failure of Wallah waste rock dump

Hazard	Consequences	Likelihood	Overall Risk
Failure of the WRD	**Major** Potential injuries or fatalities	**Remote** Not anticipated to occur	**Moderate**
	Minor (operations) Localised, short term environmental contamination affecting Nam Pangyun, and terrestrial and aquatic ecosystems	**Remote** Not anticipated to occur	**Low**
	Major (after closure) Potential long term environmental contamination with no rectification	**Remote** Not anticipated to occur	**Moderate**
	Severe (after closure) Moderate impacts to community due to damage of infrastructure, property after project closure	**Remote** Not anticipated to occur	**Low**

7.4.4 Water storage dam failure

The project has three main water storage dams. The existing Nam Pangyun Reservoir will be upgraded and two new dams will be constructed, the Nam La raw water dam and TSF A diversion dam. Failure of the dams may occur due to geotechnical failure, earthquakes exceeding the design criteria, or blocking of the spillway and eventual embankment failure.

Stability analyses of the proposed Nam La water harvest dam has not yet been conducted as geotechnical investigation of the site is still required (Knight Piésold, 2020c). Hence the facility has been conservatively designed. Failure of the Nam La water harvest dam could result in the loss of up to 1,125,840 m^3 water.

The Nam Pangyun Reservoir will be upgraded to have a capacity of 483,390 m^3. Stability analyses by Knight Piésold (2020c) determined the Nam Pangyun Reservoir upgrade will have acceptable FoS values. Failure of the dam could result in the loss of water and inundation of the Nam Pangyun valley.

A smaller diversion dam will be constructed on the northwestern arm of TSF A, to intercept water flowing from upstream in the catchment and divert it around the TSF, thereby reducing run-on to the dam. The dam also provides an opportunity to pump the accumulated water for use as process water. Knight Piésold, (2020c) have designed an embankment based on the same features used for the Nam La water harvest dam. Failure of the dam could result in the loss of water into the Nam Pangyun catchment.

Overtopping of dams may occur during operations and after closure if the PMF (probable maximum flood) is exceeded, potentially causing downstream flooding.

Consequences

The potential consequences of failure of the Nam La water storage dam include:

- Loss of water with the potential to limit the ability to maintain compensation flows in the Nam La.
- Loss of water from the Nam La water storage dam, resulting in downstream flooding and potential injuries and/or fatalities.

The potential consequences of failure of the Nam Pangyun reservoir and TSF A diversion dam include:

- Loss of water from the reservoir, resulting in downstream flooding and potential injuries or fatalities.

Management measures and design controls

Management measures and design controls implemented to reduce the likelihood and consequences of water storage dam failure are to:

- Design dams in accordance with the recommended seismic design criteria (Knight Piésold, 2020).
- Design dam spillways to safely pass a probable maximum flood event.

Assessment of risk

The risk of failure of the water storage dams have been assessed considering the consequences and likelihood of the consequences occurring (Table 7.11).

Table 7.11 Risk assessment of water storage dam failure

Hazard	Consequences	Likelihood	Overall Risk
Nam La water storage dam failure	**Severe** Moderate impacts to communities due to reduced flows (and water supply) in the Nam La and/or flooding	**Remote** Not anticipated to occur.	**Low**
	Major Potential injuries and/or fatalities	**Remote** Not anticipated to occur.	**Moderate**
Nam Pangyun Reservoir water storage dam failure	**Major** Potential injuries and or fatalities	**Remote** Not anticipated to occur.	**Moderate**
TSF A diversion dam failure	**Major** Potential injuries and or fatalities	**Remote** Not anticipated to occur.	**Moderate**

7.4.5 Pit wall failure

The existing open pit will be expanded from 21.9 ha to 98.2 ha. The open pit comprises a series of benches and batters, with haul roads connecting the benches. Recommended geotechnical designs for the open pit lithologies are outlined in Section 4.5 Mining (Table 4-5). Modelling and slope stability analysis indicated the pit design is stable, exceeding the acceptance criterion of a FoS of 1.3. After closure of the mine, the pit will fill with surface water inflow and groundwater recharge, resulting in a permanent pit lake.

During operations and after closure, failure of the pit wall could occur as a result of heavy rainfall leading to landslips. During operation or post-closure, failure could be caused by an earthquake causing a section of wall to collapse. After closure once the pit lake is filled this could result in a wave of poor-quality water from the pit-lake spilling into the Nam Pangyun catchment. This may cause downstream flooding and contamination in the Nam Pangyun catchment.

Consequences

The potential consequences of failure of the pit wall during operations include:

- Potential injuries or fatalities to non-project related people.
- Temporary or permanent mine closure.

The potential consequences of failure of the pit wall after project closure include:

- Potential injuries or fatalities to non-project related people.
- Disturbance to terrestrial and aquatic habitats and ecosystems.
- Contamination of watercourses and groundwater systems.

Management measures and design controls

Management measures and design controls implemented to reduce the likelihood and consequences of pit wall failure include:

- Incorporating the results of slope-stability modelling and testing into the slope designs, based on ongoing geotechnical and hydrological data collection throughout the life of mine.
- Implement measures to manage vibration as outlined in Section 6.7.

Assessment of risk

The risk of failure of the pit wall has been assessed taking the consequences and likelihood of consequences occurring into consideration (Table 7.12).

Table 7.12 Risk assessment of failure of the pit wall

Hazard	Consequences	Likelihood	Overall Risk
Failure of pit wall (operations and after closure)	**Major** Potential injuries/fatalities	**Remote** Not anticipated to occur.	**Moderate**
	Severe Mine closure causing moderate impacts to communities	**Remote** Not anticipated to occur.	**Low**
Failure of pit wall (after closure once the pit lake is filled)	**Major** Potential long-term effects to the environment, including disturbance to habitats and ecosystems and contamination of waterways	**Remote** Not anticipated to occur.	**Moderate**
	Major Potential injuries/fatalities	**Remote** Not anticipated to occur.	**Moderate**

7.4.6 Pipeline breaks

Tailings slurry and decant water will be transported between the process plant and the TSFs through HDPE pipes located within bunded corridors. As described in Section 7.4.2, the tailings are expected to be enriched in heavy metals. Decant water is the supernatant water from the TSFs, which is expected to be of poor quality, with elevated levels of metals.

Pipeline breaks may occur as a result of pipe degradation, malfunction, accidental or deliberate interference, or by earthquakes greater than the design of the pipeline allows. The degree of failure may vary from a leak to full loss of containment.

Failure of the pipeline transporting tailings slurry and decant water between the process plant and the tailings storage facilities could result in the release of poor-quality tailings or decant water into the surrounding environment.

Consequences

Consequences will vary based on the severity of the break (i.e., leaking, or total loss of containment). The bunded corridor is designed to contain most spills and leaks, limiting the extent of failure. The potential consequences of pipeline breaks include:

- Contamination of waterways or soils, with subsequent impacts on aquatic or terrestrial habitats and ecosystems, and potable water supply.
- Temporary or permanent project closure.
- Potential minor injuries or illness of project personnel.

Management measures and design controls

Management measures and design controls implemented to reduce the likelihood and consequences of pipeline breaks and reduce the likelihood of consequences occurring are to:

- Comply with the Global Industry Standard on Tailings Management (ICMM, 2020) in relation to design, construction, operation, monitoring, management, governance, emergency response and community consultation of the TSF facilities, including associated water quality treatment plant.
- Design pipelines to be able to contain spills, including the use of HPDE pipes and bunded corridors to contain spills.
- Implement a maintenance regime to reduce likelihood of breaks occurring
- Regularly monitor the tailings pipeline for leaks, ruptures or failures and, in the event of such failures, implementing shutdown procedures.
- Monitor pump pressure and flows to assist with detecting leaks or blockages within the tailings pipeline.
- Regularly complete visual inspections of the pipeline during operations.
- Ensure there are provisions for emergency containment in the event of pipeline failure.
- Use seismic data and geohazard assessment, including test pit and drilling data, to inform route selection and subject it to third party independent design review.

Assessment of risk

The risk of pipeline breaks has been assessed taking the consequences and likelihood of the consequence occurring into consideration (Table 7.13).

Table 7.13 Risk assessment of pipeline breaks

Hazard	Consequences	Likelihood	Overall Risk
Pipeline breaks	**Severe** Localised contamination of the environment, including contamination of soils and waterways.	**Unlikely** Unlikely to occur but possible	**Moderate**
	Minor Potential temporary mine closure may have short-term minor effects on communities	**Remote** Not anticipated to occur	**Low**
	Minor May cause illness or injury to project personnel requiring first-aid	**Unlikely** Unlikely to occur but possible	**Low**

7.4.7 Chemical spills, leakages and unintended releases of hazardous materials

Hazardous materials such as diesel, fuel, oils, lubricants and processing reagents will be transported to and within the project area and stored on site for use. Handling of hazardous materials such as chemicals, fuels, lubricants and oils will be at its peak during construction, and the bulk of the hazardous materials will be handled and stored at key construction areas including the power station, process plant, ROM pad and mine services area, explosives facility and accommodation camp. Processing reagents include sodium metabisulfite, sodium cyanide, sodium ethyl xanthate and copper sulphate. Chapter 4 outlines the volumes of each hazardous substance to be stored.

During construction, spills and leaks have the highest likelihood of occurring around key construction areas. During operations, spills and leaks could occur around the process plant as large volumes of process reagents will be stored at this site. The process plant is located on the catchment divide between the Nam Pangyun and Nam La catchments and represents a risk to both catchments. Localised spillage of fuels and oils could also occur during both construction and operations around road and vehicle fuelling and warehouse areas.

Accidental spills or leaks have the potential to occur in the construction and operations phase of the project during transport or storage as a result of equipment failure or operator error, or as a result of vehicle accidents (see Section 7.4.1). This may include spills or leaks of lead and zinc concentrate during export.

Contamination of soils may occur as a result of uncontained spills or leaks of hazardous materials. Contamination of shallow groundwaters or surface water features may occur if contaminants seep to the water table or watercourse, respectively. People and biota may be exposed to hazardous materials through direct contact with the material or by exposure to contaminated soil or water.

Consequences

Consequences of large-scale accidental spills, leaks and unintended releases of hazardous materials will vary based on the amount and type of material and the location the incident occurs. Consequences to the Nam Pangyun catchment would be less severe than the Nam La or Myitnge River catchments due to the highly degraded nature of the stream. The potential consequences of chemical spills, leaks and unintended release of hazardous materials include:

- Large spills or leaks may cause contamination of soil or surface water, potentially affecting drinking water and terrestrial or aquatic habitats and biota.
- Depending on the type and extent of the release, spills and leaks may reduce the water quality within the saprolite or fractured rock aquifer and limit their ability to support groundwater-fed springs, aquatic ecosystems and other beneficial uses. Once the contaminant is cleared, aquifers are expected to recover.
- Increases in dissolved and particulate metal concentrations, TSS and turbidity in streams if material reaches watercourses.
- Potential illness to project and non-project related people.
- Adversely impacts to the soils' capacity to support vegetation growth, depending on the type and extent of the release.

Management measures and design controls

Management measures and design controls implemented to reduce the likelihood and consequences of chemical spills, leaks and unintended releases of hazardous materials are to:

- Meet and comply with good international practice for hazardous materials transportation, storage, handling and disposal.

- Store and handle hazardous materials including fuels, oils and chemicals in accordance with good international practice, including designing appropriately secured and bunded facilities to meet appropriate standards for storage of hazardous materials.
- Train personnel involved in the handling, transportation and storage of hazardous materials in hazardous materials management, transfer procedures and spill prevention and emergency response.
- Implement a hazardous materials management plan, detailing specific requirements for the handling, transport, storage and disposal of hazardous materials.
- Create an Emergency Response Team and include spill response in the team’s responsibilities. Specifically:
  - Equip the team with reference material, spill response and decontamination equipment (including PPE), using a risk-based approach that is appropriate to the nature of hazardous materials on site.
  - Train the team in spill response techniques and implement regular practice of those techniques.
- Refuel vehicles at designated sites and approved locations.
- Store processing reagents in the dedicated reagent shed.
- Bund zinc and lead concentrate areas to fully contain uncontrolled discharge.
- Regularly inspect hazardous materials storage facilities and work sites for accidental spills and leaks of hazardous materials.
- Treat and dispose of hazardous waste including chemicals, lubricants, oils and contaminated soil offsite using suitably qualified contractors.
- Treat and dispose of, or manage on site, contaminated soils based on the type and scale of contamination.
- Complete routine soil testing to identify contaminated soils and ensure they are not used for land rehabilitation.
- Monitor groundwater around the process plant to provide an early warning of potential groundwater contamination so that risk assessment and, if warranted, remediation efforts can be implemented to prevent impacts to groundwater receptors.
- Implement measures to manage vibration as outlined in Section 6.7.

Assessment of risk

With implementation of management measures, it is considered that accidental spills or leaks would be localised and able to be cleaned up without permanent impacts to land capability. With these management measures in place the likelihood of this incident occurring is probable.

The risk of chemical spills, leakages and unintended releases of hazardous materials has been assessed taking the consequences and likelihood of the consequences occurring into consideration (Table 7.14)

Table 7.14 Risk assessment of chemical spills, leakages and unintended releases of hazardous materials

Hazard	Consequences	Likelihood	Overall Risk
Chemical spills, leakages and unintended releases of hazardous materials	**Minor** Spills and leaks may cause localised, short term contamination to soils, waterways and aquifers, with potential impacts to terrestrial habitats and biota.	**Unlikely** Unlikely to occur but possible	**Low**
	Minor Illness or injury requiring hospital treatment	**Unlikely** Unlikely to occur but possible	**Low**

7.4.8 Fire and explosion

Flammable and explosive materials are required for project operations, including diesel, oils, fuels and explosives. Up to 10,000 kg of explosives can be stored in the emulsion and explosives magazine facility north of the proposed pit. These explosives will be transported and used for blasting during mining.

Potential causes of fire or explosions include electrical failures, equipment malfunctions, operator error, and accidental spills or leaks of flammable/hazardous materials. Fires that have the potential to affect the project may occur in periods of drought or in nearby communities. Dry conditions may enhance the magnitude of project- and non-project-related fires.

Explosions as a result of unexploded ordnance (UXO) are unrelated to the project and are not typically considered mining industrial hazards. Nonetheless, UXO is considered in the fire and explosion risk assessment as there may be the potential for UXOs to be encountered during project construction.

Explosions and fires generally have direct consequences to the environment they occur in, as well as consequences relating to the transport of emissions of burning contaminants by water or air.

Consequences

The potential consequences of fire and explosion include:

- Potential injuries or fatalities to project and non-project related people.
- Damage to buildings and infrastructure in nearby communities.
- Loss of terrestrial habitat and biota.
- Contamination of waterways, potentially affecting drinking water quality and aquatic habitat and biota.
- Reduced air quality from emissions from burning of contaminants.
- Potentially combustible emissions released from explosions.
- Temporary or permanent project closure.

Management measures and design controls

Management measures and design controls implemented to reduce the likelihood and consequences of fire and explosion are to:

- Store explosives in the emulsion and magazine facility located approximately 400 m from the mine pit, complying with Australian Standard 2187 1998 (Explosives - Storage, Transport and Use) to have a separation distance of 960 m to any vulnerable facility.
- Transport explosives in accordance with national regulations.
- Store and handling all flammable and combustible substances, including waste, under conditions that minimise the risk of fire and toxic emissions, in accordance with national regulations.
- Apply good international practice form the mining industry for all aspect of explosives management and usage.
- Specify plant and facility design criteria for fire prevention, detection, control and personnel safety requirements.
- Ensure that ‘hot works’ do not take place in the vicinity of flammable or combustible materials.
- Identify fire-fighting equipment suitable for the level of risk at hand, and regular maintenance and testing to ensure that this equipment remains in good working order.
- Implement a hazardous materials management plan, detailing specific requirements for the handling, transport, storage and disposal of hazardous materials.

Assessment of risk

The risk of fire and explosions have been assessed taking the consequences and likelihood of the consequences occurring into consideration (Table 7.15). The high risk of fire and explosions is common across the mining industry and will be managed through implementation of good industry practice, as outlined above.

Table 7.15 Risk assessment of fire and explosions

Hazard	Consequences	Likelihood	Overall Risk
Fire and/or explosions	**Major** Major effects to environment and nearby communities.	**Unlikely** Unlikely to occur but possible	**High**
	Major Potential injuries and/or fatalities.	**Unlikely** Unlikely to occur but possible	**High**
	Severe Moderate effects on communities due to damage to infrastructure.	**Unlikely** Unlikely to occur but possible	**Moderate**

7.4.9 Electrical failures, equipment malfunction and mechanical failures

A range of mining and processing equipment will be utilised throughout the project (outlined in Chapter 4 Project description), along with equipment for construction and dewatering.

Major electrical failures, equipment malfunction and mechanical failures may occur as a result of faulty equipment, malfunction, degradation or operator error and have the potential to cause fires (see Section 7.4.8), explosions (see Section 7.4.8), infrastructure failure, electrocution or other injuries.

Consequences

The potential consequences of electrical failures, equipment malfunction and mechanical failures include:

- Potential injuries or fatalities, particularly project workforce.

Consequences associated with fires and explosions are addressed in Section 7.4.8.

Management measures and design controls

Management measures and design controls implemented to reduce the likelihood and consequences of electrical failures, equipment malfunction and mechanical failures include:

- Maintain equipment in accordance with the manufacturers specifications.
- Follow applicable electrical standards/codes/legislation during all project phases, including design.
- Implement permit-to-work and lockout and tagout procedures in accordance with good international practice
- Avoid the use of the old transmission lines and connections, which would have higher electrocution risk.
- Ensure that employees, including electricians, at all levels receive appropriate training and are competent to safely carry out their duties and accountabilities.

Assessment of risk

The risk of major electrical failures, equipment malfunctions and mechanical failures have been assessed taking the consequences and likelihood of the consequences occurring into consideration (Table 7.16).

Table 7.16 Risk assessment of electrical failures, equipment malfunction and mechanical failure

Hazard	Consequences	Likelihood	Overall Risk
Electrical failures, equipment malfunction and mechanical failure	**Major** Potential injury/fatalities.	**Unlikely** Unlikely to occur but possible	**High**

7.4.10 Building failure

Mining-related ground vibration has the potential to affect the structural integrity of landform and buildings and may result in landslips and building damage and/or collapse, however this is an unplanned event given the implementation of management measures outlined in Section 6.7, including development and implementation of a Blast Management Plan (Attachment 4). Causes of vibration associated with the project (discussed further in Section 6.7) include:

- Construction earthworks.
- Blasting, drilling and excavation during mining operations.
- Compaction from vibratory rollers during construction.
- Heavy vehicle traffic.

Bawdwin lower village will remain until 40 to 42 months after commencement of the project (30 to 32 months after commencement of mining operations). During this time, vibration-generating activities, outlined above will be taking place. Due to the proximity of Bawdwin lower village to the open pit and mining activities (blasting and drilling), there is the potential for buildings to be damaged and/or collapse in response to vibration exceeding expected levels, or by ground vibration induced landslips.

Consequences

The potential consequences of building failure include:

- Potential injuries or fatalities.
- Damage to buildings and infrastructure in nearby communities.

Management measures

Management measures and design controls implemented to reduce the likelihood and consequences of vibration-induced building failure include:

- Implement measures to manage vibration as outlined in Section 6.7.3 and contained within the Blast Management Plan (Attachment 4).

Assessment of risk

The risk of vibration-induced building failure has been assessed taking the consequences and likelihood of the consequences occurring into consideration (Table 7.17).

