Environmental Geochemistry Overview Report

Macraes Phase 4 Project

31 August 2026

J-NZ0498-023-R-FINAL

MINE WASTE MANAGEMENT
GREENROAD GROUP

OCEANAGOLD

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Environmental Geochemistry Overview Report

Macraes Phase 4 Project

Document Number: J-NZ0498-023-R-FINAL

Document Date: 31 August 2026

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REVISION	DATE	AUTHOR	RECORD OF REVIEW
Rev0	22/08/2026	EC	PW
FINAL	31/08/2026	EC	PW

EXECUTIVE SUMMARY

OceanaGold (New Zealand) Limited (OGNZL) currently undertakes open pit and underground gold mining operations at the Macraes Operation located at Golden Point Road, Macraes Flat, East Otago. As part of their ongoing operations, OGNZL continually review the remaining life of the Macraes Operation in light of updated knowledge of the gold resource and the economics of mining.

Reflecting recent exploration success and optimisation work, together with higher gold prices, the Macraes Phase Four Project (MP4 or the Project) seeks to extend the life of mining at the Macraes Operation until at least 2039. The Project, which will enable ongoing gold production at a rate of approximately 130,000 ounces per annum, is identified as a Listed Project in Schedule 2 of the Fast-track Approvals Act 2024 (FTAA) as a project providing significant national or regional benefits.

To support the development of the substantive application for the Project, OGNZL has engaged Mine Waste Management Limited (MWM) to provide an assessment of the Project's effects on surface water and groundwater quality and, to the extent required, identify any necessary management and operation measures to address any such effects.

Report Scope

The objectives of this report are to:

- Provide a succinct summary of the geoenvironmental hazards for the Project.
- Provide a summary of waste rock stack (WRS) water quality and estimate future water quality for WRSs associated with the Project.
- Provide estimates of pit lake water quality following closure of the pit voids and the development of pit lakes.
- Explain management measures that may be required to minimise the potential effects of mine impacted water from WRSs and Pit Lakes.
- Provide recommendations.

Geochemical Characteristics

Extensive testing, supported by a historical acid base accounting (ABA) database of over 850 samples, confirms that the bulk waste rock across the Project is non-acid forming (NAF). The materials are characterised by low total sulfur (S) and moderate acid neutralisation capacity (ANC). Consequently, acid rock drainage (ARD) is not a risk for the site.

The drainage chemistry for the MP4 Project will instead be affected by neutral metalliferous drainage (NMD) and residual nitrogenous blasting compounds. The primary parameters potentially requiring management as identified by laboratory leach testing include:

- Arsenic (As): Arsenic exhibits significant enrichment and mobility within the intra burden and footwall zones of the rock that is mined.

- Metals/Metalloids: Aluminium (Al), boron (B), copper (Cu), and Zinc (Zn). However, elevated aluminium is likely to be an artifact of laboratory testing processes and is not anticipated to be elevated in circum-neutral waters at the Macraes Operation.

Elemental enrichment was assessed using pXRF data (50 samples) and this indicated that As, cadmium (Cd), and antimony (Sb) were elevated. Enrichment does not necessarily mean the potential constituents of concern (PCOCs) will be mobile in mine impacted waters, and only As was identified as being both elevated in waste rock above crustal norms and mobile in leachate tests.

Waste Rock Stack Water Quality

The primary objective of this study was to derive WRS seepage source terms for five WRS associated with MP4, including Golden Bar (GB), Coronation (CO), Coronation North (CN), Trimbells (TR), and Frasers West (FW). A detailed analysis of WRS seepage water quality was undertaken to provide guidance on estimating future water quality of WRS seepage associated with the Project:

- The correlation between sulfate (SO_4) concentration and average WRS height remains the most robust predictor for long-term water quality for the Project. To ensure a conservative assessment, an updated linear upper-bound relationship was derived:

$$[SO_4\ (mg/L)]\text{max} = 87 \times \text{Average WRS height (m)}$$

- This equation envelopes the maximum observed concentrations across the site (i.e., Northern Gully East (NGE) WRS, which appears to have reached geochemical maturity), providing a conservative basis for predicting long-term, post-closure SO_4 concentrations.
- Major cations (calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K)) demonstrate strong linear correlations with SO_4 and were modelled via site-specific regression slopes.
- Parameters independent of SO_4 concentrations (typically trace metals and some nutrients) were defined using median values of the consolidated dataset to represent steady-state release rates.
- CO and TR WRSs have elevated Zn in seepage compared to other WRS. Geochemical studies confirm that dissolved Zn is independent of SO_4 trends. Instead, elevated Zn is potentially controlled by localised mineralogical differences in the host rock that prevents the formation of alkaline drainage (i.e., pH ≥8). CO and TR WRS have circumneutral seepage (pH ~7.0), which would limit pH-dependent adsorption of dissolved Zn onto iron (Fe) oxyhydroxides. It is likely that the pH of WRS seepage may be driven by the quantity of carbonate minerals within the waste rock, the higher the carbonate content the higher the pH of seepage.
- Nitrogenous compounds are elevated due to the use of ammonium-nitrate based explosives. Lower concentrations of nitrate in the CO WRS are potentially related to biogeochemical processes that remove nitrate from WRS seepage waters within the WRS due to the placement of organic waste at the base of the WRS.

Pit Lake Water Quality

Predictive 200-year hydrogeochemical models integrated with site water balances were developed for the GB, CO, CN, and Innes Mills (IM) Pit Lakes. During the filling and equilibrium phases, the lakes will remain highly buffered containing modest amounts of alkalinity and maintaining an equilibrium pH of approximately 7.7.

The modelling indicates that the MP4 pit lakes will operate as fully mixed systems (although seasonal stratification may occur) with the following overarching post-closure hydrogeochemical signatures:

- pH and Alkalinity: All four pit lakes are predicted to be highly buffered and circumneutral, maintaining a stable pH between 7.6 and 7.7, supported by total alkalinity concentrations consistently exceeding 140 mg/L as $CaCO_3$.
- Salinity and Major Ions: The pit lake waters will be brackish to saline and dominated by SO_4 and Mg. Long-term average SO_4 concentrations will range from approximately 500 mg/L in CN up to over 2,000 mg/L in IM.
- Trace Metals and Attenuation: The oxidising, circumneutral conditions will promote the rapid oxidation and precipitation of iron as amorphous ferrihydrite ($Fe(OH)_3$). This precipitate provides critical reactive surface areas that adsorb and sequester most dissolved trace metals and metalloids (e.g., Cu, Pb) through surface complexation, maintaining generally low dissolved concentrations.
- Nitrogen Species: Nitrate and ammoniacal nitrogen loads, derived primarily from explosive residues in backfill and pit walls, will decline to negligible levels within the first 10 to 20 years post-closure.
- Predicted long-term water quality was screened against site-specific, hardness-modified ecological trigger values (TVs) established for the downstream receiving environments. Arsenic concentrations are predicted to range between 0.2 and 0.45 mg/L across all four pit lakes, consistently exceeding the 0.013 mg/L TV. Furthermore, driven by ongoing mass loading from adjacent WRS and backfill seepage, Zn concentrations in the CO and CN Pit Lakes are predicted to exceed the TV of 0.016 mg/L, whilst SO_4 exceeds the hardness-modified 1,000 mg/L TV in the more saline CN and IM Pit Lakes.

Management

To proactively address the predicted As and Zn exceedances and manage potential compliance risks prior to surface discharge, an active in-pit treatment strategy has been proposed. This strategy utilises the controlled addition of ferric chloride ($FeCl_3$) to stimulate further ferrihydrite precipitation and enhance surface complexation of metals. Applying an optimal 10:1 Fe:As mass ratio, combined with a management process that promotes active mixing, will trigger the rapid formation of reactive ferrihydrite flocs. This proven treatment will effectively precipitate the dissolved As and trace metals from the water column with any acidity generated being neutralised by the ambient acid buffering capacity of the pit lakes.

