

BOGP Post Closure Active Water Treatment Plant (WTP)

Order of Magnitude (Oom) Study

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EXECUTIVE SUMMARY

This report provides an order of magnitude assessment of the water treatment requirements following BOGP mine closure. During the mine closure phase, water treatment will be required by an active Water Treatment Plant (WTP) for years eleven to thirty-one. There are three water management stages during the project.

- Internal water management during the operations phase
- Active water treatment post closure (Summarised in this report)
- Passive water treatment within decades of the mining cessation

This report details the recommended process requirements for an active WTP with the capacity to treat an average flow of 26.9 l/sec.

Potential constituents of concern (PCOC) have been identified for the BOGP based on baseline water quality studies, environmental geochemistry studies, and proposed water quality compliance limits: It is expected that mining of the BOGP will affect waters within the project area, and these effects will include:

- Elevated total suspended solids (TSS) in surface waters.
- Neutral metalliferous drainage (NMD) that may have elevated PCOC such as arsenic (As), Sulphate (SO₄), and trace metals.
- Nitrate-rich drainage due to the use of ANFO.

Following a review of predicted water quality and a literature review of available treatment processes, and the suitability of these processes to remove the PCOCs, an Ettringite precipitation process is recommended.

Known commercial chemical precipitation sulphate removal processes include the SAVMIN process, the CESR (Cost effective Sulphate removal Process) and the Outotec (now Metso) Ettringite process.

The available treatment processes for Ettringite precipitation have been developed for Sulphate concentrations above 2000mg/l, which indicate performance removal of sulphate to 200-100mg/l. (Within the proposed consent limits for surface and ground waters).

Ettringite formation can also provide a polishing effect, allowing precipitation of metals, Ni, Cd, Cu, Zn, Cr, As and Se, often below their compliance limits and laboratory detection limits. Boron, fluoride and up to 30% of chloride and nitrate-nitrite in wastewater have also been removed (Reinsel 1999)

During the operations phase of the project and prior to detailed design of the active WTP it is highly recommended that detailed testing of the actual BOGP water quality take place. This testing should simulate each of the required precipitation steps which would give real data to present and reference for final water quality. This would also give certainty about the effectiveness of the treatment process on the BOGP proposed mine water quality and assurance that the water treatment system will achieve the final water quality and cater for final flow rates.

From the water quality and literature review, the proposed sulphate and metals removal processes will have several sludge management streams with different product outputs, some which will need disposal either on site or off site and some that could be recycled or form a product for export off site.

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1 INTRODUCTION

Process Flow Limited (PFL) has been engaged by Matakanaui Gold Limited (MGL) to provide guidance on water treatment for Mine Impacted Water (MIW) for the proposed Bendigo-Ophir Gold Project (BOGP).

Input water quality data used in this study has been referenced from J-NZ0464-002-R-Rev1 Report on Water Treatment requirements by Mine Waste Management, dated 7 October 2025.

The MWM water and load balance model (WLBm) indicates that the BOGP needs to focus on the management and treatment of MIW that will contain potential constituents of concern (PCOC).

The following PCOC may require treatment by the WTP and PTS to achieve the proposed water quality limits for the BOGP (Ryder, 2025):

- Nitrogenous compounds (N) that include nitrate (NO₃) and ammoniacal-N (Amm-N).
- Sulfate (SO₄).
- Metals and metalloids that may include Aluminium (Al), arsenic (As), cadmium (Cd), cobalt (Co), copper (Cu), chromium (Cr), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni), lead (Pb), antimony (Sb), selenium (Se), strontium (Sr), uranium (U), and zinc (Zn)
- Cyanide (CN) within the tailings water.

Our work specifically involves carrying out an order of magnitude (OoM) study for:

- Treatment of MIW by a WTP during the active closure phase, until the PTS can be successfully established (~ 50 years after closure).

1.1 Project Description

This section provides an introduction to the BOGP.

1.2 Introduction

MGL is proposing to establish the BOGP (Figure 1), which comprises gold mining operations, processing operations, ancillary facilities and environmental mitigation measures on Bendigo and Ardour Stations in the Dunstan Mountains of Central Otago. The project site is located approximately 20 km north of Cromwell and will have a maximum disturbance footprint of 550 hectares.

The total Mineral Resource Estimate for the BOGP using a 0.5 g/t cut-off for open pit and 1.5 g/t for underground is 34.3 Mt at 2.1 g/t for 2.34 M oz (MGL, 2025). The Bendigo-Ophir resources occur in four deposits: Come in Time (CIT), Rise and Shine (RAS), Srex (SRX), Srex East (SRE). The majority of identified mineral resources are located within the RAS deposit. Three primary geological units are recognised at site:

- RSSZ – Rise and Shine Shear Zone
- TZ3 – Lower Greenschist facies Textural Zone 3 rocks of the Otago Schist
- TZ4 – Upper Greenschist facies Textural Zone 4 rocks of the Otago Schist

The resources will be mined by open pit methods at each deposit within the project site, with underground mining methods also proposed to be utilised at RAS to access the deeper gold deposits. The majority of the mining activities, ancillary facilities and associated infrastructure will be located in the Shepherds Valley with non-operational infrastructure located on the adjoining Ardgour Terrace. The BOGP also involves the taking of groundwater from the Bendigo Aquifer for use in mining-related activities and the realignment of Thomson Gorge Road via Ardgour Station.