Table 7.17 Risk assessment of vibration-induced building failure

Hazard	Consequences	Likelihood	Overall Risk
Building failure	**Major** Potential injury/fatalities.	**Remote** Not anticipated to occur.	**Moderate**
	Severe Moderate effects on communities due to damage to infrastructure.	**Remote** Not anticipated to occur.	**Low**

7.4.11 Blasting and fly rock

Blasting is required during open pit mining operations given not all material will be free dig. Blasting introduces the risk of overpressure, flyrock and vibration impacts to the project workforce and infrastructure, and nearby communities and private property, particularly Bawdwin lower village whose residents will remain for 30 to 32 months after commencement of mining operations.

Overpressure is a pressure wave in the atmosphere caused by the use of explosives and consists of both audible and inaudible energy measured in dB. Sudden increases in pressure can cause damage to pressure sensitive organs such as the lungs and ears. Fly rock is the unplanned projection of rock fragments beyond the blasting zone. Fly rock may travel large distances and therefore represents a safety risk to mine workers and Bawdwin lower village. Expected (i.e., residual) project impacts to receptors regarding vibration are assessed separately in Section 6.7. The risk of ground vibration resulting in building failure is outlined in Section 7.4.10 above.

Consequences

The potential consequences of blasting and fly rock incidents include:

- Potential injuries or fatalities.
- Temporary or permanent hearing loss.
- Damage to buildings and infrastructure in nearby communities.

Management measures

Management measures and design controls implemented to reduce the likelihood and consequences of blasting and fly rock incidents include:

- Resettlement of Bawdwin concession communities to remove these communities from most of the physical impacts and risks associated with the project in the long term.
- Development and implementation of a Blast Management Plan which includes site and project-specific measures to manage blasting and blasting-related impacts associated with mining operations.
- Compliance with statutory requirements regarding blasting and blasting-related impacts, including the criteria for overpressure and ground vibration stipulated in Myanmar EIA Guidelines.
- Establishment of an exclusion zone from the blast to be enforced by a clearance team who will inspect the blast radius, sound a pre-blast siren and warn surrounding personnel of the upcoming blast. The exclusion zone will be monitored and adapted as blasting practices, procedures and monitoring are optimised.
- Communication procedures with the project workforce and residents within the Bawdwin concession area regarding notification of scheduled blasting, and process for receiving and responding to complaints or grievances regarding blasting.
- Implement measures to manage vibration as outlined in Section 6.7.

Assessment of risk

The risk of fire and explosions have been assessed taking the consequences and likelihood of the consequences occurring into consideration (Table 7.18).

Table 7.18 Risk assessment of blasting and fly rock incidents

Hazard	Consequences	Likelihood	Overall Risk
Blasting and fly rock	**Major** Potential injury/fatalities	**Unlikely** Unlikely to occur but possible	**High**
	Severe Moderate effects on communities due to damage to infrastructure	**Unlikely** Unlikely to occur but possible	**Moderate**

7.5 Occupational and community safety and health hazards

Key occupational and community safety and health associated with open pit mining projects include exposure to hazardous substances (including chemicals and hydrocarbons and lead or other heavy metals in air, dust, water or soils), noise and vibration, use of explosives for blasting, fly rock, use of electrical systems and equipment, fatigue, work at height, slips, trips and falls, thermal stress, lifting and hoisting devices and moving machinery and vehicles. Given the proximity of Bawdwin lower village to open pit mining operations, industrial hazards such as blasting and fly rock have the potential to impact safety of nearby communities.

7.5.1 Consequences

The potential consequences of occupational safety and health hazards include:

- Potential injuries or fatalities.
- Temporary or permanent hearing loss.
- Acute or chronic illness or disease.

7.5.2 Management measures

The management measures associated with occupational health and safety hazards are primarily outlined in the Occupational Safety and Health Plan, Community Health and Safety Plan and Blast Management Plan (Attachment 4).

Additional measures can be found in the following sections:

- Air quality (Section 6.2).
- Noise and vibration (Section 6.7).
- Human health (Section 6.11).

Other commitments made by WMM regarding occupational safety and health (OSH) are as follows:

- WMM will fully comply with the Myanmar Occupational Safety and Health Law, 2019.
- Provide a working environment that is conducive to OSH.
- Place the management of OSH as a prime accountability of line management from the executive through management and employees.
- Comply with all relevant national, regulations, and other requirements as a minimum standard for WMM OSH practices and management procedures.
- Define OSH objectives on an annual basis and measure performance against those objectives.
- Maintain and continuously improve OSH management programs, standards and procedures to achieve the OSH objectives.
- Prevent occupational injuries, illness and other loss by adopting proactive hazard identification and a risk focused approach.
- Investigate all incidents to ensure remedial actions are identified and completed to prevent reoccurrence.
- Integrate OSH considerations into all designs and activities.
- Provide all necessary resources to enable compliance with OSH management procedures.
- Require all contractors to comply with WMM OSH policies and standards while undertaking work for WMM.
- Ensure that employees at all levels receive appropriate training, including in OSH and are competent to safely carry out their duties and accountabilities.
- Communicate and consult openly on OSH issues with all employees, contractors, OSH committees and other stakeholders to gain commitment to the implementation of the policy.
- Promote innovation and best practice to continually improve OSH performance.
- WMM will develop a OSH management system to give effect to the commitments in the WMM OSH Policy. Key aspects of this system will include:
  - A register of risks and focus on reducing risks to as low as a reasonably practicable.
  - An OSH Committee involving workers' representatives to review OSH issues.
  - OSH standards and procedures and training in these to relevant personnel.
  - Nominated persons with responsibility for OSH and an OSH team to provide guidance and monitoring of OSH performance, as shown in Figure F119.

- An emergency response plan.
- An emergency response team with responsibility for primary response to emergency situations.

7.5.3 Risk assessment

The risk associated with occupational health safety hazards have been assessed taking the consequences and likelihood of the consequences occurring into consideration (Table 7.19).

Table 7.19 Risk assessment of occupational health and safety hazards

Hazard	Consequences	Likelihood	Overall Risk
Falls from height	**Major** Potential injury/fatalities.	**Unlikely** Unlikely to occur but possible	**High**
Hearing loss	**Severe** Requires hospital treatment/ long term injury	**Unlikely** Unlikely to occur but possible	**Moderate**
Exposure to hazardous substances as a result of a spill, leak or incident	**Severe** Requires hospital treatment/ long term injury	**Unlikely** Unlikely to occur but possible	**Moderate**

7.6 Civil unrest and conflict

Ethnic armed groups control parts of Shan State, including areas close to the mine concession, and often clash with each other and the Myanmar military, posing a risk to project activities at Bawdwin. Armed conflict primarily occurs as groups fight for autonomy, resources and territory. The major groups in Northern Shan State are the Ta'ang National Liberation Army (TNLA), Shan State Army (SSA), Restoration Council of Shan State (RCSS), Myanmar Nation Democratic Alliance Army (MNDAA) and United Wa State Army (UWSA).

The Union Government of Myanmar has designated Self-Administered Zones within Shan State and initiated a Nationwide Ceasefire agreement (NCA), both aimed at curbing tension. Despite these efforts, armed conflict remains an issue in the State. Members of the SSA and TNLA reside in the villages surrounding Bawdwin, and conflict occurred between these two groups in the Mine Yin village tract in Namtu township in December 2017.

The project will involve the resettlement of Bawdwin and Tiger Camp villages. Conflict within communities could occur as a result of conflicts surrounding resettlement or as a result of changes in social structure and the distribution of wealth within local villages. Real or perceived inequality concerning employment, benefits, and wealth may cause conflict within or between social groups or communities. Additionally, tension may develop between new migrants employed by the project and local communities.

Grievances regarding the Bawdwin project may cause conflict between local communities and project authorities.

7.6.1 Consequences

Civil unrest or conflict and associated demonstrations or riots may result in:

- Potential injuries or fatalities.
- Damage to project and/or non-project related infrastructure and property.
- Impairment of wellbeing and security.

7.6.2 Management measures

Management measures and design controls implemented to reduce the likelihood and consequences of civil unrest and conflict include:

- Establish buffer zones and site access control strategies along the infrastructure corridor to control access to the mine site.
- Preferential use of local labour where possible to limit in-migration.
- Develop and follow the Community Health, Safety and Security Management Plan.
- Develop and implement a grievance management process to allow affected villages and workers to register any issues or other complaints.
- Engage displaced communities in resettlement planning and implementation, in a thorough, fair, equitable and transparent manner that fosters their full participation and respects human rights.
- Develop, implement and monitor compliance with a workforce code of conduct that governs internal workforce interaction and project affected communities.
- Facilitate the development of measures to manage issues that have the potential to induce social conflict and tension in partnership with local level governments, NGOs and local churches.
- Implement effective community engagement and community development strategies in line with the Community Development Plan (Attachment 4).
- Ensure community benefits are shared with host community.

7.6.3 Assessment of risk

The risk of civil unrest and conflict as a result of the project has been assessed taking the consequences and likelihood of the consequences occurring into consideration (Table 7.20).

Table 7.20 Risk assessment of civil unrest and conflict

Hazard	Consequences	Likelihood	Overall Risk
Civil unrest and conflict as a result of the project	**Major** Few fatalities and injuries possible and major off-site social impacts	**Unlikely** Unlikely to occur but possible	**High**
	Major Major impacts to the wider community due to social disruption and unrest	**Unlikely** Unlikely to occur but possible	**High**

Bawdwin Project

Environmental Impact Assessment
Cumulative Impact Assessment

October 2023

Bawdwin Project

Prepared for

Win Myint Mo Industries Company Limited

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8 Cumulative impact assessment

This cumulative impact assessment considers potential impacts of other operating, approved or proposed developments within the area of influence of this project and assesses the potential combined impacts from these projects and the Bawdwin project on key environmental, social and cultural values.

The assessment focuses on material residual impacts from the Bawdwin project identified in Chapter 6; and how the magnitude of these impacts could change after considering the impacts of other identified projects. The assessment takes into consideration the context of the Bawdwin project as a brownfields development in a remote mountainous area that has had a long history of lead-silver-zinc mining and smelting.

The greenhouse gas assessment includes cumulative impacts and this aspect is not discussed further in this chapter.

The assessment took a high-level approach, whereby the impacts of the Bawdwin project were compared to potential impacts of other proposed projects in Northern Shan State, Myanmar. The cumulative impacts where looked at in nine categories:

- Landforms and soil.
- Air quality.
- Surface water.
- Groundwater.
- Biological.
- Cultural heritage.
- Noise and vibration.
- Social.
- Human health.

8.1 Cumulative impact assessment method

Cumulative impact in relation to a project means the impact or impacts of a project that in itself or themselves may not be significant but may become significant when added to the existing and potential impacts eventuating from similar or diverse projects or undertakings in the same geographic area or region (i.e., area of influence). For practical reasons, identification and management of cumulative impacts are limited to those effects generally recognized as important on the basis of scientific concerns and/or concerns of affected communities.

The assessment of potential cumulative impacts of the project draws on the findings of the impact assessments carried out by technical specialists for relevant environmental, social, health and cultural aspects (as presented in Chapter 6). Publicly available information on other projects up to 375 km from the Bawdwin project was also reviewed. These projects may have discrete localised impacts and are present over a broad geographic area. Cumulative impacts may occur when these impacts overlap within the same spatial or temporal boundaries.

The cumulative impact assessment follows the general approach outlined in the Good Practice Handbook on Cumulative Impact Assessment and Management prepared by International Finance Corporation (2013) (IFC 2013). This is the approach recommended in Myanmar’s EIA Mining Guidelines (Myanmar Mining EIA Guidelines Working Group).

The approach has six steps, as follows:

1. Assess the potential impacts and risks of a proposed development over time, in the context of potential effects from other developments and natural environmental and social external drivers on a chosen environmental or social value.
2. Verify that the proposed development's cumulative social and environmental impacts and risks will not exceed a threshold that could compromise the sustainability or viability of selected values.
3. Confirm that the proposed development's value and feasibility are not limited by cumulative social and environmental impacts.
4. Support the development of governance structures for making decisions and managing cumulative impacts at the appropriate geographic scale (e.g., air shed, river catchment, town, regional landscape).
5. Ensure that the concerns of affected communities about the cumulative impacts of a proposed development are identified, documented, and addressed.
6. Manage potential risks.

8.1.1 Material residual impacts of the project

Material residual impacts of the Bawdwin project are defined as residual impacts of high or major significance. The material environmental, socio-economic and cultural residual impacts of the Bawdwin project have been summarised from Chapter 6 and include:

Landforms and soils: Material impacts to landforms and soil due to the Bawdwin project were associated with changes to landform due to formation and operation of the open pit, construction of the tailings storage facility and Wallah waste rock dump and loss of topsoil due to increased erosion or poor soil management.

Air quality: Impacts to the airsheds of the Bawdwin Concession villages from increased dust from vegetation stripping and earthworks, mining, mine waste management and ore handling. The residual project impact on the cleanliness of air and visual amenity was assessed as high to major significance for airsheds of Concession villages and the military base. Reduced air quality due to gaseous pollutants from operation of the power station was also assessed as high significance for the airshed of the military base.

Surface water: Impacts to the upper Nam Pangyun catchment from direct loss of aquatic habitat, disturbance of habitat in the Myitnge River, changes to surface water flow in the Nam La, altered flood risk from construction of project infrastructure affecting the Nam La and reduced water quality from runoff with elevated turbidity, TSS, metal contaminants and potentially residual processing reagents affecting the upper Nam Pangyun, Nam La and Myitnge River. The residual project impact on the ability of these catchments to support ecosystems and beneficial uses was assessed as high significance.

Groundwater: Impacts to the Nam Pangyun catchment and Nam La catchment will be due to changed groundwater flow and contamination of groundwater from seepage from the TSFs and Wallah waste rock dump. Seepage is likely to contain elevated metals and sulphate, and potentially residual cyanide. The saprolite and fractured rock aquifers in each catchment may be affected to varying degrees. Springs will be impacted by seepage, by direct loss due to project facility placement and by groundwater drawdown. This residual project impact on groundwater values was assessed as high or major significance, noting the high uncertainty due to lack of geochemical or groundwater modelling.

Biological: Material impacts to the biological environment due to the Bawdwin project identified by the EIA were limited to habitat loss and degradation of the sub-tropical mixed hill forest habitat.

Cultural heritage: As the Bawdwin mine is one of the world's oldest mine sites the project area contains a substantial number of heritage sites and artefacts. Material impacts to cultural heritage are expected to include restricted access to sites and direct loss or disturbance of historical physical features or infrastructure due to ground clearance and excavation, positioning of buildings, stockpiles, dumps and infrastructure, and decommissioning activities to make way for new project infrastructure. This residual impact was assessed as high to major significance to cultural heritage.

Noise and vibration: Impacts to the military base, Nam La farms and Bawdwin lower village from project-related noise and ground vibration during construction and operations are expected to be of high significance. The residual project impact on the acoustic environment that supports human health and wellbeing, sleep and enjoyment of amenity was assessed as high significance.

Socio-economic: Impacts to the physical living conditions of communities within the concession during construction and operation of the project due to reduced amenity, convenience and liveability are expected. These communities may also face altered social cohesion and loss of identity as a result of resettlement. With provision of improved housing and essential services following resettlement, the residual impact to living conditions of the Bawdwin communities is considered of major positive significance.

Human health: Project disturbance, emissions and discharges will increase exposure of nearby receptors to hazardous materials and may affect community health. The significance of this to the community health of most communities within the concession and the Nam Pangyun valley is considered high or major. Conversely, resettlement of these communities to an area with lower exposures to hazardous materials is considered positive (high to major) significance. Community health of the resettled communities is expected to improve due to improved water and sanitation facilities (positive moderate to high impact).

8.1.2 Temporal boundaries

Three studies have been undertaken by WMM to assess the feasibility of the Bawdwin project: scoping study, pre-feasibility study (PFS) and definitive feasibility study (DFS). The project scoping study was completed in September 2018, the PFS report was prepared in February 2019 and the DFS report was completed in June 2020. This EIA assumes that the construction of the Bawdwin project will commence in late 2021 and first concentrate production will take place in late 2023. This timeframe is however dependent on all approvals being obtained and financing in place by mid-2021. Open pit mining will take place for a 13-year period and WMM intends that with further exploration work, a mine life of up to 50 years may be feasible. Assuming a 13-year operation period, cessation of mining will begin nominally in 2035. Decommissioning will last for up to 24 months while rehabilitation works will last up to 36 months. Following decommissioning and rehabilitation there will be a period of post-closure monitoring and maintenance. When monitoring has provided evidence that the closure objectives and closure criteria have been met to the satisfaction of ECD, the WMM will be formally released from all obligations regarding the Bawdwin mineral concession, with a third-party assuming responsibility. Some residual impacts are predicted to extend into the post-closure period.

8.1.3 Spatial boundaries

The spatial boundaries of the cumulative impact assessment coincide with the locations where the material residual impacts are expected to occur, and where impacts from other projects may occur that would, together, add to the material residual impacts from the Bawdwin project. The spatial boundaries differ according to the environmental or socio-economic aspect under assessment and are defined as follows:

Landforms and soil: Includes the same 'terrain units' as defined in Section 5.1, located within the Bawdwin concession. These terrain units include steep mountain terrain, lower mountain slopes and valley floors, undulating hills of the northern and western area of the concession.

Air quality: Includes airsheds of all individual residences in the receptor groups: Bawdwin lower village and associated farms, Tiger Camp village and associated farms, Loi Mi village and associated farms, Nam La farms, project workforce, military base, villages surrounding the concession, residents of Nam Pangyun valley, Namtu and residents along the export route beyond Namtu.

Surface water: Includes areas where the Bawdwin project is likely to have residual impacts (i.e., downstream of the mine, specifically Nam La, Myitnge River and Nam Pangyun (upper, mid and lower) catchments).

Groundwater: Includes the Nam Pangyun and Nam La catchments and local springs, partly within existing disturbance areas and within previously undisturbed (or low-level disturbance) areas.

Biological: Includes areas of grassland, bamboo, sub-tropical mixed hill forest, Nam Pangyun catchment and Nam La which may lie in partly or completely undisturbed areas within the concession.

Cultural heritage: Includes areas around the Bawdwin project infrastructure and activity and downstream of the mining area, wherever cultural heritage values are present within the concession, and along the existing rail corridor.

Noise and vibration: As per air quality defined spatial boundary.

Social: As per the defined spatial boundary for air quality at the local scale, as well as the regional and national economy.

Human health: Receptor groups defined within the air quality spatial boundary.

8.1.4 Projects that could contribute to cumulative impacts

Northern Shan state hosts a number of large-scale development projects due to its proximity to the Myanmar-China border trade area. The state also has high potential for future development of mineral resources. Projects which may contribute to cumulative impacts were identified and collated through desktop research, local knowledge and investigation by Valentis staff. A list of these is presented in Table 8.1 and shown in **Error! Reference source not found.**. The list in the table includes some projects that were identified and initially considered, but have not been included in the assessment as they were unlikely to fall within the area of influence of the Bawdwin project.