While nitrogenous compounds will naturally attenuate within the pit lakes, as validated by previous studies at the Macraes Operation (e.g., Navarro-Valdivia et al., 2023), unmitigated seepage from the WRS presents a longer-term water quality risk. To manage elevated NO_3 concentrations from WRS seepage, two options are being considered as part of the Project:

- Seepage capture and return to the mine water circuit.
- Carbon-based passive treatment systems for any seepage that cannot be returned to the mine water circuit.

Recommendations

Recommendations relating to specific studies are provided in this report under the various report sections.

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1 PROJECT INTRODUCTION

1.1 Introduction

OceanaGold (New Zealand) Limited (OGNZL) currently undertakes open pit and underground gold mining operations at the Macraes Operation located at Golden Point Road, Macraes Flat, East Otago. As part of their ongoing operations, OGNZL continually review the remaining life of the Macraes Operation in light of updated knowledge of the gold resource and the economics of mining.

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1.3 Site Location and Description

OGNZL owns and operates the Macraes Operation at Macraes, approximately 30 km northwest of Palmerston in the Otago Region. The Macraes Operation is the largest gold mine in New Zealand and, since commissioning in 1990, has produced more than 6 million ounces of gold.

Macraes Flat is situated on an elevated plateau at approximately 500 m above sea level. The plateau is flanked by the Taieri Ridge to the northwest, Shag Valley and Horse Range to the east, and the coastal hills and extinct volcanic cones of Palmerston and Waikouaiti to the southeast. Macraes Road provides access to Macraes Flat and the Macraes Operation, connecting to State Highway 85 to the east and State Highway 87 (SH87, the Middlemarch–Hyde Road) to the west.

The environment within and surrounding the Macraes Operation has been shaped by historic and current mining activities. Figure 1 shows the arrangement of the major mine features at the Macraes Operation. In summary, the current components of the Macraes Operation include:

- Numerous open pits (both operational and non-operational);
- Two underground mines (Frasers, now closed, and Golden Point, which is actively mined);
- Waste rock stacks (WRSs) at various stages of operation and rehabilitation;
- A network of haul roads and general mine service tracks;
- A Processing Plant;
- Five tailings storage facilities (TSFs) (three inactive, one active but nearing capacity, and one under construction and currently receiving tailings);
- An extensive network of water management infrastructure, including diversion drains, silt ponds, sumps, pit lakes, and freshwater storage reservoirs;
- Two consented but not yet constructed water storage reservoirs (Camp Creek Dam and Coal Creek Dam); and
- Associated infrastructure supporting ongoing operations, including district roads, powerlines, workshops, offices, and associated water and amenity facilities.

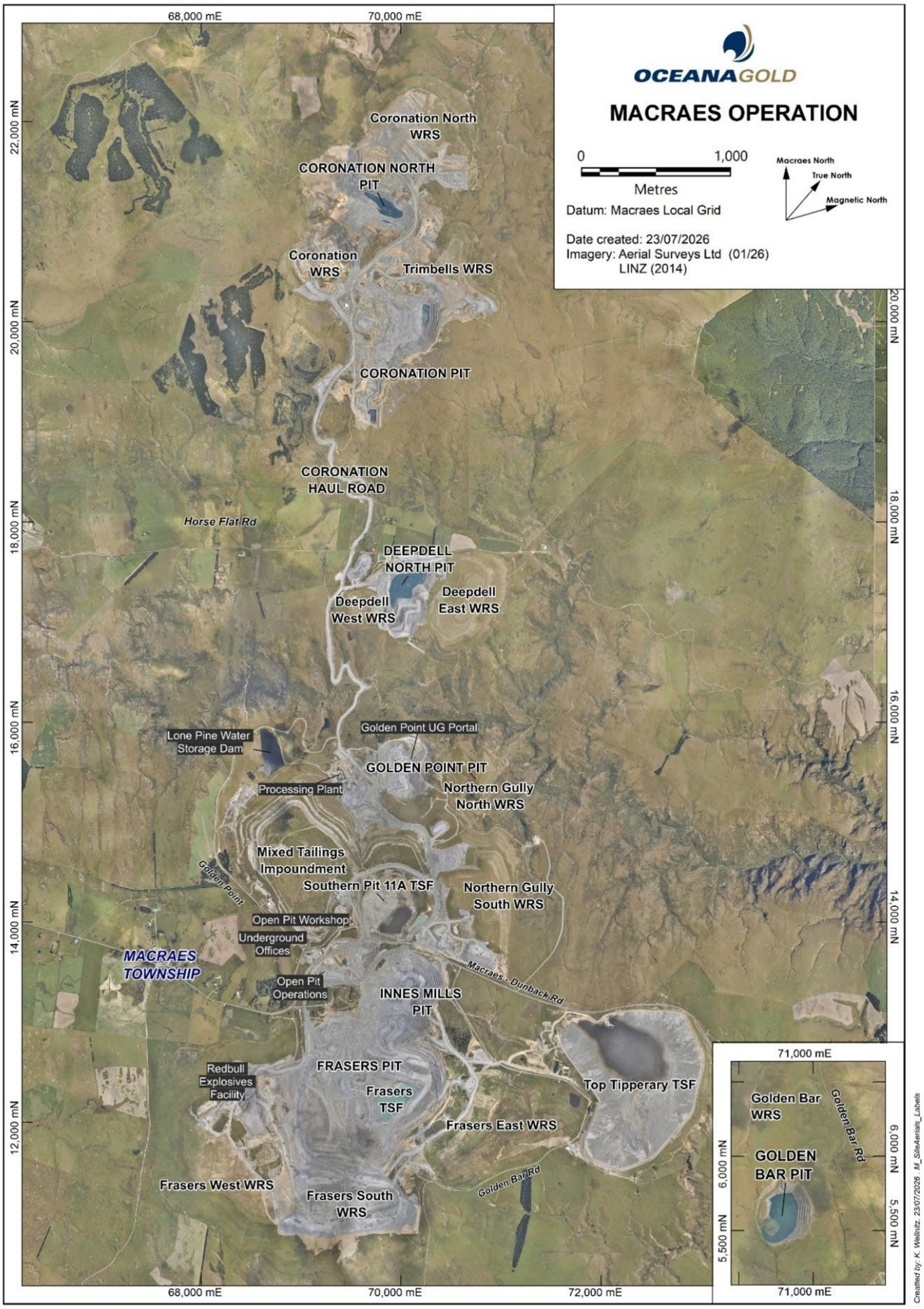

Figure 1: Existing site layout at the Macraes Operation (as of July 2026).
Source: OGNZL (2026).

1.4 Project Overview

The Project is made up of the following proposed key activities:

- Open pit extensions at Coronation (CO), Coronation North (CN), Innes Mills (IM), and Golden Bar (GB).
- Underground mine expansion through further development of the Golden Point Underground mine (GPUG).
- Tailings management, including:
    - Construction of the Frasers Tailings Storage Facility (FTSF) Stage 3 to accommodate a total tailings storage of up to 153 Mt; and
    - Hydraulic mining and relocation of tailings from the Mixed Tailings Impoundment (MTI), Southern Pit Option 10 TSF (SP10), and Southern Pit Option 11A TSF (SP11) to FTSF.
- Waste rock disposal, including increased storage capacity within open pits and at existing WRSs at CO, CN, IM, GB, Golden Point, and Frasers.
- Water management infrastructure and operations, including:
    - Construction of Camp Creek and Coal Creek water storage dams for flow and water quality management;
    - Construction, operation and maintenance of a Water Treatment Plant; and
    - Ongoing operation and maintenance of the Mine Water Management System (MWMS).
- Infrastructure and roading works, including:
    - Realignment of Macraes Road in two stages; and
    - Relocation of the Open Pit Mining Workshop.
- Ecological enhancements, including establishment of:
    - Murphys Ecological Enhancement Area (MEEA) near Murphys Creek, including predator fencing, access tracks, and site facilities;
    - Mt Highlay restoration area;
    - Cranky Jims Link shrubland enhancement area;
    - Murphy Link tussock protection area; and
    - Additional compensation measures for residual ecological impacts.
- Mine closure and rehabilitation activities, including rehabilitation of mining landforms, creation of pit lakes, dry capping of TSFs, and revegetation in accordance with closure objectives.