The following mine facilities are proposed (Figure 2):

- Open pits targeting the RAS, SRX, SRE, and CIT deposits.
- An underground mine targeting the RAS deposit.
- Three ex-pit engineered landforms (ELFs) – Shepherds ELF, SRX ELF, and West ELF (WELF).
- Two in-pit landforms (backfill) – CIT and SRE¹.
- Plant and processing area, where CIL extraction technologies will be used as part of the ore recovery process.
- A tailings storage facility (TSF) and TSF Embankment.
- Other ancillary support services / structures (e.g., roads, water management infrastructure, water treatment plants, etc).

These facilities will be placed in the catchment of Shepherds and Bendigo creeks. Understanding baseline water quality (surface and groundwater) is important to enable the establishment of site-specific water quality compliance criteria for any resource consent that may be granted in the future.

¹ Note: SRE Pit is backfilled by the SRX ELF.

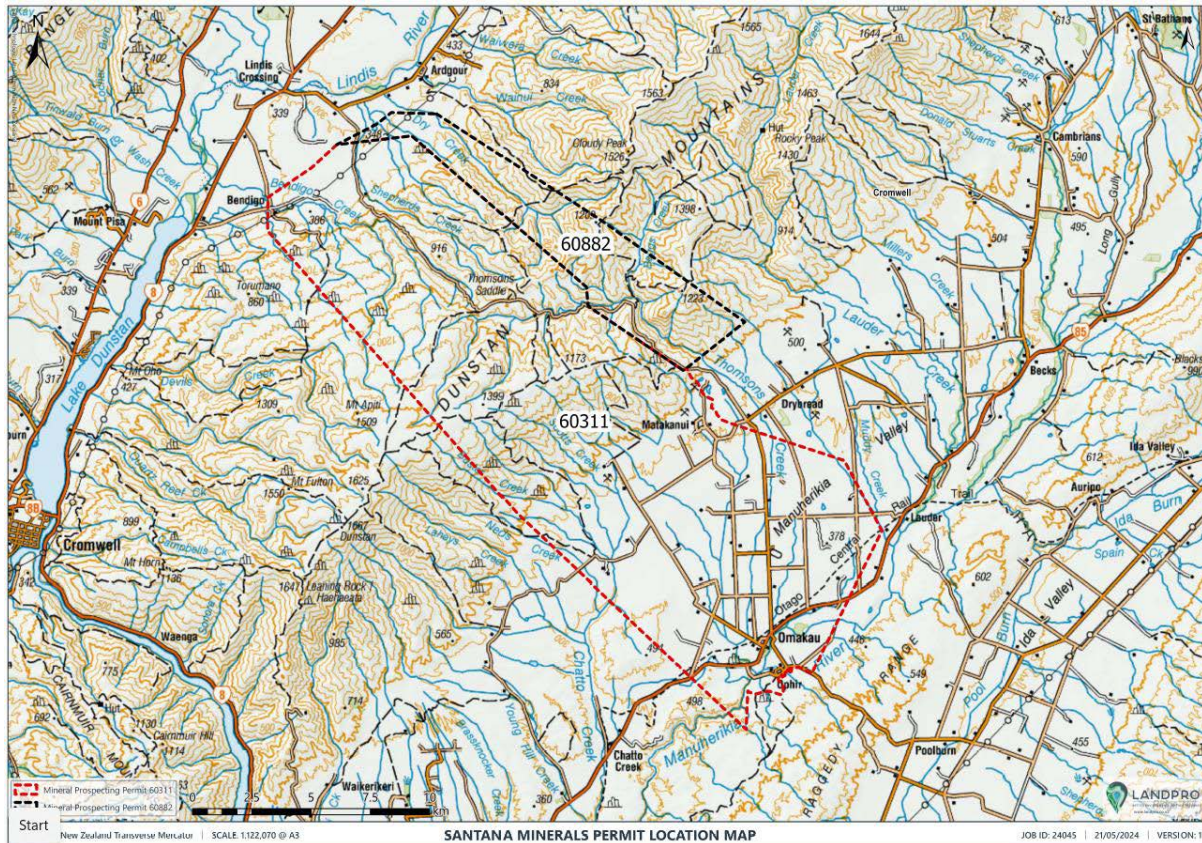


Figure 1. BOGP mineral permit boundaries showing MEP60311 and PEP60882.