Table 8.1 Projects that could contribute to cumulative impacts

Project	Project Proponent	Project description	Spatial boundary (area of influence)	Temporal boundary	Status in 2020	Sources
Mineral Projects						
Small-scale oxide mining and 32 Mile Processing	Win Myint Mo Industries Company Limited (WMM)	This project commenced development in late 2020 to process ore from oxide resources from the Bawdwin mine. The ore will be mined and crushed on the Bawdwin concession at a rate of around 1,000 tonnes per day and transported via truck to Namtu for processing at the existing 3 Mile processing plant. Trucking movements are expected to be about 90 to 100 return journeys per day on the Namtu-Manton public road. Note: The project is not part of the Bawdwin project being assessed by this EIA and is outside the scope of its assessment. The oxide mining project is being conducted by WMM under the existing Bawdwin project approvals and mineral licence.	The mining activity will occur within the Bawdwin concession area, largely within the footprint of existing disturbance (with all mining within the existing open pit). The processing activity will occur at the existing 32 Mile processing plant within the WMM Namtu concession area. The transport of ore will occur on the Namtu-Manton public road.	Haul road construction commenced in 2020 and operations are scheduled to commence in mid-2021 and continue until 2024, or until ore mining commences for the Bawdwin project.	The project has commenced preparatory works in the Bawdwin concession area to support mining operations.	WMM Company Presentation
Zinc production from slag in Namtu	Myanmar Apex Mining Company Limited	This project is privately owned and run under a small-scale mineral processing license issued by the Ministry of Natural Resources and Environmental Conservation (MONREC). The company purchases stockpiled slag located in Namtu from the government that come from the former Bawdwin mine operations and processes it in Namtu for sale to China via the land border. The local community is concerned that the operation emits chemicals to the atmosphere as well contaminated discharge to the Namtu river.	The operation is located in a 5 acres area containing a processing plant in the Namtu concession itself where the slag stockpiles are located. The operation is approximately 6 km away from the Bawdwin concession area.	The license was issued in 2001 but had limited operations. In 2010, the company renegotiated with the government and continued operations. It employed 200 people and had purchased 63,000 tonnes (t) of slag from the government.	Still under operation.	Htoon 2018
Lead, zinc and copper exploration	Unity E & R Metal Co.,Ltd	This project is at exploration stage. It focuses on lead, zinc and copper in Namtu and Lashio. (Mong Yin)	The concession area size is 23,852 acres. This area is 16 km away from the Bawdwin concession area.	The concession is valid until 01/07/2023.	Exploration	Department of Mines, (August Permits)
Lead, zinc and copper exploration	Unity E & R Metal Co.,Ltd	This project is at exploration stage. It focuses on lead, zinc and copper in Namtu, Manton, Lashio and Theinni. (Mon Par)	The concession area size is 18,250 acres. This area is 33 km away from the Bawdwin concession area.	The concession is valid until 01/07/2023.	Exploration	Department of Mines, (August Permits)

Project	Project Proponent	Project description	Spatial boundary (area of influence)	Temporal boundary	Status in 2020	Sources
Lead exploration	New Day Asia Mining Company Limited	This project is at exploration stage. It focuses on lead and associate minerals in Manton, Baho Chaung.	The concession size is 4,200 acres. This area is around 37 km away from the Bawdwin concession area.	The concession is valid until 18/09/2021	Exploration	Department of Mines, (August Permits)
Lead and zinc exploration	Asia Pacific Mining Limited	This project is at exploration stage, focuses on lead, zinc and associated minerals in Namtu, Manton.	The concession area size is 46,232.41 acres. This area is 54 km away from the Bawdwin concession area.	The concession is valid until 02/10/2021.	Exploration	Department of Mines, (August Permits)
Coal mining	Mandalay Distribution and Mining Company Limited	This project focuses on production of coal in Thibaw Township, Namtu Region.	The concession area size is 2,796.75 acres. This area is around 66 km away from the Bawdwin concession area.	The concession is valid until 30/08/2020	Production	Department of Mines, (August Permits)
Lead and zinc mining	Lin Pyae Mining Company Limited	This project focuses on production of lead, zinc and associate minerals located in Nyaungkio (Shan North), Yadanar Theingi Region.	The concession area size is 2,479.33 acres. This area is around 100 km away from the Bawdwin concession area.	The concession is valid up to 30/04/2025.	Production	Department of Mines, (August Permits)
Copper and gold exploration	Locrian Precious Metals Co. Ltd	This project is in the exploration phase for copper, gold and associated minerals.	The concession area size is approximately 470 square kilometers (km^2). This area is around 375 km away from the Bawdwin concession area.	The concession is valid until 2029.	Exploration	Department of Mines, (August Permits)
Electricity and Power Projects						
The Namtu (Hsipaw) Dam Project	Natural Current Energy Hydropower Co.,Ltd (NCEH).	This project involves a 210 megawatt (MW) dam on the Namtu/Myitnge river, about 25 kilometres (km) north of Hsipaw town. Dam height is 114 meters (m).	The project is located on Namtu/Myitnge river flowing down to Hsipaw. Area to be submerged under the reservoir is 866.69 hectares and villages to be submerged are Li Lu Village (47 houses, 212 people); and most of them are Shan. This area is around 36 km downstream of the Bawdwin concession area.	Construction period (66 weeks). Construction cost 436.28 million USD.	Ministry of Electricity and Energy is still considering feasibility of the project. The company has constructed building worker accommodations and temporary bridge in March 2020.	Complaint document by Shan Human Rights Foundation

Project	Project Proponent	Project description	Spatial boundary (area of influence)	Temporal boundary	Status in 2020	Sources
Shweli 3 Hydropower Project	Implemented by the Ministry of Electricity and Energy	The 671-MW hydropower project is located on Shweli River, about 19 km north of Moemeik, Northern Shan State. It projects to generate 3,000 million kilowatt hours (kWh) of annual electric energy to the national grid and supply electricity to more than 8.5 million residents nationwide.	By 2025-2026, it plans to contribute to electrification of about eight million households. This area is around 65 km from the Bawdwin concession area in a different river catchment.	The project is targeted to complete in Fiscal Year 2022-2023 with the project cost of 1.51 billion USD.	It is still under construction.	Myanmar Project Banks, Save Namtu River by Shan Human Rights Foundation
66kV Muse-Nanphatkar line (30 miles) and substations	Understood to be commissioned by the Ministry of Electricity and Energy	The project is located in Muse and Nanphatkar, Northern Shan State.	This project includes line installation and construction of Nanphatkar Substation. This project is around 81 km from the Bawdwin concession area.	The project is to end in 2020 approximation.	Ongoing	Ministry of Electricity and Energy, new projects in Shan State.
Upper Yeywa Dam for Hydro Power	Led by the Myanmar Electric Power Enterprise (MEPE)	This project involves a 280 MW dam on the Namtu/Myitnge river between Kyaukme and Naungkio. It is planned to produce 1.409 billion kilowatts (kW) and is located 20 miles from Kyaukme. There will be two 41 foot length iron reinforced tunnels with 70 MW turbine. 40% of the project is completed. It is financed by China Exim Bank.	It is located on Dotawaddy river known as Namtu or Myitnge river. It is 1.5 miles from Taung Che Vilalge, Loi Jong tract, Kyaukme township. This area is around 97 km downstream of the Bawdwin concession area.	Due to protest, it halted but again it plans to continue and finish in 2022.	Under construction headed by the MEPE. Other companies involved in construction are China – Yunnan Machinery Import and Export Co.,Ltd, Zhejian Orient Engineering, Germany, Lahmeyer International GmbH Switzerland – Stucky SA, Japa – Toshiba, High Tech Concrete Technology Co., Ltd (Japan)	Save the Namtu River by Shan Human Rights Foundation, Eleven Myanmar Media news article.

Project	Project Proponent	Project description	Spatial boundary (area of influence)	Temporal boundary	Status in 2020	Sources
Highway and railway projects						
Muse – Htikyaing-Mandalay Express Way Project	Implemented under the Department of Highways, Ministry of Construction	The project will involve construction of a 446 km, 4-lane asphalt concrete expressway. The first part of the expressway will be a new construction with a length of 206 km, from the border trade township of Muse in Shan State, passing through Si-u in Kachin State and to Htigyaing in Sagaing Region, will be an important part of the main trunk line of the country's east-west highway. The second part of the expressway has a length of 240 km and starts at Htigyaing, passes through Male, Kyauk Myaung, Sagaing and ends at Mandalay.	The project is aimed at improving regional connectivity of China-Myanmar border and North South Corridor of Myanmar and further boosts Mandalay-Yangon trade flow. Given the country's strategic location between China and the Indian Ocean, Myanmar is expected to become an international trade logistics hub. This area is around 8 km from the Bawdwin concession area at its closest point.	Project is targeted to start fiscal year 2019-2020 and end fiscal year 2024-2015. The project cost is 820.00 million USD	Pre-feasibility/Feasibility Study	Myanmar Project Bank
Muse-Mandalay Railway Project	(Myanmar government and China Railway Eryuan Engineering Group	This project is part of the lines to Mandalay – Kyaukphyu line. The line would connect a deep sea port in Kyaukphyu, which is developed by China with Kunming, China, via Muse on the Myanmar-China border. This project would also connect Mandalay with Yangon, and improve access between China and the India ocean.	The project will involve the construction of the 431 km-long Muse-Mandalay line. The line will be built for 160 km/h operation between Mandalay and Muse to support the China-Myanmar Economic Corridor. The project cost is predicted to be 8.9 billion USD. This rail line is still in early stage of feasibility and may pass through the Bawdwin concession or around 35 km from the Bawdwin concession area.	The government of Myanmar signed the Memorandum of Understanding with China Railway Eryuan Engineering Group (CREEG) in October 2018. Project is still at early stage of feasibility.	Feasibility stage	International Railway Journal (Jun 30, 2020)

Project	Project Proponent	Project description	Spatial boundary (area of influence)	Temporal boundary	Status in 2020	Sources
Goteik Bridge Project	The Ministry of Construction, local company Oriental Highway Co, China Harbour Engineering Co Ltd, and China Communications Construction Co Ltd will the build the project	The GoTeik Bridge project consists of a 887 m bridge and a 19.3 km link road. This will shorten the original route by 7.5 miles and greatly shortened travel time. Once finished, traffic along Mandalay-Muse road will become more convenient, improve the investment environment between China and Myanmar.	The project area is located in in western Shan State in Nwaungkio township and near the famous Goteik railway viaduct (115 years old). It is between Pyin Oo Lwin and Kyaukme. It is also a major infrastructure project along the Mandalay-Muse road, a significant border-trade route, and this expect significantly boost the transportation of goods between China and Myanmar once it is completed. This area is around 95 km from the Bawdwin concession area.	It is targeted to be complete in 2022.	Feasibility Study/Planning stage	National Infrastructure Holding Co.Ltd, Myanmar Times, Article dated 10 Jan 2019 by Chan Mya Htwe, Yee Ywal Myint
New Muse 105th Mile Trade Zone Import Vehicle Inspection Area Development Project	Proposed by the Department of Trade	Muse 105th Mile Trade Zone is congested with the capacity not being enough to provide sufficient services for average maximum of 1600 heavy-loading-twenty-two wheelers vehicles per day. Therefore, the new Muse 105th Mile Trade Zone Import Vehicle Inspection Area Development Project aims to reduce traffic at Muse (105 Miles) Trade Zone and along the Mandalay-Lashio-Muse Union Road, by developing and constructing the modernized trade related infrastructure, implementing of Single Window inspection and exercising the containerized cargo with e-lock system. In the short term, the project will solve the heavy traffic contributing the trade facilitation of the Trade Zone with the smooth cargo flow. In the long term, it is expected to bring the socio-economic benefits to the local people creating the job opportunities and enhancement of trading across border and being supportive to the elimination of illegal trade.	Total acres of existing Muse 105th Mile Trade Zone is 370.83 acre including the vehicle inspection area, vehicle waiting area, warehouses area. This area is around 123 km from the Bawdwin concession area.	Project is expected to commence and be complete within three years after receiving commitment. Project cost is 25.40 million USD.	Pre-feasibility/Feasibility Study	Myanmar Project Bank

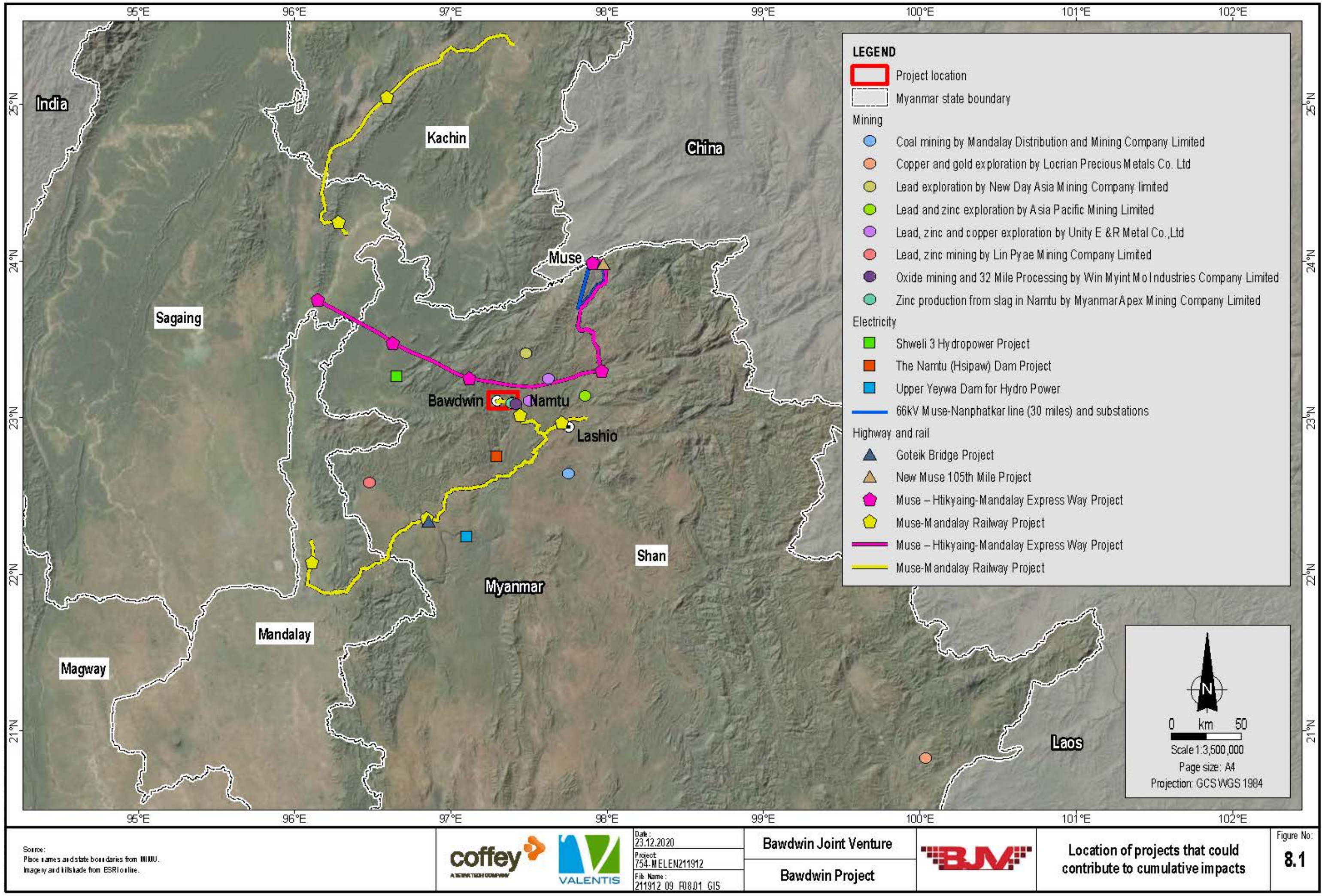

Figure 8.1 Location of projects that could contribute to cumulative impac

8.2 Cumulative impact assessment

The potential cumulative impacts associated with the projects identified in Table 8.1 that could contribute to cumulative impacts, taking into consideration the temporal and spatial boundaries of the assessment, are outlined in the following section. The potential cumulative impacts identified are discussed in Section 8.2.1and Table 8.2.

8.2.1 Cumulative impact discussion

Landforms and soil

Material impacts to landforms and soil due to the Bawdwin project identified by the EIA were associated with changes to landform due to formation and operation of the open pit, construction of the tailings storage facility and Wallah waste rock dump and loss of topsoil due to increased erosion or poor soil management.

At a broader landscape scale, all of the mining and exploration projects listed in Table 8.1 are likely to locally impact landforms and soil in the region, caused by ground disturbance and erosion due to mining activities. The construction activities associated with the electricity and power projects as well as the railway and road projects are also likely to impact landforms and soils. The number of mining and exploration projects represent a further (cumulative) threat to landforms and soil quality in Northern Shan State.

Air quality

Impacts to air quality from the Bawdwin project will occur primarily due to increased dust generation from earthworks and mining, dust deposition and gaseous emissions from the power station. These material impacts of the Bawdwin project are limited to the airsheds in proximity to mine area and will therefore overlap with the oxide mining within the Bawdwin concession. The temporal overlap is expected to be minimal as oxide mining will conclude at or very shortly after the commencement of mining by the Bawdwin project. Some cumulative air quality impacts may occur due to dust generation from construction of the Bawdwin project, alongside oxide mining. All other identified projects do not fall within the Bawdwin project area of influence relevant to air quality.

Processing activities by other projects are occurring and will continue in Namtu during the timeframe of the Bawdwin project. These projects include processing of oxide ore by WMM (proposed between 2021 and 2024) and zinc by Myanmar Apex Mining Company Limited (in operation currently). Whilst no material residual air quality impacts from the Bawdwin project are expected at this location, the resettlement site may be located within the area.

At a broader scale, mining and exploration projects are likely to impact air quality in similar ways to the Bawdwin project. Electricity and power projects are likely to have similar impacts though to a lesser extent, while impacts to air quality from road projects are likely to stem from earthworks and construction. The identified proposed and current projects are expected to have cumulative impacts to air quality (along with the Bawdwin project) in Northern Shan State, albeit in separate airsheds apart from the projects mentioned above at Bawdwin and Namtu.

Surface water

Surface water impacts due to the Bawdwin project will occur due to runoff with elevated metals and TSS entering waterways, aquatic habitat removal and altered flood risk from construction of project infrastructure. It is unlikely the oxide mining operation will contribute to cumulative impacts during construction of the Bawdwin project as it is assumed surface water runoff will be collection within the catchment of the open pit. No other identified projects are located within the Nam La or Nam Pangyun catchments.

However, several projects are located along or may discharge to the Myitnge River, including zinc production from slag in Namtu by Myanmar Apex Mining Company Limited (operational) and the processing of oxide ore at the existing 32-Mile concentrator plant by WMM (in development). Collectively, these projects may impact the water quality and beneficial uses of Myitnge River.

The Namtu (Hsipaw) Dam Project by NCEH (proposed) and Upper Yeywa Dam for Hydro Power headed by the MEPE (in construction) may impact hydrological regimes, flood risks and cause inundation as well as construction related impacts to water quality. While these impacts will potentially affect the same river (Myitnge), the impacts are likely to occur in separate areas of the Myitnge to the area of influence of the Bawdwin project.

Groundwater

The Bawdwin project's primary impacts to groundwater will stem from contamination of groundwater within Nam Pangyun catchment and potentially the Nam La catchments due to seepage from the TSFs and Wallah waste rock dump which is likely to contain elevated metals and sulphate, and residual processing reagents (in the case of TSF seepage). Other mining projects are likely to have similar impacts to groundwater such as coal mining by Mandalay Distribution and Mining Company Limited and lead and zinc mining by Lin Pyae Mining Company Limited. However, these mining projects are located at a significant distance from the Bawdwin project, around 66 km and 100 km, respectively and are not expected to fall within the area of influence relevant to groundwater. The remainder of the identified mining projects are in the exploration phase. There may be some groundwater-related cumulative impacts if these exploration projects proceed to large scale mining and development. However, they range from around 16 km to 365 km from the Bawdwin project, and are therefore not likely to impact the saprolite or fractured rock aquifers within the Nam Pangyun and Nam La catchments.