An overview of the proposed activities which make up the Project is shown in Figure 2 below.

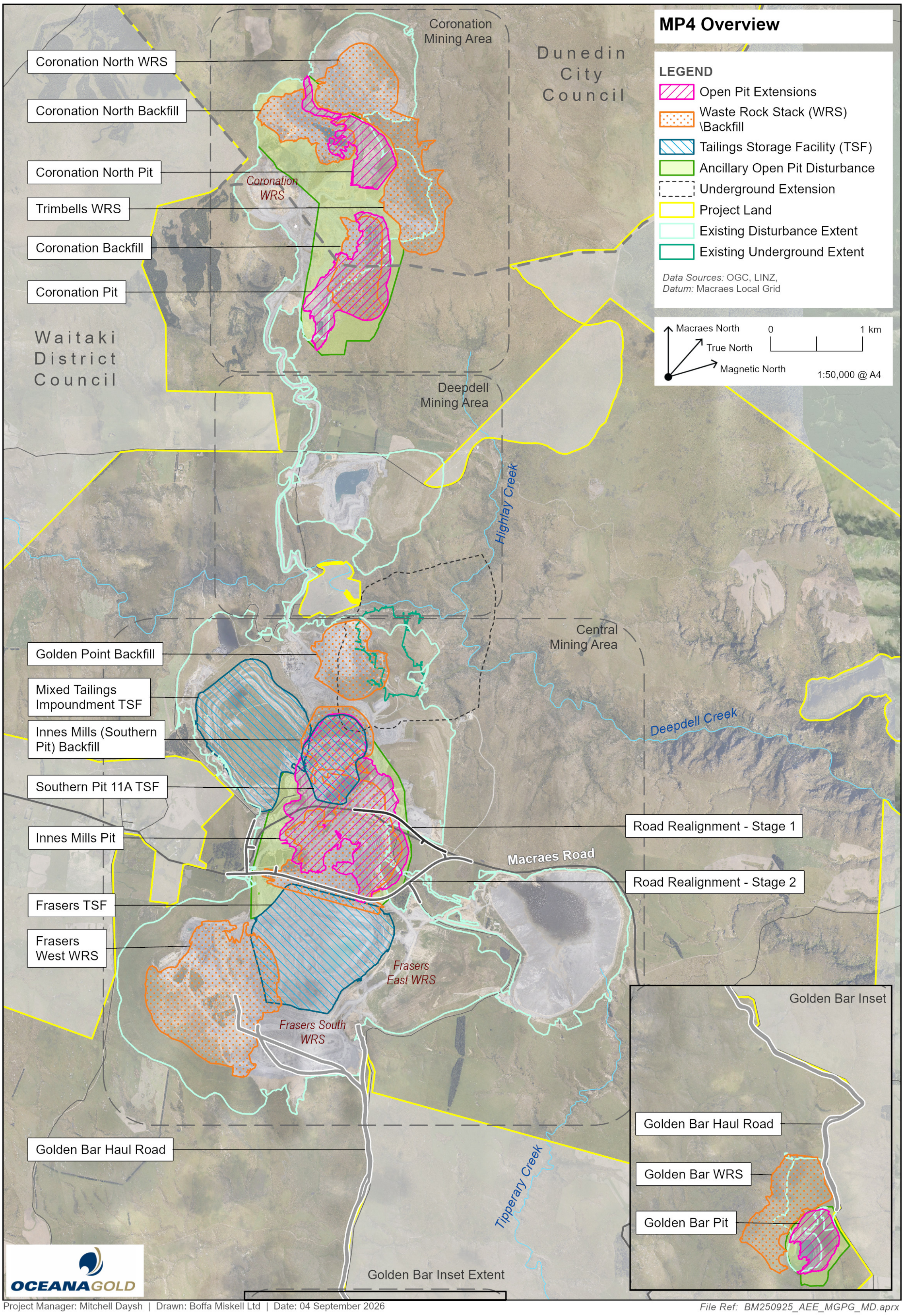

Figure 2: MP4 Overview Plan.

Source: OGNZL (2026).

1.5 Report Structure

This overview report synthesises the technical assessments and hydrogeochemical modelling undertaken by MWM for the MP4 Project. The report is structured as follows:

- Section 1 – Project Introduction: Provides an overview of the Project context, objectives, and scope of work.
- Section 2 – Project Background: Describes the Project environmental setting (climate, geology) and relevant mining operations (mine planning and ore processing).
- Section 3 – Geoenvironmental Hazard Assessment: Summarises the geoenvironmental hazard assessment (Appendix A) and associated investigations.
- Section 4 – Waste Rock Stack Assessment: Summarises the WRS assessment (Appendix B) and associated investigations.
- Section 5 – Hydrogeochemical Pit Lake Modelling Assessment: Summarises the hydrogeochemical pit lake modelling assessment (Appendix C) and associated investigations, including an evaluation of post-closure pit lake water quality evolution across the four pit domains (GB, CO, CN, and IM).

2 PROJECT BACKGROUND

2.1 Environmental Setting

2.1.1 Geology and Geoenvironmental Risks

The Macraes deposit is a structurally controlled orogenic gold deposit hosted within the metamorphic greenschist facies Otago Schist. Mineralisation is associated with the Hyde-Macraes Shear Zone (HMSZ), the principal gold-bearing structure, and the Macraes Fault, which offsets the HMSZ by approximately 250 m in a reverse sense. This primary deformation is accompanied by numerous subsidiary faults, both foliation-parallel and foliation-cutting, which influence local hydrogeological pathways.

Gold mineralisation formed within the brittle-ductile transition zone at temperatures of approximately 300ºC. Hydrothermal activity created a 120 m thick altered zone (Craw, 2002), comprising mineralised sheared graphitic schist and quartz veins. This zone is enriched in sulfide minerals, primarily pyrite (FeS_2) and arsenopyrite (FeAsS).

Minor fine-grained sulfide minerals include chalcopyrite ($CuFeS_2$), sphalerite (ZnS), and galena (PbS) (Golder Associates, 2011). The mineralised rocks exhibit variable enrichment in arsenic (As), gold (Au), bismuth (Bi), molybdenum (Mo), antimony (Sb), and tungsten (W) (Craw, 2002). Current resource consent conditions relate to specific mobile potential constituents of concern (PCOCs) associated with the ore and host minerals, which includes As, copper (Cu), iron (Fe), lead (Pb), sulfate (SO_4), and zinc (Zn). Compliance monitoring is undertaken for these PCOCs to ensure management processes are appropriate and environmental effects are acceptable.

A key indicator for environmental geochemistry risk, particularly acid and metalliferous drainage (AMD), is total sulfur (S) content. The Macraes Operation maintains an extensive geochemical database comprising routine drillhole total S assays, including approximately 3,000 samples from the CO Pit area, supplemented by site-wide static acid-base accounting (ABA) testing (O'Kane Consultants, 2016). These data indicate that interburden waste rock (Au <0.15 g/t) typically contains higher S content than overburden materials, while low-grade ore (LGO; 0.15-0.4 g/t Au) exhibits S contents comparable to those of the interburden (O'Kane Consultants, 2016). Consequently, interburden materials present a relatively higher risk of AMD generation and therefore require specific management within the WRS (O'Kane, 2016). The cross-sectional distribution of these material types and their relative S risk levels is illustrated in Figure 3.