The other project types (i.e. electricity and power projects, and highway and railway projects) are unlikely to have groundwater-related cumulative impacts.

Biological

Material impacts to the biological environment due to the Bawdwin project identified by the EIA were limited to habitat loss and degradation of the sub-tropical mixed hill forest habitat.

All of the other proposed projects are expected to impact the biological environment to some extent, resulting in cumulative impacts at a broader landscape scale. The impacts will depend on the exact location of projects and their impacts on vegetation, habitats and flora and fauna.

Cultural heritage

Material impacts to cultural heritage from the Bawdwin project are expected to include, loss or disturbance of cultural heritage, and modification to the surrounding landscape. No cumulative impacts to cultural heritage values as a result of the oxide mining are expected given its disturbance will fall within the larger Bawdwin project disturbance footprint and occur prior to the Bawdwin project.

No cumulative impact is currently expected impact between the Muse-Mandalay Railway Project and the Bawdwin project given the existing Bawdwin-Namtu railway corridor lies within a concession held by WMM. However, it is noted that the rail line project is still in early stage of feasibility and information on its alignment is uncertain.

Given most of the significance and uniqueness of cultural heritage at the Bawdwin mine is related to the history of the mine itself, it is not expected that there will be any cumulative impacts to cultural heritage features within the Bawdwin concession and along the existing railway corridor related to the other proposed projects.

Noise and vibration

Increased levels of noise and vibration from the Bawdwin project will arise from a number of activities including construction, vehicle traffic, mining activities and the operation of processing plant and power station. Material noise and vibration impacts are limited to the receptor groups residing within the Bawdwin concession, who may experience cumulative impact during the temporal overlap between oxide mining and construction of the Bawdwin project. Given the location of the other proposed projects, cumulative impacts related to noise and vibration are not expected.

Socio-economic

Changes in physical living conditions as a result of construction and operation of the Bawdwin project will impact those communities residing within the concession, in an adverse manner prior to resettlement and positively following resettlement through provision of improved housing and essential services. These impacts will therefore overlap with the oxide mining within the Bawdwin concession which is also expected to reduce amenity and increased traffic and road use However, the temporal overlap is expected to be limited to the Bawdwin project construction period, with some Bawdwin communities being resettled during this time.

Projects that are located in Namtu may lead to cumulative socio-economic impacts with the Bawdwin project. Particularly, if the Bawdwin concession villages are resettled to a location near Namtu. These cumulative socio-economic impacts may include impacts to convenience and liveability associated with potential in-migration from all projects and altered social cohesion. There may also be positive cumulative impacts of all the projects associated with increased local employment and procurement.

The period of initial construction of the Bawdwin project, which will utilise the Namtu-Manton Road for site access while the Namtu-Tiger Camp Access Road is under construction, presents a substantial increase in the traffic levels on this public road from both projects.

All other identified projects do not fall within the Bawdwin project area of influence relevant to socio-economic impacts.

Human health

Material impacts to human health as a result of the Bawdwin project are primarily related to the Concession villages, which will be resettled either during construction or within the first few years of mining operations. Cumulative human health impacts may result during the temporal overlap between operation of the oxide mining project and construction of the Bawdwin project from inhalation, ingestion or dermal contact of dust emissions with elevated metals. Given the significant distance between the Concession villages and other identified projects prior to their resettlement, , cumulative human health impacts are not expected during this period. Following resettlement, the communities will face significantly lower exposures from the Bawdwin project. However, if resettled to a location near Namtu they may be impacted by reduced air quality resulting from the processing projects in the area including oxide ore processing by WMM (proposed) and zinc processing from slag by Myanmar Apex Mining Company Limited (operational).

Table 8.2 Potential cumulative impacts

Aspect	Potential cumulative impacts
Mineral Projects	
Landforms and soil	• **Potential for cumulative impact** with other mining projects in Northern Shan State at a regional scale given the extent of ground disturbance associated with mining projects.
Air quality	• **Potential for cumulative impact** during Bawdwin project construction phase and oxide mining occurring within the Bawdwin concession. • **Potential for cumulative impact** may be observed at a regional scale , albeit in different airsheds.
Surface water	• **No cumulative impact** expected during Bawdwin project construction and oxide mining occurring within the Bawdwin concession given surface water runoff will likely be captured in the open pit and allowed to settle before discharge or reuse. • **Potential for cumulative impact** to water quality of Myitnge River due to the Bawdwin project and other processing projects in Namtu.
Groundwater	• **No cumulative impact** with the oxide mining expected given the operations lack of interaction with groundwater. • **No cumulative impacts** on groundwater systems in the Bawdwin project area are expected from other mining projects within the region given the significant distance from the Bawdwin concession.
Biological	• **No cumulative impact** expected between Bawdwin project and oxide mining operations as disturbance is contained to the same footprint. • **No cumulative impacts** on the biological values from other mining projects are expected given the separation distance.
Cultural heritage	• **No cumulative impact** expected between Bawdwin project and oxide mining operations as disturbance is contained to the same footprint. • **No cumulative impacts** from other mining projects are expected given their distance from Bawdwin cultural heritage features.
Noise and vibration	• **Potential for cumulative impact** during construction of the Bawdwin project and oxide mining occurring within the Bawdwin concession. • **No cumulative impacts** from other mining projects are expected given their distance from residents living within the Bawdwin concession.
Social	• **Potential for cumulative impact** on physical living conditions due to Bawdwin project and oxide mining occurring within the Bawdwin concession. • **Potential for cumulative impact** on Namtu due to inmigration associated with the other local mining and processing projects and the Bawdwin project and the resettlement of Bawdwin communities in Namtu (potentially). • **Potential for cumulative impact** relating to positive socio-economic impacts in Namtu due to increased employment and wealth due to Bawdwin project and other local mining and processing projects. • **No cumulative impacts** from other mining projects are expected given their distance from residents.
Human health	• **Potential for cumulative impact** during Bawdwin project construction and oxide mining occurring within the Bawdwin concession. • **No cumulative impacts** from other mining projects are expected prior to resettlement of residents of Bawdwin given their distance from communities at highest risk of exposure. If resettled to a location near Namtu, the communities may be impacted by reduced air quality from processing activities.
Exploration projects	
Landforms and soil	• **Potential for cumulative impact** at a regional scale given the ground disturbance associated with mining and exploration projects.
Air quality	• **Potential for cumulative impact** at a regional scale , albeit in different airsheds.

Aspect	Potential cumulative impacts
Surface water	• **No cumulative impacts** to surface water are expected as a result of exploration projects and the Bawdwin project.
Groundwater	• **No cumulative impact** on groundwater are expected as a result of exploration projects and the Bawdwin project. Exploration activities may have an impact on groundwater levels however these are not expected to be significant.
Biological	• **Potential for cumulative impact** to forest habitat at a regional scale, as exploration projects are understood to be located in an area of medium impacted mountainous forest.
Cultural heritage	• **No cumulative impact** expected as there potential cultural heritage are local to the Bawdwin project and discrete from exploration projects.
Noise and vibration	• **No cumulative impact** as there is no causal pathway between potential noise and vibration impacts from exploration projects and the Bawdwin project.
Social	• **No cumulative impact** as there is no causal pathway between potential socio-economic impacts from exploration projects and the Bawdwin project.
Human health	• **No cumulative impact** as the exploration projects are outside the catchment where health impacts from the Bawdwin project are likely.
Electricity and power projects	
Landforms and soil	• **Potential for cumulative impact** at a regional scale given the ground disturbance associated with both project types.
Air quality	• **No cumulative impacts** are expected given the distance between the mine area and electricity and power projects.
Surface water	• **Potential for cumulative impact** on the water quality and flow regime of the Myitnge River, albeit in different reaches of river.
Groundwater	• **No cumulative impact** as there is no causal pathway between potential groundwater impacts from electricity and power projects and the Bawdwin project.
Biological	• **No cumulative impact** as there is no electricity or power projects within the Bawdwin area of influence related to biodiversity.
Cultural heritage	• **No cumulative impact** as there is no causal pathway between potential cultural heritage impacts from this project and the Bawdwin project.
Noise and vibration	• **No cumulative impact** as there is no causal pathway between potential noise and vibration impacts from electricity and power projects and the Bawdwin project.
Social	• **No cumulative impact** as there is no causal pathway between potential socio-economic impacts from electricity and power projects and the Bawdwin project
Human health	• **No cumulative impacts** are expected given the distance and dilution between the mine area and electricity and power projects and the small proportion of the Myitnge River total catchment area impacted by the Bawdwin project.
Highway and railway projects	
Landforms and soil	• **Potential for cumulative impact** at a regional scale given the ground disturbance associated with both project types.
Air quality	• **No cumulative impacts** are expected given the limited impacts the highway and railway projects will have.
Surface water	• **No cumulative impacts** expected as water quality and aquatic ecology impacts from these projects are expected to be localised and minor.
Groundwater	• **No cumulative impacts** as there is no causal pathway between potential groundwater impacts from highway and railway projects and the Bawdwin project
Biological	• **No cumulative impacts** expected as the highway and railway projects are not in the proposed area of influence of the Bawdwin project. Road and railway construction will have specific regional impact on terrestrial biodiversity. It is unlikely to be combined with the impact of the Bawdwin project.
Cultural heritage	• **No cumulative impacts** as there is no causal pathway between potential cultural heritage impacts from highway and railway projects and the Bawdwin project.

Aspect	Potential cumulative impacts
	• The Muse-Mandalay Railway Project potentially falls within the Bawdwin project area of influence (dependent on final alignment). However, no overlap in impacts to the Namtu-Bawdwin rail lines is expected.
Noise and vibration	• **No cumulative impacts** as there is no causal pathway between potential noise and vibration impacts from highway and railway projects and the Bawdwin project.
Social	• **Potential cumulative impacts** that are positive as these projects will potentially support economic development of the region and improve transport and access.
Human health	• **No cumulative impacts** as the highway and railway projects are unlikely to impact the human health in a cumulative manner with impacts associated with the Bawdwin project.

8.2.2 Cumulative impact management strategies

WMM has developed mitigation measures to avoid and/or minimise cumulative impacts and mitigate risk to the greatest extent possible. These management measures are outlined in Chapter 6. Cumulative impacts fall within the remit of the environmental and social management framework (Chapter 10) and environmental and social management plan (ESMP) (Attachment 4). The governance, responsibilities and accountabilities for implementation of the ESMP and environmental and social management are outlined in Attachment 4. Concerns of affected communities regarding potential cumulative impacts will be identified, documented and addressed through the community grievance mechanism, to be established by WMM.

In addition, WMM will undertake the following to help limit cumulative impacts:

- Cooperate with relevant government agencies and others with an interest in development of Northern Shan State to help facilitate its ongoing protection of the environment and human health and optimisation of socio-economic outcomes.
- Cooperate with WMM on the oxide mining project and seek to limit potential for cumulative impacts for the period of overlap between the two projects. In particular, a plan for the interaction of traffic for the two projects during the initial phases of Bawdwin project construction should be developed.
- Mitigate and manage water quality impacts to the Nam Pangyun to limit downstream impacts to the Mytinge and minimise potential for any cumulative impacts to this water course between the Bawdwin project and the processing activities that are (or are planned) to be taking place in Namtu.
- Look for opportunities to work collaboratively with other industries and companies in Namtu to improve environmental and social outcomes.

8.3 Conclusion

Mining, exploration, electricity and power and railway and road projects within Northern Shan State, ranging from locations within the Bawdwin concession up to 375 km away were identified and assessed for the potential to contribute to a significant cumulative impact. Whilst all projects were initially considered, not all were determined to fall within the area of influence of the Bawdwin project and therefore most were determined not to be a source of significant cumulative impact.

Material residual impacts of the Bawdwin project are primarily associated with the environment in close proximity to the mine area and residents living within the Concession. The current oxide mining within the Bawdwin concession and processing of oxide and zinc in Namtu pose the greatest potential for cumulative impact with the Bawdwin project, given they overlap in terms of airsheds and water discharge to the Myitnge River. WMM will cooperate with the proponents of these operational projects to ensure management measures support each operation and the local environment, as well as relevant government agencies to help facilitate ongoing protection of the environment and human health at the regional scale within Northern Shan State.

The value and feasibility of the Bawdwin project are not limited by cumulative social and environmental impacts.

Bawdwin Project

Environmental Impact Assessment
Chapter 9 – Public consultation and disclosure

October 2023

Bawdwin Project

Prepared for

Win Myint Mo Industries Company Limited

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9 Public consultation and disclosure

This chapter provides an overview of the public consultation and community engagement undertaken in relation to the project. The chapter provides a summary of all public consultation and disclosure activities conducted since the planning of the mine redevelopment started up until December 2020. The results of consultations and other community engagement activities are described in this chapter, together with a summary of the main public issues and concerns and WMM's response to address those issues and concerns.

9.1 Overview

Public participation in the environmental impact assessment (EIA) process is critical to ensure potential environmental and socioeconomic impacts of the project are clearly understood and appropriately assessed in the EIA process. The Draft Guideline on Public Participation in Myanmar's EIA Processes (31 May 2017), hereafter referred to as the Public Participation Guideline, is a guide to public participation as part of the EIA process in Myanmar. This Public Participation Guideline has been followed when planning and delivering the consultation in relation to the project.

9.2 Consultation requirements

Under Myanmar's Environmental Conservation Law and Environmental Conservation Rules an EIA is required for projects having potential significant impacts. The Environmental Impact Assessment Procedure (EIA Procedure) issued in 2015 sets out the requirements for environmental impact assessment of projects.

EIA Procedures

The EIA Procedures has some specific requirements related to consultation activities including:

- In accordance with **Article 45** of the EIA Procedure, the Project Proponent must appoint a registered third person or organisation to carry out the EIA investigation and reporting.
- The scoping stage of the EIA process will produce a detailed Terms of Reference (ToR) for the EIA which shall include a Public Participation Plan. Both the ToR and Public Participation Plan are to be approved by the ECD in accordance with **Article 54** of the EIA Procedure.
- **Articles 49(e)** and **Article 61** deals with the notification requirements of meetings.
- **Articles 50(b)** deals with the number of meetings to be held during the process.
- **Article 51(g)** and **Article 63** deals with records of meetings.
- **Article 63** of the EIA Procedure requires the EIA Report to address: methodology and approach; summary of consultations and activities undertaken, results of consultations, further ongoing consultations; and disclosure.
- **Article 67** requires public participation during ECD's review of the final EIA report.
- The EIA Procedure requires the EIA to consider the results of the public participation, not just to summarise the public participation process.

Draft Guideline on Public Participation

The Draft Guideline on Public Participation in EIA Processes (31 May 2017) has been prepared to guide public participation conducted as part of the EIA process in Myanmar. The guideline is designed to implement the EIA Procedure's public participation requirements. The guideline is highly prescriptive and describes the recommended participation activities that should be completed during the EIA process.

The Public Participation Guideline contains the following relevant requirements for EIA projects:

- **Third party EIA Consultant**: requires the consultation to be conducted by a third party consultant rather than the Project Proponent.
- **Notifications**: Provides detail on the required timing, content and distribution methods for consultation notifications.
- **Information disclosure**: Provides detail on the type of information that is required to be disclosed during public consultation and outlines that the information must be relevant to the PAPs and in sufficient detail to be useful to the PAP. The Public Participation Guidelines require distribution of information on:
    - Project Proponent website
    - Project Proponent and Consultant offices
    - Locations near the project site
    - Other relevant distribution methods
- **Public participation activities**: Explains the suggested number of public participation meetings; the requirement to liaise with relevant Government departments to organise the meetings; and an outline of the content of the information disclosure at the meetings.
- **Public participation outcomes**: The Guidelines require the feedback received to be incorporated into the Scoping document and EIA drafting. The Guidelines further require comments received by the PAP to be responded to by the Project Proponent and any feedback and ideas incorporated into the planning and concerns addressed.
- Other requirements such as the requirement for a call for public submissions on the EIA report.

Public Participation Plan

At the commencement of the project and as outlined in the Scoping Report, WMM prepared a Public Participation Plan (Attachment 3) to guide the consultation and disclosure of project information and feedback. This Public Participation Plan was used to guide public consultation and disclosure for the project EIA and has been based on the Public Participation Guidelines and International Finance Corporation (IFC) Performance Standards (IFC, 2012). Potential lender requirements and guidelines have also been considered, including the Equator Principles (EPFI, 2013) and Stakeholder Engagement: A good practice handbook for companies doing business in emerging markets (IFC, 2007).

The Public Participation Plan sets out the objectives of public participation and disclosure process as follows:

- Identify key stakeholders, their relationship to the mine and/or proposed mining and processing activities, and their concerns.
- Provide comprehensive information about the proposed project and its potential impacts, risks and opportunities to the identified stakeholders (consistent with international good practice).
- Provide stakeholders (including consultants, relevant authorities, project developers, and interested and affected parties) with the opportunity to express their views and concerns regarding the project.
- Understand thoughts, perceptions and concerns associated with redevelopment of the mine.

- Document and provide feedback to stakeholders on the outcomes of the public participation process, and how the participation process has shaped the project design.
- Reduce the potential for project-affected persons (PAP) and other stakeholder disaffection, which can result from a misunderstanding of the project, and, particularly for local communities, either a real or perceived exclusion from the EIA process.
- Provide input to the development and implementation of a community/stakeholder relations program by WMM, to be used as the project and operation progress.

9.3 Identification of stakeholders and project affected people

Stakeholder identification is the process of determining who the project stakeholders and interested parties are, the particular interests held by those groups and the influence they may have on the project. This informs the development of a suitable stakeholder engagement strategy. Stakeholders have been identified through both a 'top down' and 'bottom up' process drawing on previous work in the area and verified through engagement with stakeholders and host communities to ensure that all likely stakeholders have been identified.

A detailed stakeholder identification and analysis exercise was undertaken in 2018 as part of the initial planning meetings at the commencement of the feasibility studies. This initial stakeholder identification exercise has continually been reviewed and updated on completion of various baseline studies and surveys as well as consultation as the EIA has progressed.

The review of project stakeholders and interested parties was based on the IFC's Performance Standard 1: Social and Environmental Assessment and Management Systems. This process was based on the following steps:

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

   Stakeholders were initially identified through a stakeholder mapping workshop in 2018 in which the Project Proponent and all key consultants participated. The list has been expanded through the consultants' time spent working on site, conduct of the baseline studies and surveys and engagement with the various stakeholders.

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

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

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

   Stakeholder representatives were identified through engagement with the various levels of Government, from the relevant Natural Resource Parliamentary Committees, Union level Government, Shan State Government and local administration as well as during engagement with the communities.

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

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

Stakeholder identification and analysis will continue to be undertaken iteratively throughout the progression of the project as new information becomes available and annually thereafter.

Myanmar context

In the context of Myanmar's EIA Procedures, the stakeholder identification process described above resulted in identification of project-affected persons (PAP). A PAP is defined in accordance with EIA Procedure (2015), Article 2(f) as:

> *a natural person, legal entity, or organisation that is, or is likely to be, directly or indirectly affected by a project or a proposed project, including without limitation effects in the nature of legal expropriation of land or real property, changes of land category, and impacts on the ecological and environmental systems in the settlement areas of such person, entity or organization.*

A stakeholder is defined in the Public Participation Guideline as persons, groups, or communities external to the core operations of a project who may be affected by the project proposal, or have interest in it, at any stage in the project cycle (whether planning and construction, operation, or closure and decommissioning); this includes individuals, vulnerable and disadvantaged groups and individuals, businesses, communities, other government ministries, local government authorities, academia, national and international non-government organisations (NGOs), the media, and people who are concerned about the project proposal that may not live in the area directly impacted by the project.