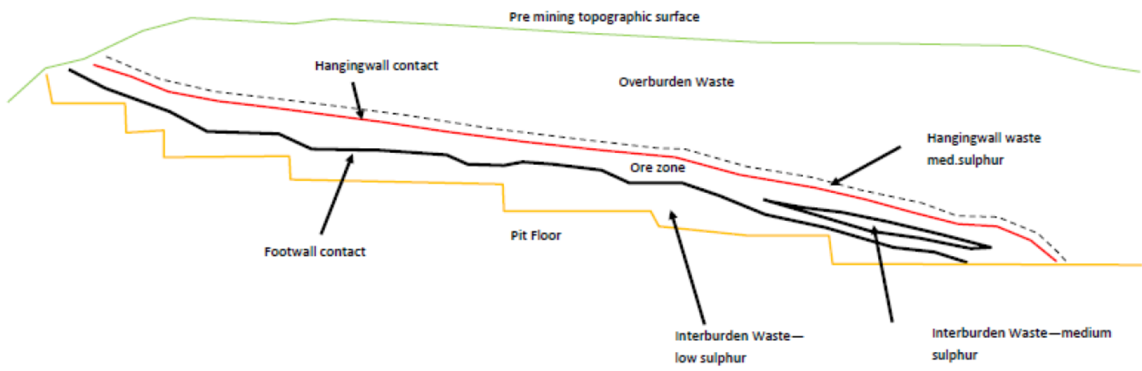

Figure 3: Stylised geological cross-section of the Coronation orebody.

Source: O'Kane Consultants (2016).

2.1.2 Climate

The MP4 Project area is characterised by a semi-arid climate with significant seasonal temperature variations, low average annual rainfall, and high wind speeds. The local climate is primarily influenced by the Rock and Pillar Range to the west, which acts as a barrier to westerly weather systems, resulting in limited precipitation.

Climate conditions are monitored via three weather stations: Glendale, Deepdell, and Golden Point. Evaporation data are derived from the national weather station in Middlemarch (located 30 km south-southwest at 200 mRL), which is considered the most representative regional dataset. Key characteristics of the historical climate record are summarised below:

- Daily average temperatures range from approximately 15ºC in summer (December to February) to 5ºC in winter (June to August). Snowfall is common during winter months.
- Average annual rainfall is approximately 650 mm. Although rainfall exhibits limited seasonal variation, the area is susceptible to prolonged dry periods and droughts, particularly during summer.
- Mean annual pan evaporation is approximately 952 mm (based on 1991-2018 data). This significantly exceeds annual rainfall, resulting in a negative water balance.

2.2 Historical Mining and Tailings Deposition

2.2.1 Macraes Operational History and Tailings Geochemistry

The Macraes Operation was commissioned in 1990, establishing initial open pits, a gold processing plant, and a TSF. Over more than three decades of continuous operation, the processing plant capacity has been increased through successive upgrades to its current capacity of nearly 6 Mt of ore per annum. Ore feed has historically been sourced from multiple open pits, dominated by the large Frasers Pit, and supplemented by the Frasers Underground Mine, which began operating in 2006.

Tailings geochemistry is influenced by both processing technology and ore sources, resulting in three distinct operational phases (Weightman et al., 2021; 2022):

- Carbon-in-pulp (CIP) cyanidation (pre-1999): Processing via the historical CIP circuit produced tailings with elevated sulfide mineral content. Material deposited between 1993 and 1999 contains up to 0.5 wt% sulfide S, primarily as pyrite and arsenopyrite. Tailings from the initial 1990-1993 production period exhibit lower sulfide concentrations because the flotation concentrate was stored separately.
- Pressure oxidation (POX) (1999 - present): An autoclave system was commissioned in 1999 to oxidise sulfide minerals at approximately 225°C, significantly reducing residual sulfide content in the tailings. The acidic conditions generated during autoclave oxidation partially degraded host silicate phases to form kaolinite, clays, and amorphous silicates. This altered the tailings mineralogy by increasing the proportion of secondary minerals and processing residues, including gypsum, jarosite, ferric sulfate, and ferric arsenate.
- Stibnite-rich ore processing (2007-2016): During this period, the mill processed stibnite-rich (Sb_2S_3) ore sourced from the Globe-Progress Mine (Reefton) (OGNZL, 2011). Tailings

deposited during this period are characterised by elevated Sb concentrations, typically in the form of ferric antimonate ($FeSbO_4$) precipitates.

2.2.2 Tailings Storage Facilities

Four TSFs have been commissioned to date at the Macraes Operation. The depositional timelines and distribution of processed materials across these facilities are summarised below:

- Mixed Tailings Impoundment (MTI): Operated as the primary deposition site from 1990 to 2013. It initially comprised the separate Concentrate Tailings Impoundment (CTI) and Flotation Tailings Impoundment (FTI), which eventually merged behind a single shared embankment. Tailings deposited between 1991 and 1999 were generated from the CIP circuit, while tailings deposited from 1999 to 2013 underwent POX treatment. The 2006 to 2013 deposition period also included high-Sb concentrate imported from the Reefton operation.
- Southern Pit Option 10 TSF (SP10): Utilised periodically between 2003 and 2004 for the storage of POX-processed tailings.
- Southern Pit Option 11A TSF (SP11): Utilised periodically from 2006 onwards, constructed over the footprint of the SP10 facility. SP11 eventually merged with the adjacent MTI behind their shared embankment. All deposition within SP11 consists of POX-processed tailings and includes high-Sb material imported from Reefton.
- Top Tipperary TSF (TTTSF): Maintained as the primary active disposal facility since 2013. The impoundment contains POX-processed tailings, with high-Sb Reefton material deposited exclusively during the early operational phase (2013-2016). Subsequent inputs consist of standard Macraes operational tailings.
- Frasers TSF (FTSF): The FTSF is an in-pit TSF currently under development within the Frasers Pit and has a consented storage capacity of 35 Mt.

2.3 Proposed MP4 Activities

2.3.1 Overview

The primary proposed MP4 activities included in the scope of the environmental geochemistry assessment are summarised in Table 1.

Table 1: Proposed MP4 project facilities and associated activities.

MINE FACILITY	AREA
Open pits and underground mine extensions	Innes Mills (Stages 11-13), including Southern Pit integration and Mixed Tailings Impoundment (MTI) tailings relocation
	Coronation (Stages 6-8)
	Coronation North (Stage 6)
	Golden Bar (Stages 2-3)
	Golden Point Underground (GPUG)
Waste Rock Stacks (WRSs)	Frasers West WRS height raise
	Trimbells WRS height raise and extension

MINE FACILITY	AREA
	Coronation North Backfill height raise
	Coronation Backfill
	Coronation North WRS height raise
	Innes Mills Backfill
	Southern Pit Backfill
	Golden Point Backfill
	Golden Bar WRS extension
Tailings Storage Facilities (TSFs) and return water	Frasers TSF Stage 3

Source: OGNZL (2026).

2.3.2 Open Pit Extensions

MP4 involves extensions to four existing open pits and the continued development of the GPUG (Figure 2). These developments will generate significant volumes of waste rock and require long-term management of pit lake water quality and site water balances.

- Golden Bar: The GB Pit currently covers a footprint of 14 ha. The proposed pit extension comprises an approximate 340 m expansion to the east and northeast, increasing the total pit footprint to approximately 29.2 ha with an expanded GB WRS.
- Coronation: The proposed CO Stage 6-8 Pits (CO6, CO7, and CO8) extend the operation by approximately 560 m to the southeast. Expanding beyond the currently authorised CO Stage 5 Pit (CO5) of 85 ha, the extension will increase the total pit footprint to approximately 125 ha.
- Coronation North: The proposed CN Stage 6 Pit (CN6) extends approximately 205 m to the southeast, predominantly over tussockland and the TR WRS. This will expand the currently authorised CN Stage 5 Pit (CN5) with a footprint of 40 ha to a total footprint to approximately 57 ha.
- Innes Mills: The proposed extensions (IM11 to IM13) expand north, east and west into the Southern Pit area to access downdip and stockwork ore. These extensions will increase the pit footprint by approximately 49 ha.
- GPUG: Continued development of underground operations will proceed via existing portals in the Golden Point Pit highwall. Mining will take place between 105 m and 379 m below surface, generating approximately 256,000 m^3 of waste rock.