To place this project in a cultural and historical context, there are various ethnic groups in the region that have lived alongside and been employed or worked in the Bawdwin mining operations over its 600-year history. It is understood, the term 'indigenous' is not used locally and is not a term with which people self-identify. Coffey-Valentis and WMM adhered to the principles and intent of the Public Participation Guidelines, as they relate to indigenous groups and public participation, in identifying and engaging with ethnic groups in the project affected area and providing translated materials and opportunities for engagement.

Stakeholder categorisation

The ongoing stakeholder identification process has resulted in the categories of stakeholders (PAP) and interested parties as shown in Table 9.1.

Table 9.1 Stakeholder categories / project affect people

Category	Stakeholder / PAP
Communities	• Tha Ta La Ward, Namtu • Bawdwin village (Upper and Lower – 8 wards) • Tiger Camp Community • Hillside communities surrounding the concession • Mansam Falls Village • Manton Village
Community leaders	• Namtu Town Dignitaries • Bawdwin elders and leaders • Religious leaders
Religious groups	• Islam, Christian and Hindu religious groups at Bawdwin • Buddhist Monks, Township Buddhist Association, Bawdwin
Ethnic groups	• Shan persons • Palung persons • Kachin persons • Kayin persons • Chin persons

Category	Stakeholder / PAP
Vulnerable groups	• Disabled persons • Women headed households • Single person households
Government	• Natural Resources Parliamentary Committee (Upper House) • Natural Resources Parliamentary Committee (Lower House) • Locally elected Parliamentary Representatives • Ministry of Natural Resources and Environmental Conservation - Minister's Office • Ministry of Natural Resources and Environmental Conservation - Mining Enterprise Number 1 • Ministry of Natural Resources and Environmental Conservation – Department of Geological Survey and Exploration • Ministry of Natural Resources and Environmental Conservation - Department of Mines • Ministry of Natural Resources and Environmental Conservation - Environmental Conservation Department • Ministry of Natural Resources and Environmental Conservation - Environmental Conservation Department • Ministry of Home Affairs - District Police, Immigration Department, Township administration, General Administration Department • Myanmar Military (Tatmadaw) - The Office of Commander-In-Chief; North East Command Office in Lashio; Tactical Operation Command Office, Namtu • Shan State Cabinet (Taunggyi) • Kyaukme District Office - General Administration Department; Land Department; Other Departments • Namtu Township Office - General Administration Department; Land Department • National Economic Committee • Ministry of Planning and Finance • Ministry of Health • Ministry of Religious Affairs and Culture • Ministry of Ethnic Affairs • Ministry of Transport and Communications • Ministry of Electricity and Energy • Ministry of International Cooperation • Border authority/customs
Non-government organisations	• Myanmar Centre for Responsible Business (MCRB) • Myanmar Alliance for Transparency and Accountability (MATA) • World Bank Extractive Industries Transparency Initiative Committee (EITI) • Natural Resources Governance Institute (NRGI) • Oxfam • Publish What You Pay • Myanmar Mining Watch Network • Historical Narrow Gauge Railway Society • Northern Shan State Women Network and International Rescue Committee • Mana • Karuna Mission Social Solidarity
Existing workforce	• Bawdwin Labour Organisation • Existing workforce at Bawdwin and Namtu
Ethnic armed organisations	• Ta'ang National Liberation Army (TNLA) • Kachin Independence Army (KIA)

Category	Stakeholder / PAP
	• Restoration Council of Shan State (RCSS)
Railway corridor	• Artisanal miners in railway corridor • Internally displaced persons
Contractors, suppliers and service providers	• Existing and future contractors, suppliers and service providers
Media	• Local and international media
Owners and investors	• Myanmar Metals Limited and public shareholders • Win Myint Mo Company Limited • East Asia Power Global Mining Company Limited

9.4 Public consultation methods

Different stakeholder groups require methods of communication and consultation to be tailored according to their interest and understanding of the project, how they may be affected by the project and their language and literacy skills. Tailored mechanisms for engagement were used for each stakeholder group, depending on their needs. The project has planned its engagement activities to align to the needs of the project and of the specific stakeholder groups across the following two themes:

1. Seeking views, input and feedback.
2. Building general project awareness and awareness of the EIA process.

Table 9.2 outlines the mechanisms of engagement for each engagement theme along with a description of the methods employed for respective stakeholder groups. Throughout the EIA process there were several periods in which Coffey-Valentis had limited or no ability to engage directly face to face with PAP, due to security and access restraints and also the COVID19 pandemic.

Table 9.2 Types of stakeholder engagement

Type	Description	Stakeholder / PAP
Seeking view and input		
Formal public consultation rounds	• Three comprehensive rounds of formal public consultation took place with PAPs and stakeholders prior to the submission of the EIA	• Communities • Community leaders • Religious groups • Ethnic groups • Existing workforce
Ad hoc community meetings and updates	• Since 2018 informal consultation meetings have been held onsite between the Bawdwin, Namtu and Tiger Camp communities and members of WMM's management, led by the Health, Safety, Community and Environment Manager	• Communities • Community leaders • Religious groups • Ethnic groups • Existing workforce • Vulnerable groups
Stakeholder meetings and one-on-one briefings	• The formal consultation rounds have also included formal briefings to individual stakeholders as described below	• Government • Vulnerable groups

Type	Description	Stakeholder / PAP
	• In addition, numerous meetings have been held on an ongoing basis between WMM Management and various Union Government Ministries	• Non-government organisations
Community information centres	• The establishment of Information Centres in Bawdwin North, Bawdwin South and Tiger Camp villages as described below.	• Communities • Community leaders • Religious groups • Ethnic groups • Existing workforce • Vulnerable groups
Liaison officer in communities	• The Project's EIA consultant, Coffey-Valentis, has had a full time Community Liaison Officer on site since project inception. This person is responsible for the running of the community Information centres and managing the community question and answer process described below.	• Communities • Community leaders • Religious groups • Ethnic groups • Existing workforce • Vulnerable groups
Community newsletters and publications	• Throughout the project various community presentations have taken place by WMM Management. Information has also been disseminated via newsletters and fact sheets.	• Communities • Community leaders • Religious groups • Ethnic groups • Existing workforce • Vulnerable groups • Local Government
EIA baseline surveys	• The socio-economic survey that took place, along with other community meetings and engagement with surrounding villages also presented an engagement opportunity with various local stakeholders.	• Communities • Community leaders • Religious groups • Ethnic groups • Existing workforce • Vulnerable groups • Local Government
Workforce presentations and meetings	• Various meetings have been held with the Win Myint Mo workforce as well as the workforces of the various contractors on site, throughout the project development.	• Existing workforce
General project awareness and EIA process		
Project videos	• Various videos have been produced to provide stakeholders the opportunity to review detailed project information in their own time. • The videos are available on the WMM website and also on You Tube. • The videos include: a) Project overview b) Detailed project description c) Resettlement overview d) ESIA and EMP overview	• All stakeholders

Type	Description	Stakeholder / PAP
WMM website	• WMM created a project specific website which contains detailed project information: https://www.bawdwinjv.com/	• All stakeholders
Myanmar Metals ASX announcements	• Regular and ongoing project announcements are made via the Australian Stock Exchange website by Myanmar Metals Limited: https://www2.asx.com.au/markets/company/MYL	• Owners and investors • All stakeholders
Media interviews	• Senior management of Myanmar Metals Limited make regular project updates through media interviews. For example: https://hotcopper.com.au/asx/myl/	• All stakeholders • Media
Community development projects	• Some community development projects have been undertaken during the feasibility study stage of the project, including donations and celebrations during public holidays, upgrade of school infrastructure and donations of computers.	• Communities • Community leaders • Religious groups • Ethnic groups • Existing workforce

In addition to the formal consultation rounds, other channels have been used to keep the PAP and other stakeholders up to date on the progress of the project and provide the stakeholders with opportunities to provide comment, suggestions and lodge grievances with WMM as outlined below.

Community Information Centres

The Community Information Centres were established in April 2020 to provide a communication channel with local community stakeholders. The information centres:

- Are located in three community centres of Bawdwin North, Bawdwin South and Tiger Camp.
- Are open every week and staffed by an EIA consultant staff member.
- Contain hard copies of project information such as the Scoping Report, TOR and Public Participation Plan and the Draft EIA including Draft EMP.
- Contain visual diagrams and pictures of the current concession and the planned infrastructure development.
- Contain the WMM Grievance mechanism.

The Community Information Centres provide the opportunity for stakeholders to ask questions about the project. The questions can be lodged in an anonymous way if desired. Questions and answers are logged and recorded. To date a total of 26 questions have been lodged and answered.

Grievances and complaints can also be lodged at the Community Information Centres and can be lodged anonymously if desired. Grievances are addressed by WMM Management per the WMM Grievance Mechanism. Any actions required from the grievances are tracked on a regular basis. To date a total of four (4) grievances have been lodged and actioned.

Project website

WMM developed a project website which contains detailed project information: https://www.bawdwinjv.com/

The website is in both Myanmar and English language.

The following information can be found on the website:

- Overview of the project.
- History of the mining operations.
- Overview of the development plans.
- Key project phases.
- Feasibility study overview.
- Planned mining operations.
- Information about the owners of the mine.
- Information on the project development team.
- Environmental and social impact assessment information.
- Public consultation information.
- Various downloads including:
    - Project videos.
    - Community newsletters.
    - Question and answer records from public consultation.
    - Public consultation presentations.
    - Formal notifications.
    - The Scoping Study Report.
    - The Grievance Mechanism.

The website also provides the opportunity for stakeholders to lodge questions to WMM or the Consultant.

Project videos

Various videos have been produced to provide stakeholder the opportunity to review detailed project information in their own time.

The videos are available on the WMM website and also on You Tube. The videos have been produced in English, Myanmar and Shan languages.

The videos include:

a) Project overview: https://www.youtube.com/channel/UCUJGqk7W6NQYaU6rKE2Fy9Q/featured
b) Project development overview https://www.youtube.com/watch?v=pj7stIATYfM&t=2s
c) Resettlement overview https://www.youtube.com/watch?v=nWaPYbE2cHI

Community newsletters

Throughout the project various community presentations have taken place by WMM Management. Information has also been disseminated via newsletters and fact sheets. The newsletters and fact sheets have helped to keep the community up to date on feasibility study progress, planned consultation rounds and general project developments.

9.5 Formal public consultation

Three rounds of formal public consultation took place with PAPs and stakeholders prior to the submission of the EIA as outlined in Table 9.3 and Table 9.4. Various additional informal consultations took place throughout the EIA through the following channels:

- Onsite meetings between the Bawdwin, Namtu and Tiger Camp communities and members of WMM's management, led by the Health, Safety, Community and Environment Manager, and

- Discussions during attendance at the Information Centres established in three locations at Bawdwin and Tiger Camp, as discussed further below.

The public participation was advertised in accordance with the Public Participation Guidelines, as follows:

- Public meetings were advertised locally via posters displayed in Namtu, Bawdwin and Tiger Camp.
- Advertisements were placed into local newspapers at least 14 days prior to the meetings.
- Notifications were placed on WMM's website.
- Targeted invitations were issued to Government, religious and community leaders.
- Meetings were advertised at the Community Information Centres established in Bawdwin and Tiger Camp villages.

Examples of the advertisements, notices and posters as contained in Appendix B.

Plate 9.1 Bawdwin North Information Centre (outside)

Plate 9.2 Bawdwin North Information Centre (inside)

Plate 9.3 Bawdwin South Information Centre

Plate 9.4 Tiger Camp Information Centre

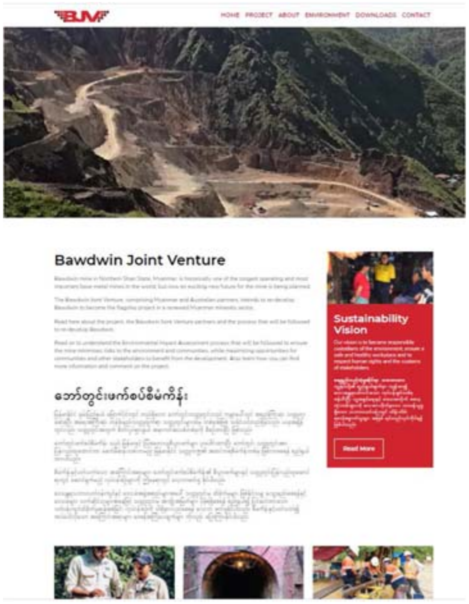

Plate 9.5 Project website

Plate 9.6 Downloads section of website

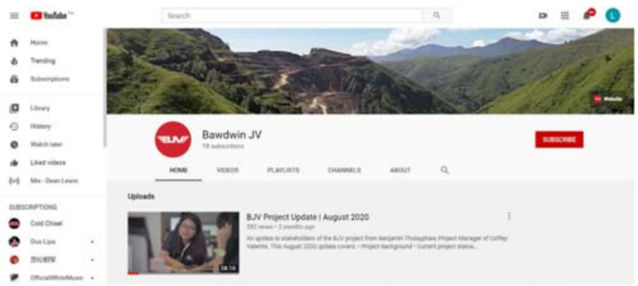

Plate 9.7 You Tube channel hosting project videos

Plate 9.8 Example of community newsletter

Plate 9.9 Meeting with Parliamentary Natural Resources Committee

Plate 9.10 Bawdwin community meeting

Plate 9.11 Namtu community meeting

Plate 9.12 Monks Association meeting

Public consultation round 1: January/February 2019

Consultation meetings as part of the first round of public participation were held with a cross section of project-affected persons and other stakeholders including Union, Shan and Township Governments and NGOs. The meetings took place in January and February 2019. Meeting photos are displayed in Appendix A and attendance records are displayed in Appendix C.

This first round of public participation intended to disclose project and provide high level information on the Project Proposal. A presentation was provided during the meetings, which was followed by questions and answers. The presentation included information on:

- Details of the project proponent (WMM).
- The history of the project.
- The proposed project including type, size and location.
- The main phases of the project (design, preconstruction, construction, operation, decommissioning/closure/post closure).
- Planned timeframes for the project.
- Planned mining operations at a high level.
- The EIA process.
- The EIA consultants.
- The baseline study process (including field surveys and interviews) and timeframes.
- The draft Scoping Report, TOR and Public Participation Plan.
- Potential environmental and social issues to be investigated in the EIA process.
- The public participation process.

Key issues raised in the first round of public consultation related to resettlement, employment opportunities, access to health services, mine waste handling, education and care for the elderly as further described below.

Table 9.3 PAPs and stakeholders consulted in public participation Round 1

PAP/Stakeholder
Union Government
Ministry of Natural Resources and Environmental Conservation – Mining Enterprise Number 1 Ministry of Natural Resources and Environmental Conservation – Mines Department Ministry of Natural Resources and Environmental Conservation – Minister's Office
Townships Government
Kyaukme District Office – General Administration Department Namtu Township Office – General Administration Department
Shan State Government
Shan State Cabinet
Local Communities
Tha Ta La Ward, Namtu Engagement with Bawdwin monks Bawdwin Police Chief Bawdwin Village Tiger Camp Community Tiger Camp Community #2 Bawdwin Village #2

PAP/Stakeholder
Mansam Falls Village
Military
Myanmar Military (Tatmadaw) – Tactical Operation Command Office, Namtu
NGOs
Myanmar Centre for Responsible Business (MCRB) Natural Resources Governance Institute (NRGI) Myanmar Alliance for Transparency and Accountability (MATA) World Bank Myanmar EITI International Labour Organisation (ILO) Oxfam Bawdwin and Tiger Camp Schools

Public consultation round 2: August 2020

Consultation following round 1 was made challenging by the outbreak of the COVID19 pandemic. Despite this, the second formal round of public consultation proceeded and was organized in close collaboration with the Namtu General Administration Department and in adherence to the ECD guide for EIA processes during the pandemic (ECD, 2020). COVID19 prevention protocols were developed and adhered to in the delivery of the consultation.

The second round of public consultation was held with a cross section of project-affected persons and other stakeholders including local communities, Union, State and Township Governments, NGOs and the military. Stakeholders were given the opportunity to raise their concerns, suggestions and recommendations. This round of consultation included 37 engagements with 1,088 attendees. Separate meetings were held with female community members via meetings organised by the Women's Affairs Federation. Meetings held are shown in Table 9.4. Meeting photos are displayed in Appendix A and attendance records are displayed in Appendix C.

During each of the meetings, a presentation was provided which was followed by questions and answers. The information presented included:

- Details of the project proponent (WMM).
- A description of the proposed project including planned infrastructure location, layout and operations.
- An overview of the requirement to resettle residents of Bawdwin and Tiger Camp, including:
    - The rationale for resettlement.
    - The resettlement planning and consolation process.
    - The objectives, principles and aims of resettlement.
- Description of the EIA process including the identification and assessment of impacts and the process of planning of impact management.
- An overview of the approved Scoping Report, TOR and Public Participation Plan.
- Potential impacts of the project and possible mitigation measures.
- Description of each of the baseline studies that were completed to support the Bawdwin Project EIA including findings, as follows:
    - Soils and existing contamination.
    - Surface water and groundwater.

  - Biodiversity.
  - Air quality and noise.
  - Socio-economic.
  - Health.
  - Cultural heritage and archaeology.
  - Landscape and visual.
- An overview of possible changes to consultation during COVID19.
- Overview of the WMM grievance mechanism and other channels for comments and complaints.
- An overview of the next steps.

Key issues raised during this round of consultation focused on the process and outcomes of resettlement and job opportunities following development.

Table 9.4 PAPs and stakeholders consulted in public participation Round 2

PAP/Stakeholder
Union Government
Ministry of Natural Resources and Environmental Conservation – Mining Enterprise Number 1
Townships Government
Kyaukme District Office – General Administration Department Namtu Township Office – General Administration Department
Shan State Government
Shan State Cabinet
Local Communities and related Groups
Pang Hai Ward residents, Namtu Tha Ta La Ward residents, Namtu Namtu Township Buddhist Monks Association Namtu Township Dignitaries Local Civil Society Organizations Political Parties Ethnic Culture Organizations Labour Unions (in both Namtu and Bawdwin) Bawdwin monks Women's Affairs Federation Islam Religious Group (Bawdwin) Christian Religious Group (Bawdwin) Hindu Religious Group (Bawdwin) Heads monks from three monasteries in Bawdwin and Two monasteries in Tiger Camp Bawdwin Police Chief Bawdwin Village both Upper and Lower (All residents) - (8 wards – Aung Tha Pyay Ward, Aung Chan Thar Ward, Aung Theik Dhi Ward, Yadanar May Ward, Mingalar Kwe Ward, Thiri Mingalar Ward, Yan Naing Kwe Ward and Pyi Taw Aye Ward) Tiger Camp Community (All residents) Communities surrounding the Bawdwin concession (village heads – Kon Kayar village, Nan Kun Village, Sin Li Village, Hpar Sum Village, Hsaik Hkawng Village, Loi Mwe Village, Namla Village, Kachin Village, Palaung Village, Lawbran Village, Hu Hsar Village and Hu Ngway Village Mansam Falls and Kon Nyaung Village
Military

PAP/Stakeholder
Myanmar Military (Tatmadaw) – Tactical Operation Command Office, Namtu
NGOs
Myanmar Centre for Responsible Business (MCRB) World Bank Oxfam

Public consultation round 3: October to December 2020

This round of consultation was made challenging by the significant spread of the COVID19 virus and the lockdown placed on Yangon residents by the Ministry of Health and Sports. The restrictions meant that the consultation team was not able to visit the project at the time planned. Government mandated gathering restrictions further hampered the ability for large groups to gather for the consultation. To enable the consultation to continue, a process of digital consultation was established, whereby a series of videos were created to provide updated project information to the communities. The videos have been prepared in Myanmar, English and Shan languages. This form of consultation is consistent with ECD's notification relating to consultation guidelines during Covid19.