2.3.3 Mine Waste Storage and Relocation

The substantial volume of waste rock generated from the proposed pit extensions will be managed through a combination of in-pit backfilling and height raises to existing WRSs. To facilitate the proposed IM Pit extension, all tailings currently stored within SP11 and SP10 and the upper 30 m of the MTI will be relocated to the FTSF (Stage 3). The mine waste movement and volumes are summarised in Table 2.

Table 2: Material movement and allocation summary for the MP4 expansion.

SITE	ORE (Mt)	WASTE (Mt)	TAILINGS (Mt)	TOTAL (Mt)	WASTE ROCK DESTINY
Golden Bar Pit	2.0	32.4	-	34.4	GB WRS
Coronation Pit	6.9	106.0	-	112.9	CO WRS, CN WRS, TR WRS; pit backfill
Coronation North Pit	0.7	34.6	-	35.3	
Innes Mills Pit	36.3	276.1	59.2	371.6	Frasers Backfill, FS WRS, IMBF, SPBF, FW WRS

Source: OGNZL (2026).

3 GEOENVIRONMENTAL HAZARD ASSESSMENT

The key findings of the geoenvironmental hazard assessment are summarised in this section. The full assessment is presented in MWM (2026a). This report is referenced as:

- Mine Waste Management (MWM), 2026a. Macraes Phase 4 Project: Geoenvironmental Hazards Assessment. Mine Waste Management Document No. J-NZ0498-004-R-FINAL.

This report (MWM, 2026a) includes the following reports as attachments:

- Mine Waste Management (MWM), 2026e. Macraes Phase 4 Project: Column Leach Testing Factual Report. MWM Document No. J-NZ0498-009-R-FINAL.
- Mine Waste Management (MWM), 2026m. Macraes Phase 4 Project: Sampling and Analysis Plan. MWM Document No. J-NZ0498-002-M-FINAL.

3.1 Purpose and Objectives

This assessment enhances the existing geochemical knowledge base for the Project to support the FTAA application. The primary objective is to characterise the geochemical properties of waste rock and tailings associated with the Project through:

- Collation and review of previous geochemical investigations and the OGNZL acid base accounting (ABA) database to establish a baseline understanding of material characteristics.
- Identification of data gaps relating to materials that will be disturbed by the proposed mine expansions.
- Targeted geochemical testing of selected MP4 waste rock samples.
- Identification of geochemical hazards associated with the proposed pit extensions and TSFs, including the active TTTSF and SP10/SP11.
- Interpretation of analytical data to characterise acid generation potential and solute leaching risks.

3.2 Tailings

To facilitate the proposed IM Open Pit extension (Stages 10-13), the Project involves the hydraulic relocation of approximately 59 Mt of historical tailings to the FTSF Stage 3. This comprises the removal of all tailings from SP10 and SP11 (approximately 26 Mt) and the upper approximately 30 m of tailings from the MTI (approximately 33 Mt). Tailings from the Macraes Operation are classified as non-acid forming (NAF).

Water quality associated with the MTI tailings is characterised by elevated concentrations of SO_4 and As. However, POX processing promotes the formation of stable ferric antimonate minerals, which are considered responsible for the very low dissolved antimony (Sb) concentrations (< 0.1 mg/L) observed in tailings influenced waters (Weightman et al., 2022).

Sodium cyanide is added during gold extraction; however, cyanide concentrations in tailings decant water appears to decrease through volatilisation and decomposition due to ultraviolet radiation, resulting in low residual cyanide concentrations.

3.3 Waste Rock

An extensive ABA dataset collected between 2007 and 2025 was compiled from the OGNZL geochemical database and reviewed as part of the assessment. This dataset confirms that waste rock at the Macraes Operation is predominantly NAF, characterised by net acid generation (NAG) pH > 4.5 and rocks that have an acid neutralisation capacity (ANC) that substantially exceed maximum potential acidity (MPA) values, resulting in negative net acid producing potential (NAPP) values. These results indicate a low risk of acid rock drainage (ARD) generation from waste rock associated with the Project.

3.4 Geochemical Characterisation

3.4.1 Sample and Analysis Plan

A sampling program (MWM, 2026m) was designed to provide spatial coverage of materials to be disturbed as part of the Project (Table 3). Geochemical data for GB were sourced from previous investigations undertaken by MWM (2024). These data expand the geochemical database for materials associated with the Macraes Operation and support identification of PCOCs, assessment of potential environmental effects, and development of operational management measures.

Sample analysis utilised the following techniques:

- Standard ABA methodologies to assess the potential of materials to generate and neutralise acid,
- Static leach testing to identify and understand mobility of PCOCs, and
- Elemental composition analyses through portable X-ray Fluorescence (pXRF) to identify PCOCs.

Table 3: Sample summary

PIT DOMAIN	TOTAL SAMPLES	WASTE ROCK ZONE		
		HW WR[1]	WM / IB WR	FW WR
Coronation North	11	8	2	1
Coronation	14	13	1	-
Innes Mills	16	14	2	-
Southern Pit / Innes Mills (SPIM)	8	6	2	-
Golden Point Underground (GPUG)	5	2	2	1
Total	**54**	**43**	**9**	**2**

HW WR = hanging wall waste rock, WM / IB WR = weakly mineralised / intra burden waste rock, FW WR = foot wall waste rock

[1] Weathered samples are included from CN (1), CO (1), SPIM (1), IM (2).

3.4.2 Acid Base Accounting Data

Fifty-four waste rock samples underwent ABA testing. The results are summarised in Table 4. Key observations include:

- ABA data confirm previous investigation findings that waste rock at the Macraes Mine is predominantly NAF.

- Three samples were classified as uncertain under the Price (2009) classification scheme, with a neutralisation potential ratio (NPR)[1] of < 2.
- Four samples were classified uncertain under Resource Consent requirements (RM10.351.10.V1 – Compliance Criteria iv), with a neutralisation potential ratio < 3.

Although the assessed materials are unlikely to generate ARD, they retain the potential to generate neutral metalliferous drainage (NMD) through the release of dissolved PCOC under circumneutral conditions.

Table 4: Waste rock ABA data summary (n = 54).

METRIC	TOTAL S	NAG pH	PASTE pH (1:2)	ANC	MPA	NAPP	NPR
UNITS	wt%	pH units		kg H_2SO_4/t			-
Average	0.191	6.47	8.81	49	5.83	-43.2	13.1
Median	0.173	6.35	8.9	43	5.28	-37.5	9.5
Minimum	0.01	4.8	7.3	13	0.31	-124	1.5
Maximum	0.472	10.2	9.2	137	14.44	-5.1	68.6

NAG = net acid generation, ANC = acid neutralisation capacity, MPA = maximum potential acidity, NAPP = net acid producing potential, NPR = neutralisation potential ratio.

3.4.3 Leach Testing

Static leach testing was undertaken to assess the mobility of PCOCs. Thirteen representative samples were tested with the following observations of note:

- Alkaline pH across all leachate samples with a range from 7.47 to 9.4.
- Sulfate concentration ranged from 0.45 to 28 mg/L.
- Constituents exceeding one or more adopted water quality reference guidelines[2] included aluminium (Al), As, and Sb.

Column leach testing provides data on long-term leaching behaviour of material and has been completed as part of the Project for four samples of representative material over 10 leaching cycles (MWM, 2026a). Constituents identified as a long-term leaching risk through column leach testing included Al, As, boron (B), Cu, and Zn.

3.4.4 Elemental Enrichment

Elemental enrichment is assessed using pXRF data (50 samples) against the Geochemical Abundance Index (GAI). Generally, a GAI value of 3 or greater indicates elemental enrichment that warrants further examination, such as targeted leach testing. The following PCOCs were identified with a GAI ≥ 3: As, cadmium (Cd), and Sb. However, elemental enrichment does not necessarily indicate that a constituent will be mobile or present at elevated concentrations in mine impacted waters.