The following videos were produced:

a) Project overview: https://www.youtube.com/channel/UCUJGqk7W6NQYaU6rKE2Fy9Q/featured
b) Project development overview https://www.youtube.com/watch?v=pj7stIATYfM&t=2s
c) Resettlement overview https://www.youtube.com/watch?v=nWaPYbE2cHI

The video files were distributed via memory stick widely in Bawdwin and Namtu and through website to other stakeholders. The video files were specifically distributed to the following stakeholders:

1. Mining Enterprise (1) ME 1
2. Win Myint Mo Industries Co., Ltd and Senior staff
3. WMM Staff
4. Shan Government
5. Kyaukme District GAD
6. Namtu GAD
7. PMs (2) Daw Nan Kham Aye (SNLD), Newly elected PM (NLD)
8. CSOs in Namtu
9. Namtu Town Dignitaries
10. Bawdwin Village Administration team
11. Bawdwin Tiger Camp dignitaries
12. Bawdwin nearby villages
13. Women's associations and representatives of vulnerable groups
14. PAPs in Bawdwin and Tiger Camps
15. Community in Namtu

In Bawdwin and Namtu, video files will be distributed to all 10 houses leaders and all other interested people. A team of five people visited each ward and distributed the videos. Video file recipients were recorded as outlined in Appendix C. Each of the household leaders in each ward collected questions from the community after viewing the video files. The questions were passed back to the EIA consultant and WMM and answered accordingly.

The videos contain information on:

- Details of the project proponent (WMM)
- A description of the proposed project including:
    - the main phases of the project

  - the status of the existing and planned infrastructure, including locations, descriptions and access plans
  - construction period works and phasing
  - project alternative considerations
  - potential environmental and biological impacts
  - potential socio-economic, health, safety and cultural impacts of the project
  - impact avoidance, mitigation and management, including tabling the draft EMP.
- An overview of the requirement to resettle residents of Bawdwin and Tiger Camp, including:
  - Detailed process description
  - Consultation and decision making: Formation of committees - current status, objectives, composition
  - Asset survey process: objectives, process
  - Process of site selection: current high-level areas of investigation, community feedback process
  - New housing and infrastructure: process for design of new housing and infrastructure, Government approval and community feedback
  - Entitlements: process of determining entitlements (high-level)
- An overview of the process of incorporating community feedback and comment into project planning and the EIA.
- An overview of the draft EIA and the report review and approval process.
- An overview of the WMM grievance mechanism and other channels for comments and complaints.
- An overview of the next steps.

In February 2021 the public consultation team plans to visit the Bawdwin and Namtu and hold community meetings of whatever size is permitted to supplement the engagement process.

9.6 Results of consultation and activities

9.6.1 Government Feedback

Areas of interest and issued raised by the Government in the three consultation rounds are displayed in Table 9.5 to Table 9.7 below.

Public consultation round 1: January/February 2019

Table 9.5 Government areas of interest and issues raised: round 1

Stakeholder	Main Areas of Interest / Issues Raised	Outcomes/how the issue was addressed
Lower house (Pyithu Hluttaw) Natural Resources and Environmental committees	• Benefits to the local community and Myanmar • EIA and consultation material availability in multiple languages • The size of the mine, whether mining will be underground or open pit	• Development of WMM website in dual language • Development of summary material in Shan and Kachin languages

	• Road safety issues during redevelopment of the mine	• Development of Community Development Plan
Shan State Cabinet	• Namtu town planning and impact of mine development • Employment opportunities for locals • The importance of public consultation with local communities • EIA and consultation material availability in multiple languages • Tourism opportunities post mine closure / preservation of buildings of historical significance • Infrastructure requirements to support the mine such as transport/logistics links and energy • Domestic waste management in the mining community	• Publication of the WMM employment policy promoting local employment • Development of WMM website in dual language • Consideration of development of museum in cultural heritage plan
Parliamentary Member from Namtu	• Project needs to be transparent and local community should be informed throughout planning • Importance of the project to regional development	• Broad ranging consultation

Public consultation round 2: August 2020

Table 9.6 Government areas of interest and issues raised: round 2

Stakeholder	Main Areas of Interest / Issues Raised	Outcomes/how the issue was addressed
Shan State Cabinet	• Suggestion for the scoping study to cover the concession area and beyond • Accountability of project proponent for any issues arising from resettlement • Consideration for internally displaced persons and refugees in the project area • The significance of the resettlement process and the challenge of undertaking resettlement in a conflict zone • The importance of incorporating community opinions and concerns in the EIA • Consideration of ethnic minorities and their rights • The importance of understanding any land ownership issues during the resettlement process and the need to avoid community confrontation in this area • The opportunity for the project to bring more peace and tranquillity to the region	• Broadening of consultation to include villages surrounding the concession • High-level study, including drone survey of artisanal miners in the vicinity of the mine • Development of a Land Acquisition and Development Plan to guide the objectives and principles of resettlement
Kyaukme district and Namtu township General Administrators	• The importance of following international standards and Myanmar Laws relating to resettlement • Recognition of the significance of the challenge of resettlement	• Development of an outline of the Land Acquisition and Development Plan (Attachment 4) to guide the objectives and principles of resettlement
Parliamentary members	• Importance of local community consultation during planning stage • Understanding of the local community needs • Transparency of project development plans and impacts during consultation	• Broad ranging consultation

Public consultation round 3: January 2021

Table 9.7 Government areas of interest and issues raised: round 3

Stakeholder	Main Areas of Interest / Issues Raised	Outcomes/how the issue was addressed
Namtu GAD and Government Departments	• Project is large and involves multiple stakeholders. Desire to make this project happen and see Namtu flourish again. • Resettlement needs to go through a series of processes starting from Union Government to local authorities such as, road department, education department, social security and housing departments. • Resettlement planning should include water resources management, education, agricultural planning and disaster prevention. • When relocation is planned, it should avoid Hpakant scenarios or Mawchi mine, because people resettle near the mine and live on the waste rock dump by collecting discarded ore waste pile. • Road use from Namtu to Lashio, bridges and road width and truck weight should be considered. If needed, the road should be upgraded. • There have been missed infrastructure upgrade opportunities for Bawdwin because of the belief this project will kick off soon. This has meant the Government has not allocated any budget to infrastructure upgrades. • It is necessary to conduct planning for any archaeological sites and consider establishment of a small museum in the resettled area. • It is estimated that one third of the community would like to go back to their native land in middle part of Myanmar, but they cannot and are stuck now. • During this interval before obtaining the permit, the company should look at providing some assistance on the ground such as schools and roads and it should be done through coordination with Namtu GAD. • During the assessment period, the mental and physical impacts on the community should be identified, with different age groups considered. • When the project is permitted, the police station should be informed as well because they have police station in Bawdwin. When the work starts, they would like to be aware of workers list. • When the investment comes in, we would like to suggest upgrading the Namtu airport.	• Proposal to ME1 for formation of resettlement committees at the Union, State and Township/Community levels. • Consideration of infrastructure requests in development planning
Bawdwin GAD, and 100 houses leaders	• Although there are job prospects from this project, most people are retiring soon. • The local community expects to own the resettled house and land. They are worried about where they will be relocated to and concerned about the peace issues, conflict and illegal taxation around Namtu. • The phrase "Standard not lower than current housing" is not satisfactory because most people are living in small space. • Old people are already affected by the news of relocation and their health starts deteriorating.	• Proposal to ME1 for formation of resettlement committees at the Union, State and Township/Community levels. • Further community consultation during the resettlement planning phase.

Stakeholder	Main Areas of Interest / Issues Raised	Outcomes/how the issue was addressed
	• There is a general sad sediment to lose intangible value such as culture, religious buildings and donation that generations of people made. • If the Government approvals the relocation, the people will move, however they would like to request consideration is given to both tangible and intangible community values.	
Parliamentary Members	• The Shan National League for Democracy plans to hold discussions on Bawdwin within their party. • The party wants to understand the resettlement timeframe as this impacts various other plans for the area. • It is understood that the company is investigating a resettlement site near the village of Khyu Sawt in Namtu. It is expected that this will not be accepted by the local community. • Concerns raised over water supply and less water flow to the Namtu river due to the project. • Tiger Tunnel should be closed from the start of the operation as it is going to be used for the operation. • The importance of community consultation and community involvement in decision making. • Project should happen and people should also be treated well.	• Proposal to ME1 for formation of resettlement committees at the Union, State and Township/Community levels. • Further community consultation during the resettlement planning phase.

9.6.2 Community Feedback

Areas of interest and issued raised by the community in the three consultation rounds are displayed in Table 9.8 to Table 9.10 below. A comprehensive list of questions raised by the community and answered provided by WMM is contained at Appendix D.

Public consultation round 1: January/February 2019

Table 9.8 Key issues, questions and suggestions raised by the community at the first round of public consultation

Interest or Issues	Stakeholder Groups to Express Issues or Issue	Main Areas of Interest / Issue Raised	Outcomes/how the issue was addressed
Project Proponent and Transparency	▪ Stakeholders from Namtu including town dignitaries and wards leaders ▪ Stakeholders from Bawdwin	▪ Requests for greater transparency regarding the contracting arrangements between ME-1, WMM, and WMM particularly regarding employment as part of the redevelopment. ▪ Project proponent background and ownership structure	• Development of WMM website with information about Project Proponent
Resettlement	▪ Stakeholders from Bawdwin and Tiger Camp	▪ Resettlement for people affected by the Bawdwin mine redevelopment, including Bawdwin village, monastery, police station and administrative office located in the mine area	• Development of an outline of the Land Acquisition and Development Plan (Attachment 4).
Employment and livelihoods	▪ Stakeholders from Bawdwin and Tiger Camp	▪ Plans to improve the living standards of local communities including job opportunities, education, health and economy. ▪ Employment opportunities - whether existing WMM employees will be employed at the mine once redeveloped; salaries and contractual arrangements. ▪ Requests for the project proponent to coordinate with local people before the start of mining activities and create job opportunities and local development plans. ▪ Queries regarding retired personnel (from ME-1 and WMM) and elders currently living in mine accommodations. Participants wanted to know the plans of WMM for the retirees and older people living in Bawdwin village. ▪ Concerns regarding the declining student population at Bawdwin and Tiger Camp and suggestions that WMM should improve the education for the next generation. ▪ Compensation arrangements for destruction of plantation areas.	• Establishment of plans to undertake consultation with the community and establish resettlement working groups/committees

Interest or Issues	Stakeholder Groups to Express Issues or Issue	Main Areas of Interest / Issue Raised	Outcomes/how the issue was addressed
Environmental, health and social impact	▪ Stakeholders from Namtu ▪ Stakeholders from Bawdwin and Tiger Camp	▪ Queries regarding locations of the waste dump and plans to protect residents from failure of waste dump including maintenance of ER valley drainage system and potential for flooding. ▪ Suggestions that WMM should provide drinking water to Bawdwin residents because the reservoir water is not sufficient for drinking water during the summer season. ▪ Queries regarding mining activity waste management. ▪ Queries regarding the current stage of the study. ▪ Plans for tailing/waste dumps locations. ▪ Health services arrangement for mine redevelopment.	• Feedback taken into consideration in the engineering planning and resettlement plans • Feedback taken into consideration in EIA and forward work plans.
Infrastructure	▪ Stakeholders from Namtu ▪ Stakeholders from Bawdwin and Tiger Camp	▪ Road infrastructure upgrade plans. ▪ Provision of electricity to houses/tents which are not properties of WMM, education and medical services as part of project planning.	• Addressed through resettlement of the communities to company built new housing

Public consultation round 2: August 2020

Table 9.9 Key issues, questions and suggestions raised by the community at the second round of public consultation

Issue or Interest	Stakeholder Groups to Express Issue or Interest	Main Areas of Interest / Issue Raised	Outcomes/how the issue was addressed
Project development timing and design	▪ Local residents and PAP from Bawdwin and Tiger camp ▪ International NGOs ▪ Labour Union, Women Association	▪ Project timing for commencement of mining ▪ The location of project infrastructure and accommodation for workers ▪ Timeframe for resettlement	▪ Further information and updates provided on WMM website
	▪ Local NGOs and PAP in Bawdwin and Tiger Camp	▪ Ongoing provision of information to stakeholders regarding the project	▪ Further information and updates provided on WMM website
	▪ Labour Union	▪ Activities under current license holder and future mining plans by WMM for which water quality is a concern	▪ Taken into consideration in developing engineering plans
Resettlement, community development and livelihoods in resettled area	▪ PAP from Bawdwin and Tiger Camp	▪ Possibility of land tenure to be granted to residents at resettled site. ▪ The need to ensure resettlement compensation/benefits are greater than current situation.	▪ Taken into consideration in development of resettlement plans
	▪ Pensioners, and people who worked in the farm	▪ Availability of land for gardening/farming in resettlement sites ▪ Concerns by pensioners regarding lack of employment opportunities in redevelopment	▪ Taken into consideration in development of resettlement plans
	▪ Local residents and PAP from Bawdwin and Tiger Camp	▪ Resettlement site location is a concern if the relocated area is not peaceful. Community desires the same security condition they have now. ▪ Community expressed concern around access to jobs at the mine if the resettlement site is not close to the mine	▪ Taken into consideration options for resettlement site

Issue or Interest	**Stakeholder Groups to Express Issue or Interest**	**Main Areas of Interest / Issue Raised**	**Outcomes/how the issue was addressed**
	▪ Government Department ▪ Town dignitaries, ▪ Community of Namtu, Bawdwin and Tiger Camp	▪ Community infrastructure, services and development are major concerns if they are relocated. Desires to ensure relevant community infrastructure is provided at the resettlement site including; schools, hospitals, market, electricity and water.	▪ Taken into consideration in development of resettlement plans
	▪ Religious leaders from Buddhists, Christian, Islam and Hindu in Bawdwin	▪ Religious leaders of four major religions prefer to have their worship places close to their communities ▪ Any destruction of buildings should be done in accordance with religious belief and practice. Particularly, Buddhist temples and Hindu temples (Shrine or Pagoda) ▪ Need to ensure burial grounds are provided in resettlement site	▪ Taken into consideration in development of resettlement plans
	▪ PAP from Bawdwin and Tiger Camp	▪ Concerns expressed about livelihoods e.g. not having customers for shop keepers or finding jobs nearby	▪ Taken into consideration in development of livelihood restoration plans
Security and Conflict	▪ PAP from Bawdwin and Tiger Camp ▪ Military Strategist, Namtu ▪ Town Dignitaries	▪ Security risks of Ethnic Armed Organizations (EAO) in the vicinity of the project and whether the development will encourage clashes with the Myanmar army or between EAOs.	▪ Noted by WMM
	▪ Hamlets/Villages leaders ▪ Mine Super Intendant and Bawdwin Administrator	▪ Ethnic Communities (surrounding villages), rely on Bawdwin for education and health services. Concerns for these communities. ▪ Communication strategy with EAOs	▪ WMM intends to specifically engage these communities for further discussion of this subject

Issue or Interest	Stakeholder Groups to Express Issue or Interest	Main Areas of Interest / Issue Raised	Outcomes/how the issue was addressed
Employment, training and local businesses	▪ Labour Union ▪ PAP from Bawdwin and Tiger Camp	▪ Concerns that the community will not have the skills or relevant certifications for a modern mine ▪ Concerns expressed regarding in-migration of workforce from other regions, taking jobs of local residents ▪ Request for preferential treatment for employment of local residents and emphasis on youth employment and training to assist with the development of the next generation	▪ Local training and development plan established by WMM as part of the Community Development Plans
	▪ Residents from Namtu and Bawdwin ▪ MCRB – inclusion of Ethnic Enterprise association	▪ Opportunities for local businesses and how these can be fostered in favour to businesses established by those outside the community	▪ Taken into consideration in development of livelihood restoration plans
Environmental and Health Impacts	▪ General Administration Department ▪ PAP from Bawdwin and Tiger Camp ▪ Residence from Namtu	▪ Industrial and domestic waste are management concerns especially, chemical waste that can impact nearby communities.	▪ Addressed in management plans developed as part of the EIA
	▪ Namtu residents ▪ PAP from Bawdwin and Tiger Camp	▪ Health impacts, both physical and mental due to resettlement or mineral processing.	▪ Addressed in management plans developed as part of the EIA
Project Benefit Sharing	▪ Namtu residents ▪ PAP from Bawdwin and Tiger Camp	▪ Transparency of contractual agreement with the Government ▪ Profit sharing / benefit sharing to assist with regional development	WMM will comply with recent directives on contract transparency issued by the Union government

Issue or Interest	Stakeholder Groups to Express Issue or Interest	Main Areas of Interest / Issue Raised	Outcomes/how the issue was addressed
Cultural Heritage	▪ PAP from Bawdwin and Tiger Camp ▪ Village Elders and Towns elders ▪ Namtu residents ▪ MCRB	▪ Consideration of preservation of items of cultural heritage significance ▪ Development of a museum in/around Namtu. ▪ Social coercion of the community when relocated. Preference to be located in the same place.	▪ Development of cultural heritage management plan (Attachment 4)
Project Alternatives	▪ Woman's Affairs Association	▪ Given the history of underground mining, the query was raised as to whether the mine can continue as an underground mine or if there are other alternatives to the Project.	▪ Considered as part of project alternatives analysis in EIA

Public consultation round 3: January 2021

Table 9.10 Key issues, questions and suggestions raised by the community at the third round of public consultation

Issue or Interest	Stakeholder Groups to Express Issue or Interest	Main Areas of Interest / Issue Raised	Outcomes/how the issue was addressed
Project Description, timing and design	▪ Local residents in upper Bawdwin villages ▪ Residence from Tiger Camp and Yan Naing Kwe ▪ PAP from Bawdwin and Tiger Camp and some residence from Namtu	▪ Project timing is of concern as they are unsure about the timing of the resettlement. ▪ Current oxide mining activities on site, such as road and sedimentation dam construction is of great concern especially in the lead up to the rainy season. ▪ Sadness expressed to see the location of the proposed TSF – C because it covers Aung Chan Thar Ward.	▪ Preparation and distribution of a community flyer describing the oxide mining activities and the companies responsible
	▪ Local NGOs and PAP in Bawdwin and Tiger Camp	▪ Less interested in project description, but worried that once the operation starts no one will be able access to this stie.	▪ To be considered in resettlement planning

Issue or Interest	Stakeholder Groups to Express Issue or Interest	Main Areas of Interest / Issue Raised	Outcomes/how the issue was addressed
Resettlement, community development and livelihoods in resettled area	▪ PAP from Bawdwin and Tiger Camp	▪ Request for land tenure to be granted to residents at resettled site. ▪ The need to ensure resettlement compensation/benefits are greater than current situation.	▪ To be considered in resettlement planning
	▪ Pensioners, and people who worked in the farm	▪ Availability of land for gardening/farming in resettlement sites ▪ Concerns by pensioners regarding lack of employment opportunities in redevelopment.	▪ To be considered in resettlement and livelihoods planning
	▪ Local residents and PAP from Bawdwin and Tiger Camp	▪ Resettlement site location is a concern if the relocated area is not peaceful. Community desires the same security condition they have now. ▪ Strong desire to know the place for the resettlement. Objections raised to Namtu as a resettlement site due to concerns relating to illegal tax from ethnic groups and drug issues.	▪ To be considered in site location options
	▪ Government Department ▪ Town dignitaries, ▪ Community of Namtu, Bawdwin and Tiger Camp	▪ Community infrastructure, services and development are key areas of interest for the resettlement site. Desire to ensure relevant community infrastructure is provided at the resettlement site including; schools, hospitals, market, electricity and water.	▪ To be considered in resettlement site infrastructure planning and discussed at resettlement working groups
	▪ PAP from Bawdwin and Tiger Camp	▪ Concerns expressed about when they are relocated, they will need six months or so support before they are fully settled. ▪ Concerns expressed about relocation. Questions raised about the consent rights of the community in relation to the resettlement process. ▪ Majority of the people know that ultimately, they will have to be relocated, so they want to make sure they have safe place, own the property and have a livelihood. ▪ Concerns expressed over loss intangible heritage such as culture, landscape and monasteries.	▪ Continual consultation and community discussion during the resettlement planning. ▪ Take into consideration in development of livelihood restoration plans

Issue or Interest	Stakeholder Groups to Express Issue or Interest	Main Areas of Interest / Issue Raised	Outcomes/how the issue was addressed
Neighbouring villages	▪ Villagers from Nam La and Lwemwe ▪ Village head (Hin Poke Village Tract)	▪ Nam La and Lwemwe villages expressed their interest and concern for the resettlement because they are entirely relying on Bawdwin and if they are relocated, it is going to be very difficult for them to survive. ▪ They also request to be relocated together with Bawdwin residence. ▪ Other Kachin and Palaung villages are concerned about dust and gas that will be emitted from the plant during operation. ▪ They are also concerned about water supply that WMM is planning to source from Nan Pangyun and Nam La creeks which they are also using for their livestock and plantations.	▪ To be considered in resettlement planning
	▪ Hamlets/Villages leaders and Hinpoke Village Tract leader	▪ They would like to request for electricity connection when there is a power station installed.	▪ To be considered in resettlement planning
Employment, training and local businesses	▪ PAP from Bawdwin and Tiger Camp	▪ Many of the older residents will be within retirement age in the short term and therefore there is concern about their lack of skills and employment prospects.	▪ Taken into consideration in development of livelihood restoration plans
	▪ Residents from Namtu and Bawdwin ▪ GAD Bawdwin and 100 houses leaders	▪ Concerns raised regarding the mental health of older residents resulting from the news of resettlement. Requests for assistance.	▪ Taken into consideration in development of livelihood restoration plans
Environmental and Health Impacts	▪ General Administration Department ▪ PAP from Bawdwin and Tiger Camp ▪ Residence from Namtu	▪ The Tiger Camp community is concerned about possible flooding in the rainy season due to earth works in Wallah Gorge. ▪ Residence from Yan Naing Kwe and Yadanar Myay are worried because there is road construction on the mountain. They are worried of landslide and boulders falling in the rainy season.	▪ Construction of sedimentation ponds ▪ To be considered in resettlement planning

Issue or Interest	Stakeholder Groups to Express Issue or Interest	Main Areas of Interest / Issue Raised	Outcomes/how the issue was addressed
	▪ Namtu residents ▪ PAP from Bawdwin and Tiger Camp	▪ Health impacts, both physical and mental due to resettlement or mineral processing.	▪ To be considered in resettlement planning
Resettlement Process	▪ PAP from Bawdwin and Tiger Camp	▪ Requests for further explanation of the resettlement process and representation on the resettlement committees. ▪ Desire to know the location of the resettlement site, whether the land will be owned by the community and the design of the housing prior to acceptance of the process. ▪ The explanation of the process to date is helpful, but it does not confirm the promise.	▪ Continual consultation and community discussion during the resettlement planning and including in planning committees.
Missed opportunities	▪ Parliamentary Members ▪ General Administration Department, Bawdwin	▪ Bawdwin as a village listed in Namtu township, has the right to be considered for Government budget for development work such as road upgrades and construction of schools. ▪ The prospect of the mine redevelopment bars them from being considered for development budget from the Parliament or the Government budget.	

9.6.3 NGO / Other Stakeholder Feedback

Areas of interest and issued raised by the NGOs and Other Stakeholders in the three consultation rounds are displayed in Table 9.11 to Table 9.13 below.

Public consultation round 1: January/February 2019

Table 9.11 Key issues, questions and suggestions raised by NGOs at the first round of public consultation

Stakeholder	Main Areas of Interest / Issues Raised	Outcomes/how the issue was addressed
Myanmar Alliance for Transparency Accountability (MATA)	• Disclosure of Government arrangements / contracts • Disclosure of WMM company history, accounts and how it came to obtain the original concession from ME1 • Desire to see broad consultation on the project with local communities	• Participation by WMM the EITI process and disclosure of accounts • Broad and transparent project plan disclosure via community consultation, website and video updates
Myanmar Centre for Responsible Business (MCRB)	• Importance of wide-ranging consultation and inclusion of ethnic monitories • The importance of development of a project website for continuous disclosure and transparency	• Development and launch of WMM website • Broadening of consultation to villages surrounding the concession
Natural Resources Governance Institute (NRGI)	• Importance of transparency in relation to development plans	• Development and launch of WMM website

Public consultation round 2: August 2020

Table 9.12 Key issues, questions and suggestions raised by NGOs at the second round of public consultation

Stakeholder	Main Areas of Interest / Issues Raised	Outcomes/how the issue was addressed
Myanmar Centre for Responsible Business (MCRB)	• Importance of national level public consultation for this project • Ensure clear understanding of Government expectations for environmental /community funds management • Consideration of ethnic minorities are important, by referring to ethnic by-laws	• Consultation plans include wide ranging consultation • Plan to expand consultation to village surrounding the concession to incorporate ethnic groups
Oxfam	• Concerns around possible exacerbation of conflict with EAOs. It is important that WMM has policy. • Considerations of Free, Prior and Informed Consent of the community in relation to the project development. • Management of in-migration.	• Issue under consideration • Consideration in EIA and public participation program.
Natural Resources Governance Institute (NRGI)	• Resettlement management • Residual contamination from historical mining activities • Management of water resources for the mine operation and downstream impact.	• Environmental impacts managed through development of management plans in the EIA

Stakeholder	Main Areas of Interest / Issues Raised	Outcomes/how the issue was addressed
World Bank	• EAO consultation • Suggestion for WMM to volunteer to be part of EITI process	• Development of WMM policy related to EAOs

Public consultation round 3: January 2021

Table 9.13 Key issues, questions and suggestions raised by NGOs at the third round of public consultation

Stakeholder	Main Areas of Interest / Issues Raised	Outcomes/how the issue was addressed
Labour Union	• There are some people living in monasteries and religious buildings, they do not live in a house or workers accommodations.	• To be considered in resettlement planning
	• Concerns about increased road traffic and requirement for resettlement of people living near the road or railway line.	• To be considered in resettlement planning
	• Request for the community to also be consulted in the resettlement planning, not only the Government Administration.	• Inclusion of community leaders in the resettlement committees

Appendix A Meeting Photos

Meetings photos for Public Consultation Round 1

Figure 01 Meeting in Namtu

Figure 02 Meeting in Bawdwin

Figure 03 Meeting in Tiger Camp

Figure 04 Meeting Parliamentary Natural Resources Management Committee

Meetings photos for Public Consultation Round 2

Figure 1: Shan State Cabinets (4 Aug 2020)

Figure 2: WMM Senior Staff (10 Aug)

Figure 3: Parliamentarian Daw Nan Kham Aye

Figure 4: Bawdwin Administrator and team

Figure 5 Namtu Town Hall Public Meeting

Figure 6: Monks Association Namtu Township

Figure 7: Namtu Labour Union

Figure 8: Islam Religion Leader

Figure 9: Chief Police Office acting

Figure 10: Christian Religion Leader

Figure 11: Hindu Religion Leader

Figure 12: Head Monk Lower Monastery

Figure 13: Head Monk Middle Monastery

Figure 14: Head Monk Upper Monastery

Figure 15: Labour Union, Bawdwin

Figure 16: Aung Tha Pyay Ward, Bawdwin

Figure 17: Aung Chan Thar Ward, Bawdwin

Figure 18: Women Association

Figure 19: Aung Theikdhi/Yadanar Myay, Bawdwin

Figure 20: Mingalar Kwe Ward, Bawdwin

Figure 21: Charity Organizations, Bawdwin


Figure 22: Thiri Mingalar ward, Bawdwin


Figure 23: Yan Naing Kwe Ward, Bawdwin


Figure 24: Pyi Taw Aye Morning, Bawdwin


Figure 25: Pyi Taw Aye Ward, Bawdwin (PM)


Figure 26: Daw Nan San Hwan at Tiger Camp


Figure 27: Tiger Camp Morning


Figure 28: Tiger Camp Afternoon


Figure 29: Tiger Camp Lower Monastery


Figure 30: Tiger Camp Upper Monastery


Figure 31: 12 villages leader (near concession)

Meetings photos for Public Consultation Round 3

Figure (1) Bawdwin and Tiger Camp GAD group

Figure (2) Labour Union Bawdwin

Figure (3) Parliamentarian Daw Nan Kham Aye

Figure (4) Aung Chan Thar Ward

Figure (6) Yan Naing Kwe Ward

Figure (7) Yadanar Myay Ward

Figure (8) Thirimingalar Ward

Figure (9) Thirimingalar Ward

Figure (10) Pyi Taw Ayev Ward

Figure (11) Pyi Taw Aye Ward

Figure (12) Pyi Taw Aye Ward

Figure (13) Aung Tha Pyay Ward

Figure (14) Aung Tha Pyay Ward

Figure (15) Women Groups (general)

Figure (16) Mingalar Gwe Ward

Figure (17) Hin Poke VT (Namla and Lwemwe)

Figure (18) Aung Theikdhi Ward

Figure (19) Tiger Camp

Figure (20) Tiger Camp

Figure (21) Namtu GAD, Town dignitaries and Government Staff

Figure (22) Labour, Civil Society Namtu

Appendix B Meeting Notices and Advertisements

Shell dives to $18.1bn loss on virus-hit oil market

THE HAGUE — Anglo-Dutch energy major Royal Dutch Shell posted Thursday a colossal net loss of $18.1 billion (15.4billion euros) for the second quarter, blaming massive asset writedowns on the coronavirus-hit oil market, and flagged that job cuts are on the way.

The performance, contrasting sharply with profit after tax of $3.0 billion a year earlier, was sparked by a huge $16.8-billion charge on chronic fallout both from COVID-19 and collapsing oil prices.

The vast charge was taken "as a result of revised medium- and long-term price and refining margin outlook assumptions in response to the COVID-19 pandemic and macroeconomic conditions as well as energy market demand and supply fundamentals," Shell said in a results statement.

The dire performance meanwhile reflected lower prices for oil, liquefied natural gas (LNG) and gas, while it was also adversely impacted by lower refining margins and oil products sales volumes.

Production dipped six per cent to 3.4 million barrels of oil equivalent per day in the reporting period – and is forecast to drop further in the third quarter.

'Resizing'

"Shell has delivered resilient cash flow in a remarkably challenging environment," said Chief Executive Ben van Beurden in Thursday's statement.

"We continue to focus on safe and reliable operations and our decisive cash preservation measures will underpin the strengthening of our balance sheet."—AFP ■

Oil firms like Shell are booking massive losses as lower oil prices force them to reduce the value of their assets. **PHOTO: AFP/FILE**

Strong sales of cleaning products amid pandemic boost P&G results

CINCINNATI — Strong sales of cleaning products and soaps amid the coronavirus crisis more than compensated for lackluster demand for shaving products, lifting Procter & Gamble's quarterly earnings, the company reported Thursday.

The US consumer products giant, whose brands include Mr Clean, Cascade and Gilette, scored an impressive 11 per cent surge in second-quarter sales in fabric and home care, the standout division in the period.

"We remain highly relevent across the board," said Chief Financial Officer Jon Moeller, who said consumers were keeping larger inventories of products at home to avoid store visits.

"Consumers generally are carrying higher inventory levels. They also are consuming more," said Moeller, adding that shoppers had also had more money for household items that might have otherwise gone to travel or eating out.

Moeller said consumers were using more detergent because they were washing clothes after just one use. Sales of some items, such as Bounty paper towels, were up "strong" double digits in the quarter, he told reporters on a conference call.—AFP ■

Strong sales of soaps and cleaning products boosted Procter & Gamble earnings amid the coronavirus crisis.
PHOTO: AFP/FILE

Huawei overtakes Samsung as top smartphone seller

BEIJING — China's Huawei has overtaken Samsung to become the number-one smartphone seller worldwide in the second quarter on the back of strong domestic demand, industry tracker Canalys said Thursday.

Canalys said the embattled firm, which is facing US sanctions and falling overseas sales, shipped 55.8 million devices — overtaking Samsung for the first time, which shifted 53.7 million units.

The findings marked the first quarter in nine years that a company other than Samsung or Apple has led the market, Canalys said. —AFP ■

Notice of Commencement of EIA Investigation Phase

The members of the Bawdwin Joint Venture Company Limited (BJV) plan to redevelop the existing lead, zinc and silver mine located in Namtu township, Kyauk Me District, Northern Shan State, Myanmar.

Redevelopment will involve demolition of some existing infrastructure and construction of new infrastructure to support mining and processing activities within the 38 km² existing mining concession.

An Environmental and Social Impact Assessment is currently being undertaken in accordance with Myanmar's Environmental Laws and Procedures. The Scoping Report, Terms of Reference, Public Participation Plan and Grievance Mechanism are available at the Information Centers listed below and on BJV's website set up in the project area or from the website given below.

Public consultation relating to the project will be carried out in Namtu and Bawdwin in August 2020 and will be held in accordance with Government COVID19 public gathering guidelines.

	Namtu	Bawdwin	Tiger Camp
Time	9:00 - 3:00	9:00 - 3:00	9:00 - 3:00
Date	August 12-18	August 19-24	August 25-29
Venue	Namtu GAD office	Bawdwin Sport Complex	Theatre

For further information, to submit comments, or lodge a grievance, please visit the Information Centers located at Bawdwin Upper Village, Bawdwin Lower Village and Tiger Camp or send us an email by visiting https://bawdwinjv.com

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Bawdwin Joint Venture (BJV) Co., Ltd.

Figure 32 Notice of Commencement of EIA Investigation Phase – in The Global New Light of Myanmar (English)

EIA ဆန်းစစ်ခြင်းအဆင့်လုပ်ငန်းများစတင်ရန် အသိပေးချက်

Notice of Commencement of EIA Investigation Phase

(Bawdwin Joint Venture Company Limited)

Scoping, Terms of Reference, BJV website

https://bawdwinjv.com

Bawdwin Joint Venture (BJV) Co., Ltd.

Figure 33 Notice of Commencement of EIA Investigation Phase – in New Light of Myanmar (Myanmar)

COUNTING COSTS

Canada virus measures push deficit to record Can$382 bln

Canadian Finance Minister Chrystia Freeland - here with Prime Minister Justin Trudeau - said the government was preparing to spend up to Can$100 billion over three years to jolt the economy once the pandemic is over. PHOTO: AFP

CANADA'S budget deficit is projected to balloon to a record Can$382 billion (US$294 billion) as government spending skyrockets to combat the spread of the novel coronavirus, the finance minister announced Monday.

The amount for the 2020-2021 fiscal year, which began on April 1, is higher than an estimate of Can$343 billion announced in July and almost 20 times higher than the shortfall in the last budget released in March 2019, before the pandemic.

Finance Minister Chrystia Freeland also said the government was preparing to spend another Can$70 billion to Can$100 billion over three years to jolt the economy once the pandemic is over.

The aim, she said, is to build back the economy to be greener, more inclusive, more innovative and more competitive.

"When the virus is under control and our economy is ready for new growth, we will deploy an ambitious stimulus package to jump-start our recovery," Freeland told the House of Commons.

"Spending roughly three to four per cent of GDP over three years, our government will make carefully judged, targeted and meaningful investments to create jobs and boost growth," she said.

The pandemic shut down large swathes of the Canadian economy in March, and several regions are now under lockdown again as a second wave of Covid-19 — worse than the first — sweeps across the country.

The government has spent hundreds of billions to support out-of-work Canadians and businesses that were forced to close temporarily.

SOURCE: AFP

CAUTIOUS OPTIMISM

World economy back to pre-pandemic level in 2021: OECD

THE global economy may get back to pre-pandemic levels by the end of next year as vaccines help propel recovery, but growth is likely to be uneven, the OECD said Tuesday.

Signs that vaccines could now be weeks away from distribution have injected cautious optimism as the year limps to a close with Covid-19 having claimed some 1.4 million lives. "For the first time since the pandemic began, there is now hope for a brighter future," OECD Chief Economist Laurence Boone wrote in her introduction to the organization's latest review of the global economic outlook.

SOURCE: AFP

Notice of Completion of Draft EIA Report and Consultation Update

The members of the BJV Company Limited (BJV) plans to redevelop the existing Bawdwin lead, zinc and silver mine, located in Namtu township, Kyauk Me District, Northern Shan State, Myanmar.

Redevelopment will involve demolition of some existing infrastructure and construction of new infrastructure to support mining and processing activities within the 24.6 km2 existing Bawdwin mineral concession area.

A Draft Environmental and Social Impact Assessment has been prepared in accordance with Myanmar's Environmental Laws and Procedures.

As a result of the travel and public gathering restrictions related to the the Covid19 pandemic, BJV plans to share updated information on the project and the draft ESIA by distributing a video presentation, in the form of three stand-alone modules:

- Module 1: Project information
- Module 2: Information relating to proposed resettlement of Bawdwin and Tiger Camp communities
- Module 3: Draft ESIA overview, impacts and mitigation measures

The videos will be distributed within the community on 14 December, 2020 and will also be available on the BJV website. Questions can be lodged at the Information Centers in Bawdwin or via the website. Meetings in small groups to discuss the content of the videos will be carried out in Namtu and Bawdwin when next permissible.

For further information, to submit comments, or to lodge a grievance, please visit the Information Centers located at Bawdwin Upper Village, Bawdwin Lower Village and Tiger Camp or send us an email by visiting https://bawdwinjv.com

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BJV Co., Ltd.

Figure 34 Notice of Completion of Draft EIA and Consultation Update – in Global New Light of Myanmar (Myanmar)

Figure 35 Notice of Completion of Draft EIA and Consultation Update – in Myanma Alinn (Myanmar)

Figure 36 Vinyl Advertisement at Bawdwin upper Village Information Centre

Figure 37 Vinyl Advertisement at Namtu Town Centre

Figure 38 Vinyl Advertisement at Main Market in Bawdwin

Figure 39 Vinyl Advertisement at Tiger Camp Information Centre

Appendix C Consultation Records

Appendix D Stakeholder Question and Answers

Appendix E Issues Register

Appendix F Commitments Register

Bawdwin Project

Environmental Impact Assessment
Chapter 10 Environmental and Social Management Framework

October 2023

Bawdwin Project

Prepared for

Win Myint Mo Industries Company Limited

Prepared by	Revised by
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Rev1	Electronic	Word, PDF	Win Myint Mo Industries Co., Ltd.	22/9/2023

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Attachments

10 Environmental and Social Management Framework

10.1 Introduction

This chapter provides an overview of the environmental and social management framework (ESMF) that will be developed and implemented to manage the environmental, social, health and cultural impacts associated with the project.

10.2 Environmental and social management framework

The ESMF provides the project with a system for designating roles/responsibilities, management measures and performance outcomes so that legislative, stakeholder and good practice requirements are addressed in the Environmental and Social Management Plan (ESMP) (Attachment 4), and to allow ongoing monitoring of performance so that improvements are made where identified. Other operational plans to be developed and implemented by WMM, such as the Tailings Storage Facility (TSF) Operations, Maintenance and Surveillance Manual and the waste rock management plan, will also feed into the development and continual improvement of the ESMP.