Additional testing is being undertaken using aqua regia analysis of waste rock samples to validate pXRF results regarding element enrichment.

[1] Neutralisation potential ratio = acid neutralisation capacity / maximum potential acidity
[2] Derived from Viridis (2026), ANZG (2018) default guideline values (95% protection level), and British Columbia Ministry of Water, Land and Resource Stewardship (2023) water quality guidelines.

3.5 Summary

Data suggests that geohazard risk is more strongly controlled by weathering processes and waste rock proximity to mineralisation than by the pit domain where the waste rock is sourced. The principal environmental geohazards identified for waste rock include:

- Arsenic was identified as the main PCOC across all pit domains and waste rock zones. Enrichment was observed in all intra burden / weakly mineralised waste rock samples. Elevated concentrations were identified in both static leachate and column leach test leachate data.
- Antimony was identified as a PCOC from elemental enrichment and static leach testing.
- Aluminium was elevated in both static leachate and column leach test leachate.
- Boron, Cu, and Zn were elevated in column leach test leachate.

Additional PCOCs identified include:

- Arsenic and SO_4 identified through tailings water quality.
- Antimony identified as a PCOC for tailings, though its concentrations in tailings water are generally low.
- Nitrogenous compounds due to ammonium-nitrate-based blasting residues.

Total S data and ANC of waste rock tested as part of this investigation are within the range identified from existing waste rock, suggesting geoenvironmental hazards of sampled material are represented by existing geochemical data available for the Macraes Operation.

3.6 Recommendations

Monitoring of the following analytes is recommended based on the PCOCs identified through static leachate and column leach testing program.

- Major ion: SO_4
- Metals and metalloids: Al, As, B, Cu, Sb, and Zn.
- Nitrogenous compounds.

ABA testing of waste rock is required as part of resource consent activities. Specific monitoring requirements will be clarified in the Environmental Water Monitoring Plan and should include:

- Collection of representative waste rock drill core samples from resource drilling programs in advance of mining.
- Collection of representative waste rock samples from operational WRSs and open pit backfills to validate material placement.
- Samples numbers should be in alignment with industry guidance.

Samples should be analysed for total S and ANC to classify rocks with respect to acid / non-acid generating behaviour.

4 WASTE ROCK STACK ASSESSMENT

The key findings of the waste rock stack assessment are outlined in this section, with the full assessment documented in MWM (2026b). This report is referenced as:

- Mine Waste Management (MWM), 2026b. Macraes Phase 4 Project: WRS Assessment Seepage Quality. Mine Waste Management Document No. J-NZ0498-006-R-FINAL.

This report (MWM, 2026b) includes the following reports as attachments:

- Mine Waste Management (MWM), 2026l. Macraes Phase 4 Project: Waste Rock Stack Topography Assessment. MWM Document No. J-NZ0498-005-M-FINAL.
- Mine Waste Management (MWM), 2026k. Macraes Phase 4 Project: Adaptive Management of Elevated Nitrate in WRS Seepage. MWM Document No. J-NZ0498-025-M-FINAL.

4.1 Purpose and Objectives

The primary objective of this assessment was to derive WRS seepage source terms for the five WRSs associated with MP4: GB, CO, CN, Trimbells (TR), and Frasers West (FW).

These source terms define the chemical inputs for the subsequent water quality modelling for the Project, including pit lake modelling undertaken by MWM (2026c) and surface water and groundwater quality modelling by GHD (2026).

4.2 Approach

The assessment utilised a reference dataset comprising consolidated long-term water quality monitoring data and updated physical geometries for eight key WRSs across the Macraes Operation to understand the seepage quality expected from the five MP4 WRSs. To estimate post-closure WRS seepage chemistry, a predictive model was developed utilising the established empirical correlation between peak SO_4 concentrations and average WRS height (Navarro-Valdivia et al., 2024). This relationship was refined using the latest monitoring data and updated volumetric calculations for the Project WRS configurations. This approach ensures that the predicted WRS seepage reflects final landform geometries and incorporates a conservative upper-bound for SO_4 concentrations based on the latest WRS water quality data. The resulting predictions were adopted as the source terms for subsequent pit lake water quality modelling and other surface water and groundwater quality models being undertaken by OGNZL.

4.3 Key Findings

The correlation between SO_4 concentration and average WRS height remains the most robust predictor for long-term seepage quality for the Project. To ensure a conservative assessment, an updated upper-bound linear relationship was derived:

$$[SO_4\ (mg/L)]\text{max} = 87 \times \text{Average WRS height (m)}$$

This relationship envelopes the maximum observed SO_4 concentrations across the site (i.e., Northern Gully East (NGE) WRS, which appears to have reached geochemical maturity), providing a conservative basis for predicting long-term post-closure SO_4 concentrations.

Major cations, including calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K), exhibit strong linear correlations with SO_4 and were modelled via site-specific regression relationships.

Parameters independent of SO_4 concentrations (typically trace metals and some nutrients) were defined using median values of the consolidated monitoring dataset to represent steady-state release rates.

4.4 Outcomes

Site-specific seepage source terms were derived for the five MP4 WRSs. The predicted seepage chemistry, summarised in Table 5, incorporates the 'life-of-mine' geometric changes proposed by the Project.

Table 5: Summary of predicted WRS seepage quality at closure (Year 0).

PARAMETER	UNIT	GB	CO	CN	TR	FW
pH	pH units	6.9	7.1	7.6	6.8	8.2
Total Alkalinity	mg/L as $CaCO_3$	267	36	891	411	1,035
Ca	mg/L	586	597	1,281	1,081	198
Mg	mg/L	725	457	892	396	1,523
Na	mg/L	101	61.9	204	85.8	106
K	mg/L	13.1	10.6	14.4	24.7	31.1
SO_4	mg/L	4,481	3,706	6,081	4,193	6,125
Cl	mg/L	11	8	12	6	11
NO_x - N	mg/L	8.05	1.1	50.7	40.6	14
Amm - N	mg/L	0.005	0.245	0.017	0.92	0.05
As	mg/L	0.001	0.0005	0.00075	0.0005	0.003
Cu	mg/L	0.0011	0.0005	0.0006	0.1347	0.0015
Fe	mg/L	0.02	0.05	0.05	0.19	0.02
Pb	mg/L	0.0001	0.000075	0.00005	0.00005	0.00025
Zn	mg/L	0.049	0.36	0.0028	0.36	-

Note: NO_x = nitrate nitrogen + nitrite nitrogen; Amm-N = ammoniacal nitrogen.

4.5 Zinc and Nitrate in Seepage

Predicted Zn concentrations for the CO and TR WRS seepages are defined by a historical median of 0.36 mg/L, which exceeds the proposed ecological compliance trigger value of 0.016 mg/L (Viridis, 2026). Geochemical studies confirm that dissolved Zn is independent of SO_4 trends. Instead, elevated Zn is likely controlled by localised mineralogical differences in the host rock that prevents the formation of alkaline drainage with a pH > 8. This may be driven by the lesser abundance of carbonate minerals compared to other WRS and these WRS have circumneutral seepage (pH ~7.0), which limits pH-dependent adsorption of dissolved Zn onto iron (Fe) oxyhydroxides.

Nitrate (NO_3) concentrations as NO_3-N vary significantly across the WRS domains, with lower median concentrations at the CO WRS (1.1 mg/L) contrasting with higher median concentrations at CN (8.3 mg/L) and TR (9.7 mg/L). Studies suggest the low NO_3 levels at CO may be driven by microbially mediated natural denitrification within the rock mass, sustained by buried organic matter incorporated during dump construction. To mitigate the elevated NO_3 concentrations predicted for future WRS developments, engineered passive treatment options, specifically gravel bed bioreactors (GBBRs) and enhanced passive treatment systems (E-PTS), were evaluated (MWM, 2026k). Site-specific pilot trials demonstrate that these carbon-amended systems can reliably achieve 85% to 99% NO_3 removal depending on the design hydraulic residence time (HRT).