The framework is implemented through the ESMP. The ESMP comprises a series of integrated management subplans covering environmental, social and cultural aspects which are tailored to address the impacts identified in the Bawdwin Project environmental impact assessment (EIA). The management plans are supported by additional project-specific procedures and mechanisms, including the community grievance mechanism which will document and address stakeholder and community concerns.

Figure 10.1 provides an overview of the environmental and social management framework and associated management plans.

10.3 Environmental and social management plan

The ESMP (see Attachment 4) outlines the integrated management, monitoring, auditing and reporting processes and requirements for specific environmental, social and cultural aspects during pre-construction, construction, operation, closure and post-closure of the project.

This ESMP includes the following components:

- Project phases (see summary in 10.3.1).
- The policy and regulatory framework for the management of environmental, social, health and cultural heritage (see summary in 10.3.2).
- Responsibilities of personnel implementing the ESMP (see summary in 10.3.3).
- A summary of the impacts and hazards associated with the project and mitigation measures (see detail in Chapter 6 and Chapter 7).
- Overall budget for implementation of the ESMP (see summary in 10.3.4).
- The monitoring and reporting regime that will be implemented (see summary in 10.3.5).
- Sub-plans to address specific mitigation and management requirements for different environmental, social, health and cultural heritage aspects.

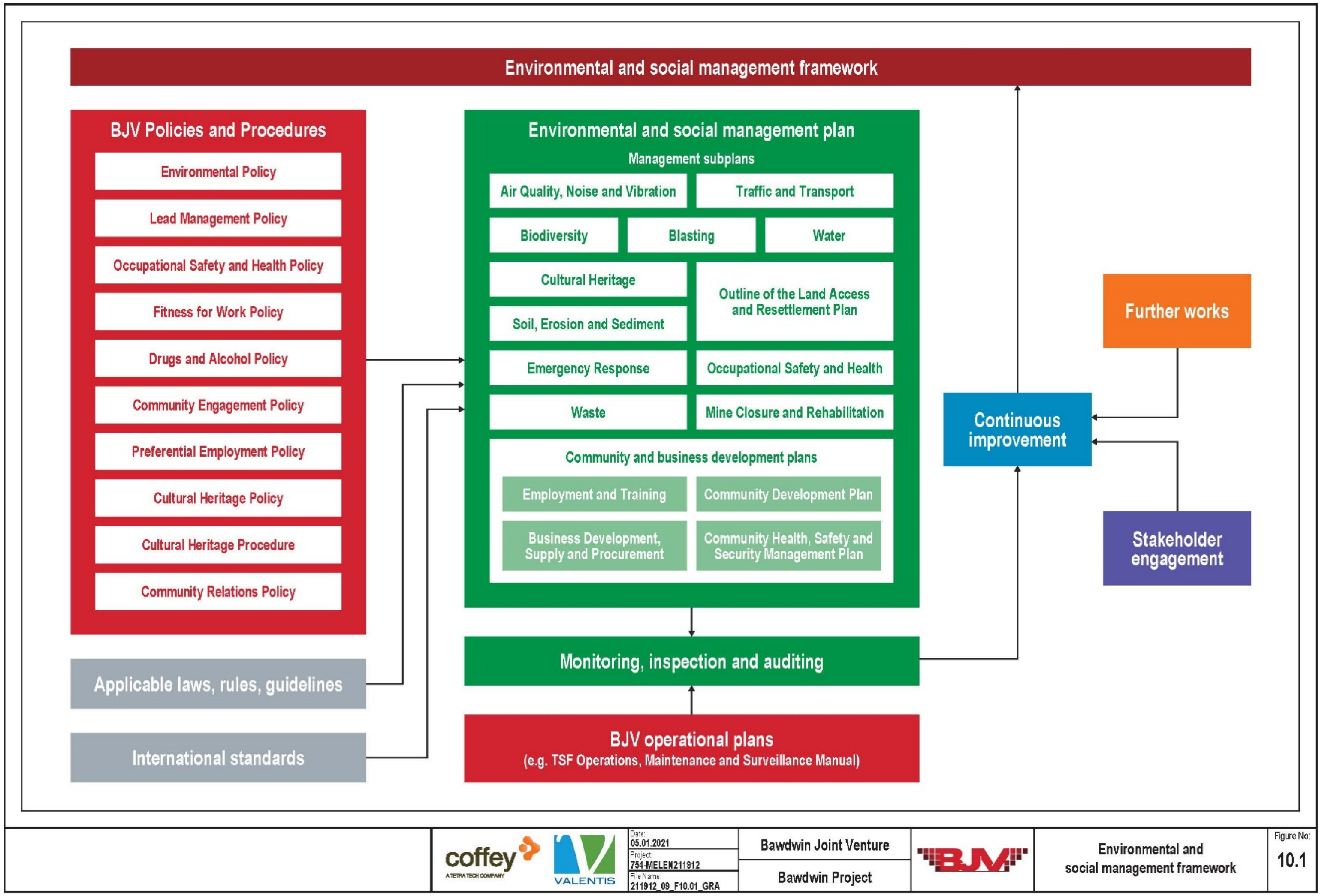


Figure 10.1 Environmental and social management framework

The purpose of the sub-plans is to outline measures to be implemented by WMM employees and contractors that aim to avoid or minimise potential adverse impacts and risks to the environment and communities and where relevant, enhance opportunities and project benefits through community development.

The sub-plans outline:

- The objectives of environmental, social or cultural management.
- Associated plans and procedures relevant to each subplan.
- The hazards and impacts associated with the project.
- Applicable laws, rules and guidelines surrounding the management of each aspect.
- Management measures to avoid, minimise or mitigate the hazards and impacts and meet environmental obligations during construction, operations and closure of the project.
- Inspection and monitoring requirements and performance and compliance criteria.

The ESMP subplans and their purpose are listed in Table 10.1.

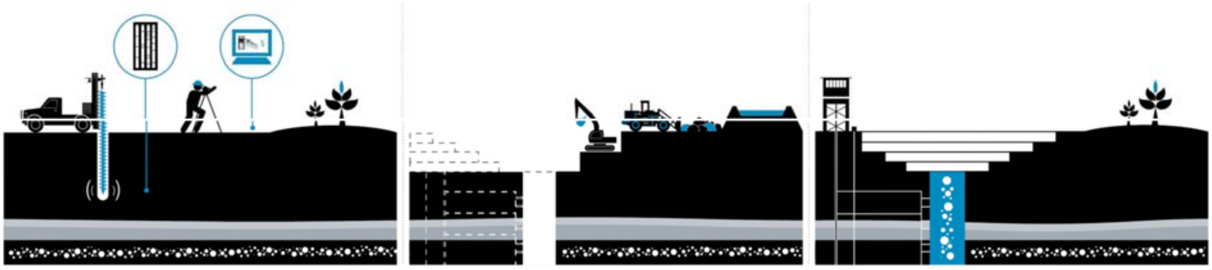
Table 10.1 Environmental and social management sub-plans

Management sub-plan	Purpose
Air Quality, Noise and Vibration	To avoid, minimise and manage impacts to human health and amenity through management of air, noise and vibration emissions caused by construction and mining activities. This is approached in accordance with the National Environmental Quality (Emission) Guidelines (MOECAF, 2014) and relevant national and international standards.
Biodiversity Management Plan	To avoid, minimise and manage impacts to terrestrial and aquatic biodiversity values. Management measures concern impacts to habitats and flora and fauna populations, including measures to address revegetation.
Blasting Management Plan	To avoid, minimise and manage impacts to human health and amenity through management of air blast and fly rock caused by blasting.
Community and business development plans comprising:	
Business Development, Supply and Procurement	To outline how opportunities will be optimised for regional businesses, a supply and procurement plan, supplier risk management program, supplier human rights training program, supplier code of conduct, a household-scale development program and a medium scale enterprise development program.
Community Development Plan	To outline the approach to community and social responsibility initiatives. Community investment priorities will include health services, education services, infrastructure and business development.
Community Health, Safety and Security Management Plan	To manage Project-related risks associated with community health, safety, the effects of in-migration, and security.
Employment and Training	To guide the projects' preferential employment practices, an inclusive communications and engagement strategy, and robust procedures for hiring practices providing for reflect equal opportunity, non-discrimination and measures to support the participation of women in training, employment and business development activities. In addition, the plan will include development of a community pre-employment training program, scholarship program and implementation of on-going training and development initiatives and on the job professional development.
Cultural Heritage Management Plan	To protect and manage cultural heritage features in the project area. Management is in accordance with relevant legislation, conventions and requirements of the IFC Performance Standard 8: Cultural Heritage.
Emergency Response	To outline potential emergencies and their consequences and include actions and procedures to follow to manage these emergencies if they occur. This includes detailed spill response procedures.

Management sub-plan	Purpose
Hazardous Materials Management Plan	To manage storage, handling, use, transport, transfer and disposal of hazardous materials including chemicals and hydrocarbons, to avoid, minimise and manage accidental spills and leaks, and impacts to human health or the environment.
Mine Closure and Rehabilitation Plan	To provide a basis for implementing the progressive rehabilitation during operations, closure of each mine domain at the end of production, detailed rehabilitation activities for the project and post-closure responsibilities.
Waste Management Plan	To avoid, minimise and manage potential adverse impacts and risks to the environment, safety and human health by appropriately managing of hazardous and non-hazardous waste, excluding bulk mine waste (i.e., waste rock and tailings) which is managed separately within WMM operational plans. This is approached in accordance with the National Environmental Quality (Emission) Guidelines (MOECAF, 2014) and relevant national and international standards.
Occupational Safety and Health Management Plan	To avoid, minimise and manage occupational safety and health risks to project workers.
Outline of Land Access and Resettlement Plan	To guide resettlement planning and livelihoods restoration. This is approached in accordance with Myanmar laws and international standards, including IFC Performance Standards. This includes outlining the proposed stages for resettlement and livelihood restoration and planning steps to be undertaken, including development of a Land Access and Resettlement Plan and Resettlement Action Plan(s).
Soil, Erosion and Sediment Management Plan	To avoid, minimise and manage erosion of soils and subsequent sedimentation of watercourses. Management measures address topsoil preservation, erosion control, sediment management and surface water and drainage management.
Traffic and Transport Management Plan	To limit the potential for incidents involving traffic and transport to occur and to avoid, minimise and manage impacts caused by vehicle traffic.
Water Management Plan	To minimise impacts to beneficial uses of surface water and groundwater through reduced water quality or change in availability (i.e., flows or groundwater drawdown or mounding). This is approached in accordance with the Myanmar mining effluent standards outlined in Mining Guidelines for Environmental Impact Assessment (Myanmar Mining EIA Guidelines Working Group, 2018).

10.3.1 Project phases

A description of key project activities by project phase is outlined below. The ESMF is applicable to all project phases.



Pre-construction (planning and approvals)	Construction (implementation)	Operations (mining and production of concentrate)	Decommissioning and Closure	Post-closure
3 Years Prior	Year 1 to 6	Year 1 to 16	Year 16 to 18	Year 18 +
• Detailed design • Further environmental and social investigations • Resettlement planning • Stakeholder engagement	• Design, construction and commissioning of project infrastructure • Resettlement of some communities • Stakeholder engagement	• Open pit mining • Deposition of waste rock to Wallah WRD • Deposition of tails to TSFs • Resettlement of remaining communities • Stakeholder engagement	• Surface infrastructure dismantled and disposed with reusable and recyclable materials sold • Rehabilitate land • Stakeholder engagement	• Post-closure monitoring and maintenance • Stakeholder engagement

10.3.2 Policy and regulatory framework overview

The environmental, social, health and cultural policies, commitments, legal requirements and institutional arrangements are outlined in EIA Chapter 2.

All new projects and project expansions having the potential to cause adverse impacts are required to submit an EIA and obtain approval in the form of an Environmental Compliance Certificate (ECC) which sets out the conditions on which a project is approved. Various ancillary permits and approvals will be required from relevant Myanmar government authorities for specific aspects of the Bawdwin project, such as water usage, upgrading of public roads, building construction and onsite health and safety.

The ESMF guides the implementation of environmental, social and cultural management through integrating WMM policies and procedures with Myanmar legislation, guidelines and standards as well as adopted international guidelines and standards (see Chapter 2). Key legal requirements and commitments will be detailed in each ESMP subplan.

The ESMF and ESMP align with WMM policies and procedures regarding the environment, communities and cultural heritage. These policies and procedures will be followed throughout the project alongside the management sub-plans and include:

- Environmental Policy.
- Lead Management Policy.
- Occupational Safety and Health Policy.

- Fitness for Work Policy.
- Drugs and Alcohol Policy.
- Community Engagement Policy.
- Recruitment Policy.
- Preferential Employment Policy.
- Cultural Heritage Policy.
- Cultural Heritage Procedure.
- Community Relations Policy.

10.3.3 Responsibilities

The responsibilities and accountabilities of key roles involved in the implementation of the ESMP and environmental and social management of the project are outlined in this section. Under the EIA Procedure (2015) WMM is required to fully implement the ESMP, all project commitments and conditions and is liable to ensure that all contractors and subcontractors of the project fully comply with all applicable Laws, the Rules and this ESMP.

The General Manager Operations at Bawdwin will have overall accountability for the environmental, social, health and cultural management of the project and operational responsibility for the project. The Safety, Health, Environment and Community (SHEC) Manager will report to the General Manager Operations and is responsible for overseeing relevant aspects of the project and following WMM policies and procedures as outlined in Section 10.3.

The operational SHEC Department will have a number of senior staff members responsible for managing environmental, social, safety, health and cultural heritage aspects of the project. These are:

- Environmental and Community Relations Manager who will be responsible for the implementation of the ESMP and environmental, social and cultural heritage social aspects of the project.
- Safety and Health Manager who will be responsible for the implementation of occupational safety and health management measures, including community health aspects of the project.
- Environmental Superintendent will be responsible for day-to-day environmental management and implementation of the ESMP. The Environmental Superintendent will report to the Environmental and Community Relations Manager.
- Community Relations Superintendent who will oversee the implementation of the social and cultural aspects of the ESMP. The Community Relations Superintendent will report to the Environmental and Community Relations Manager.
- Safety and Health Superintendent who will oversee the implementation of occupational and community-related aspects of the ESMP. This position will also oversee the company medical function and company clinics.

The ESMP describes further details regarding responsibilities and accountabilities of people involved in the environmental, social and cultural management of the project.

10.3.4 Implementation budget

Implementation of the ESMP will incur costs associated with:

- Employment of staff and subconsultants.

- Training of staff in the implementation of the ESMP, including:
  - Comprehensive training in implementation of the ESMP, compliance and enforcement, followed by onsite training on the application of the ESMP.
  - Annual refresher training.
- Monitoring and inspection procedures, monitoring equipment, consumables and laboratory analysis as outlined in Section 9.2 and ESMP sub-plans.
- Materials required in implementation of the ESMP.
- Engagement of subject matter experts, peer reviewers, technical specialists and other subconsultants as required to implement components of the ESMP.

The projected budget required to implement the ESMP and subplans is outlined in Table 10.2. The overall cost of implementing the ESMP is estimated to be approximately USD 1,450,000 (2,039,005 Kyat) annually, this excludes technical investigations and modelling required by further work programs.

Table 10.2 Estimated costs associated with implementing the ESMP, including subplans

	Cost (USD)	Cost (kyats)
Staff	800,000	1,124,968
Training	100,000	140,621
Monitoring and inspection	200,000	281,242
Materials	200,000	281,242
Engagement of subcontractors and consultants	150,000	210,931
Total	**1,450,000**	**2,039,005**

10.3.5 Monitoring and reporting

Approach

The approach taken towards environmental and social management will involve monitoring, auditing, recording and reporting results of monitoring and compliance with commitments and regulatory obligations. This will be undertaken to measure impacts and verify the predictions made in this EIA, determine the effectiveness of management measures and demonstrate compliance with permits and regulations.

Monitoring, inspections and audits

Environmental and social monitoring will include continued and additional baseline monitoring of some parameters for defined periods during pre-construction, and during construction, and operations, closure and post-closure monitoring. An overview of monitoring to be undertaken during the project is outlined in Chapter 6 Impact Assessment. Monitoring commitments made in this EIA are outlined in the ESMP.

The specific monitoring requirements will be developed further during detailed design following the collection of further baseline data and completion of further works, as outlined within the sub-plans. The monitoring programs will include objectives, performance/compliance criteria; monitoring parameters, locations and frequencies; and monitoring methods. This includes monitoring in accordance with the Myanmar National Environmental Quality (Emission) Guidelines (MOECAF, 2014) and other criteria adopted by the project.

Monitoring also includes routine and ad hoc inspection in addition to the systematic capture of data. Inspections of the Bawdwin concession area and the area of influence of operations will be undertaken periodically to confirm that the environment is being managed in accordance with the site-specific management measures agreed with regulators and potentially local communities.

Results from monitoring programs will be reviewed, reported and recorded as per Section 10.3.5.

In addition to the internal inspections and monitoring undertaken, Environmental Conservation Department (ECD) (or independent consultants) may conduct routine or ad hoc inspections and audits to assesses performance against the ESMP, or in response to an incident, such as an environmental emergency, including infrastructure failure, natural hazards or accidental discharges.

Compliance and reviewing

The project's success in achieving the environmental and social management objectives will be reviewed throughout the project. The ESMP will be regularly reviewed and updated as required to ensure that:

- Project activities are undertaken in compliance with statutory obligations.
- The environmental and social objectives of the project are achieved.
- The environmental and social management measures are effectively implemented.
- A system of continuous improvement is established.
- Further information is incorporated into the plan as it is obtained and evaluated.
- Stakeholder and community concerns raised through the community grievance mechanism are addressed.

A record of compliance requirements which captures relevant legislation and permit conditions/commitments will be maintained and updated regularly. Regular reviews will be undertaken against relevant standards and criteria outlined in the ESMP to ensure compliance with the management plans and regulatory requirements. Reporting requirements are outlined in Section 10.3.5. Monitoring and reviewing and incorporation of outputs of further works will also allow continual improvement of the management systems and processes for the project. Raised grievances concerning environmental, social or cultural heritage management will also be addressed in the continual review and development of the management plans, as will monitoring results from operational plans such as tails and waste rock management.

Reporting

Results from reviews and monitoring programs outlined in the ESMP will be recorded and regular reports will be prepared by in-house staff or suitably qualified and experienced third parties on no less than an annual basis. A monitoring report will be prepared and provided to regulators for review as required in accordance with the ECC. The requirements for reports to be submitted to regulators are outlined in the ESMP.

Reports outlining environmental and social management performance and compliance will be communicated and distributed as required by permit conditions and as outlined in the public participation plan.

Reports will contain the results from the monitoring programs outlined in the ESMP to assess the effectiveness of mitigation measures, and will assist in identifying areas where management measures need to be improved or corrective actions taken. Regular reporting will allow issues to be identified and addressed in a timely manner. Monitoring reports will generally contain:

- Introduction.
- Legislative framework and standards.
- Compliance/performance criteria.
- Methods.
- Results and discussion.
- Conclusion.
- Recommendations and corrective actions.
- Appended data and quality assurance information.

Record keeping

A record system will be established to document the ESMP results from monitoring programs outlined in the management plans, and any associated monitoring or audit reports. This record system will be periodically reviewed and revised as necessary.

Bawdwin Project

Environmental Impact Assessment
Chapter 11 - References

October 2023

Bawdwin Project

Prepared for

Win Myint Mo Industries Company Limited

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