4.6 Recommendations

The following recommendations are provided:

- Given the evolving nature of WRS seepage chemistry during active deposition of waste rock, review the empirical correlations between maximum SO_4 concentrations and average WRS heights every 12 months throughout the operational life of the facility and into closure. This annual statistical review should be utilised to update the WRS seepage source terms, including incorporating other solutes that may be elevated (such as B, Co, and Sb) as identified by column leach testing (MWM, 2026a).
- Following the completion of the final WRS landforms and the commencement of the closure phase, re-evaluate the frequency of the WRS water quality reviews, which should be based on the observed stability of seepage water quality and quantity trends, potentially transitioning to a biennial or event-based schedule.

Complete focused investigations to:

- Undertake continuous flow and electrical conductivity (EC) measurements of WRS seepage to understand geochemical trends and loads as a function of waste rock mass and flow rates over time.
- Characterise dilution effects (e.g., surface runoff and near-surface flows) at seepage monitoring locations to better understand seepage-rainfall dynamics.
- Determine why CO WRS exhibits lower nitrogen concentrations compared to other WRSs on site – assumed to be due to microbially mediated natural denitrification processes.
- Conduct targeted geochemical and mineralogical investigations of the waste rock within the CO and TR domains to understand what geochemical reactions are suppressing seepage pH and maintaining elevated Zn concentrations.
- Whilst engineering controls are proposed to manage diffuse toe seepage at the CN and FW WRSs where seepage tends to be less confined, undertake further investigations to characterise the pathways and environmental effects of other diffuse seepage pathways to ensure best-practice management of mine-impacted water.
- For the preliminary design and conceptual modelling of the recommended passive nitrate treatment systems (such as GBBRs / E-PTS) for future WRS developments, adopt a conservative NO_3 removal efficiency of 85%, assuming an HRT of approximately one day.

5 HYDROGEOCHEMICAL PIT LAKE MODELLING ASSESSMENT

The key findings of the hydrogeochemical pit lake modelling study are outlined in this section, with the full assessment documented in MWM (2026c). This report is referenced as:

- Mine Waste Management (MWM), 2026c. Macraes Phase 4 Project: Hydrogeochemical Pit Lake Modelling. Mine Waste Management Document No. J-NZ0498-007-R-FINAL.

This report (MWM, 2026c) includes the following reports as attachments:

- Mine Waste Management (MWM), 2026d. Macraes Phase 4 Project: Golden Bar Pit Lake Water Quality Model. MWM Document No. J-NZ0498-008-M-FINAL.

- Mine Waste Management (MWM), 2026f. Macraes Phase 4 Project: Solute Release Rates from IBC Field Trials. Mine Waste Management Document No. J-NZ0498-010-M-FINAL.

- Mine Waste Management (MWM), 2026g. Macraes Phase 4 Project: Coronation Pit Lake Water Quality Model. Mine Waste Management Document No. J-NZ0498-012-M-FINAL.

- Mine Waste Management (MWM), 2026h. Macraes Phase 4 Project: Coronation North Pit Lake Water Quality Model. MWM Document No. J-NZ0498-013-M-FINAL.

- Mine Waste Management (MWM), 2026i. Macraes Phase 4 Project: Innes Mills Pit Lake Water Quality Model. MWM Document No. J-NZ0498-017-M-FINAL.

- Mine Waste Management (MWM), 2026j. Macraes Phase 4 Project: Arsenic Removal by Ferric Chloride Dosing. MWM Document No. J-NZ0498-018-M-FINAL.

5.1 Purpose and Objectives

The scope of this report is to:

- Review the existing site water quality data relevant to the Project.
- Document the methodology and procedures used to develop the hydrogeochemical models for the four pits associated with the Project.
- Present and discuss the modelling outcomes that predict the long-term evolution of pit lake water quality following mine closure.

The primary objective of this assessment is to predict the long-term, post-closure water quality of the proposed open pit lakes at GB, CO, CN, and IM over a 200-year period.

5.2 Hydrogeochemical Modelling Approach

The water quality modelling adopts a consistent framework designed to simulate the evolution of the pit lake chemistry, comprising four primary components:

- Conceptual Site Model (CSM): Defines the specific model boundaries, including water sources, reactive materials, hydrological pathways, and geochemical processes.

- Water Balance Model (WBM): Provided by GHD (2026), the WBMs supply the time-series flow rates and physical water fluxes on an annual timestep.
- Source Term Derivation: Defines the specific chemical signature and mass release rates of the various inflows and reactive materials.
- Model Integration and Hydrogeochemical Modelling: Pit lake water quality simulations were conducted using PHREEQC (Parkhurst and Appelo, 2013) and the WATEQ4F thermodynamic database, executed via an automated Python computational framework to manage high-volume data inputs and couple the physical water volumes with the chemical mass loading

To reflect site-specific climatic and physical conditions, the models assume the following:

- The pit lakes will operate as fully mixed systems that maintain equilibrium with atmospheric oxygen and carbon dioxide.
- A constant oxidising environment (pE=10) and a water temperature of 10ºC were applied.
- All iron (Fe) in the source terms is assumed to be entirely ferric (Fe^{3+}), aligning with the oxidising environment assumption.
- Nitrogenous blasting residues (NO_3) attenuate via a bulk decay rate of 20% to 25% per annum.

5.3 Historical Data Review and Source Term Derivation

Site specific geochemical source terms were derived based on an extensive review of historical site water quality monitoring data and empirical modelling. The source terms represent the initial chemistry and mass flux of the various water and reactive material inputs to the pit lakes.

- Historical Data Review: OGNZL has established an extensive water quality monitoring network at the Macraes Operation site. The monitoring data were categorised into groundwater, surface water, and mine water (including tailings underdrains and waste rock seepage). Monitoring datasets for sites aligned with the CSM and WBM inflow components were reviewed to establish pre-mining and operational baseline and evaluate water quality evolution over time.
- Source Term Derivation: Source terms were tailored for distinct pit domains and inflow mechanism.
- Summaries of the diverse source term types derived to define the pit inflows are presented in Table 6 to Table 8.

Table 6: Summary of source terms – groundwater and natural catchment runoff.

Source Term Type		GROUNDWATER				NATURAL CATCHMENT RUNOFF	
Pit Domain		GB	CO & CN	IM	IM	GB	CO
Monitoring Site		RCH2775, RCH2585, RCH3004	CP01, CP02, CP04	SPMW3, SPMW4	TTTSF impound-ment	GB02 (pre-2015)	DC01 (pre-2015)
Parameter	Unit	Median	Median	Median	Median	Median	Median
pH	pH units	6.65	7.3	7.4	8.1	7.5	7.7
Total Alkalinity	mg/L as CaCO3	95.8	108	275	220	32.5	50
Ca	mg/L	22.4	26.5	234	640	8.15	12.7
Mg	mg/L	11.1	8.9	33.9	345	2.95	4.4
Na	mg/L	10.9	9.8	20.5	360	8.5	10.9
K	mg/L	1.06	1.31	2.25	95	0.725	1.15
SO_4	mg/L	14.3	7.8	515	3,600	6.45	5.35
Cl	mg/L	10.2	6.3	8.5	22	9.25	11
NO_3-N	mg/L	0.544	0.1132	0.01975	12	0.025	0.0175
Amm-N	mg/L	0.0075	0.0107	0.0225	13	0.0125	0.005
As	mg/L	0.0016	0.0011	0.0114	0.0125	0.00175	0.0011
Cu	mg/L	0.0043	0.00025	0.000625	0.089	0.00095	0.00025
Fe	mg/L	1.476	0.883	1.835	0.0265	0.18	0.22
Pb	mg/L	0.00465	0.00008	0.00022	0.45	0.0002	0.00005
Sb	mg/L	0.0005	-	-	0.00068	-	-
Zn	mg/L	0.0213	0.01375	0.0041	-	0.00235	-
WAD CN	mg/L	0.005	-	0.0015	0.01	-	0.0005

Table 7: Summary of source terms – WRS and backfill seepage.

SOURCE TERM TYPE		WRS SEEPAGE					BACKFILL SEEPAGE		
PARAMETER	UNIT	GB	CO	CN	TR	FW	COBF	CNBF	IMBF
pH	pH units	6.9	7.1	7.6	6.8	8.2	7.1	7.6	7.9
Total Alkalinity	mg/L as CaCO3	267	36	891	411	1,035	36	137	517
Ca	mg/L	586	597	1,281	1,081	198	205	479	30
Mg	mg/L	725	457	892	396	1,523	141	895	1,316
Na	mg/L	101	61.9	204	85.8	106	28.6	205	94
K	mg/L	13.1	10.6	14.4	24.7	31.1	8.8	14.6	28
SO4	mg/L	4,481	3,706	6,081	4,193	6,125	1,123	4,789	5,306
Cl	mg/L	11	8	12	6	11	8	12	11
NO_3-N	mg/L	8.05	1.1	50.7	40.6	14	1.1	7.5	14
Amm-N	mg/L	0.005	0.245	0.017	0.92	0.05	0.19	0.013	0.039
As	mg/L	0.001	0.0005	0.00075	0.0005	0.003	0.0005	0.00075	0.003
Cu	mg/L	0.0011	0.0005	0.0006	0.1347	0.0015	0.0005	0.0006	0.0015
Fe	mg/L	0.02	0.05	0.05	0.19	0.02	0.05	0.05	0.02
Pb	mg/L	0.0001	0.000075	0.00005	0.00005	0.00025	0.0008	0.00005	0.00025
Zn	mg/L	0.049	0.36	0.0028	0.36	-	0.36	0.0028	0.025

Table 8: Summary of source terms – runoffs from rehabilitated and unrehabilitated areas, FTSF seepage, and rainfall.

SOURCE TERM TYPE		PIT WALL AND UNREHABILITATED AREA RUNOFF	REHABILITATED AREA RUNOFF	FTSF SEEPAGE	RAINFALL
PARAMETER	UNIT	VALUE	MEDIAN	MEDIAN	VALUE
pH	pH units	8.4	8	8.1	5.2
Total Alkalinity	mg/L as $CaCO_3$	573	119	220	0.81

SOURCE TERM TYPE		PIT WALL AND UNREHABILITATED AREA RUNOFF	REHABILITATED AREA RUNOFF	FTSF SEEPAGE	RAINFALL
PARAMETER	UNIT	VALUE	MEDIAN	MEDIAN	VALUE
Ca	mg/L	190	40	640	0.11
Mg	mg/L	186	7.9	345	0.05
Na	mg/L	32.4	12	360	0.32
K	mg/L	11.2	1.7	95	0.09
SO_4	mg/L	719	20	3,600	0.6
Cl	mg/L	15.6	8	22	0.18
NO_3-N	mg/L	0.019	0.001	12	0.0045
Amm-N	mg/L	0.038	0.005	13	-
As	mg/L	0.409	0.0039	0.0125	-
Cu	mg/L	0.001	0.001	0.089	-
Fe	mg/L	0.065	0.07	0.0265	-
Pb	mg/L	0.0003	0.00005	0.45	-
Sb	mg/L	0.008	0.0004	0.00068	-
Zn	mg/L	0.005	0.0008	-	-
WAD CN	mg/L	-	-	0.01	-

Note: Trace element values for FTSF seepage are for total concentration.

5.4 Predicted Pit Lake Water Quality

The modelling indicates that the MP4 pit lakes will operate as fully mixed systems (although seasonal stratification may occur) with the following overarching post-closure hydrogeochemical signatures:

- pH and Alkalinity: All four pit lakes are predicted to be highly buffered and circumneutral, maintaining a stable pH between 7.6 and 7.7, supported by total alkalinity concentrations consistently exceeding 140 mg/L as $CaCO_3$.
- Salinity and Major Ions: The pit lake waters will be brackish to saline and dominated by SO_4 and Mg. Long-term average SO_4 concentrations will range from approximately 500 mg/L in CN up to over 2,000 mg/L in IM.
- Trace Metals and Attenuation: The oxidising, circumneutral conditions will promote the rapid oxidation and precipitation of iron as amorphous ferrihydrite ($Fe(OH)_3$). This precipitate provides critical reactive surface areas that adsorb and sequester most dissolved trace metals and metalloids (e.g., Cu, Pb) through surface complexation, maintaining generally low dissolved concentrations.
- Nitrogen Species: Nitrate and ammoniacal nitrogen loads, derived primarily from explosive residues in backfill and pit walls, will decline to negligible levels within the first 10 to 20 years post-closure.
- Predicted long-term water quality was screened against site-specific, hardness-modified ecological trigger values (TVs) established for the downstream receiving environments. As demonstrated in the summary table, despite active surface adsorption onto ferrihydrite, As concentrations are predicted to range between 0.2 and 0.45 mg/L across all four pit lakes, consistently exceeding the 0.013 mg/L TV. Furthermore, driven by ongoing mass loading from adjacent WRS and backfill seepage, Zn concentrations in the CO and CN Pit Lakes are

predicted to exceed the TV of 0.016 mg/L, whilst SO_4 exceeds the hardness-modified 1,000 mg/L TV in the more saline CN and IM Pit Lakes.

5.5 Management Measures

To proactively address the predicted As and Zn exceedances and manage potential compliance risks prior to surface discharge, an active in-pit treatment strategy has been proposed. This strategy utilises the controlled addition of ferric chloride ($FeCl_3$) to stimulate further ferrihydrite precipitation and enhance surface complexation of metals. Predictive inventory modelling estimates a total requirement ranging from 108 to 394 Intermediate Bulk Containers (IBCs: 1,000L) of 40% $FeCl_3$ per pit lake over the 200-year post-closure duration.

5.6 Recommendations

To validate baseline modelling assumptions, address key hydrodynamic uncertainties, and demonstrate closure-readiness prior to decommissioning when pit voids will commence filling, the following operational-phase activities are recommended:

- Stratification and Mixing Validation: Implement a targeted monitoring programme at the GB Pit Lake prior to dewatering, collecting monthly multi-depth water samples and vertical physicochemical profiles. This high-frequency monthly sampling is required to characterise physical stratification cycles, validate seasonal vertical turnover, and resolve hydrodynamic uncertainties in the long-term predictive models.
- Source Term Refinement: Refine pit wall runoff source terms by incorporating time-decaying solute release to account for progressive mineral weathering and surface passivation. This should be supported by field pit wall wash testing on exposed wall faces of varying weathering ages (such as the historical GB wall faces) to validate the transferability of the GB analogue term across all proposed pit voids.
- Comprehensive Pit Lake Modelling: Develop an integrated, multi-dimensional pit lake model for each proposed pit void to support final closure planning (i.e., closure readiness planning). During the operational phase, these models should be upgraded to simulate physical hydrodynamics, seasonal stratification, biogeochemical processes, and nutrient cycling, using refined geochemical source terms validated against site-specific data.
- Active Treatment and Field Validation: Conduct site-specific, bench-scale laboratory trials to verify exact $FeCl_3$ dosing requirements prior to full-scale deployment. Subsequently, undertake $FeCl_3$ dosing trials at GB Pit Lake to validate the process works in the field.

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7 LIMITATIONS

Attention is drawn to the document “Limitations”, which is included in Appendix D of this report. The statements presented in this document are intended to provide advice on what the realistic expectations of this report should be, and to present recommendations on how to minimise the risks associated with this project. The document is not intended to reduce the level of responsibility accepted by Mine Waste Management, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in doing so.

APPENDIX A GEOENVIRONMENTAL HAZARD ASSESSMENT

APPENDIX B WRS ASSESSMENT SEEPAGE QUALITY

APPENDIX C HYDROGEOCHEMICAL PIT LAKE MODELLING

APPENDIX D LIMITATIONS

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