1.3 Surface Water

The project area covers several catchments and sub-catchments (Figure 2), including:

- **Shepherds Creek:** This creek runs permanently through the project area and then intermittently from the Ardgour Terrace towards the Lindis River. An irrigation water-take on Shepherds Creek (RM17.301.15) downstream of SC01 monitoring site takes all available surface water in normal flow conditions, which is supplied to an irrigation dam, so the creek does not flow past this point. There is potential for groundwater to flow past this point via a thin layer of alluvial gravels along the creek bed.
- **Jean Creek:** This creek is an intermittent tributary to Shepherds Creek.
- **Rise and Shine Creek:** This creek joins Clearwater Creek south-east of the Come in Time Battery and flows into Bendigo Creek.
- **Clearwater Creek:** Flows into Bendigo Creek.
- **Bendigo Creek:** Several irrigation water-takes are in place on this creek (RM20.079.01 and RM20.079.02).

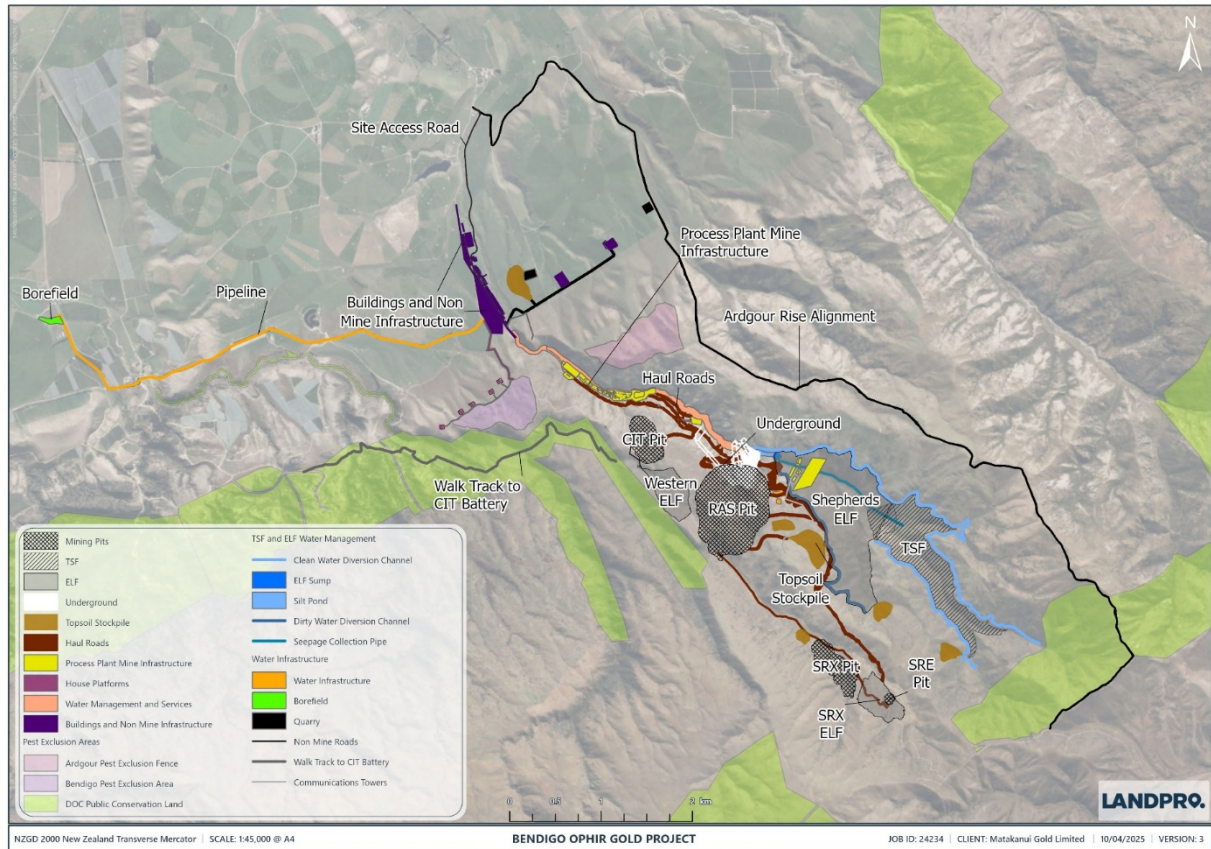


Figure 2. Bendigo-Ophir Gold Project area and water quality monitoring sites.

Baseline water quality data indicates that PCOC are elevated in the BOGP area due to historic mining activities and natural mineralisation. (MWM J-NZ0464-002-R-Rev1)

2 DISCLAIMER

This report provides information that is preliminary in nature and has been prepared to provide the client with water treatment information suitable for an “Order of Magnitude” assessment for the overall project. The information provided is not suitable for detailed design or construction purposes and the information should not be used as a specification for tendering or any other construction related purpose.

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Where data supplied by the client or other external sources, including previous site investigation data, have been used, it has been assumed that the information is correct unless otherwise stated. No responsibility is accepted by Process Flow Limited for incomplete or inaccurate data supplied by others.

Process Flow acknowledges that this report will be relied on by a Panel appointed under the Fast Track Approvals Act 2024 and these disclaimers do not prevent that reliance.

The information presented in this report is based on a literature review of known water treatment process technologies for primarily sulphate and metals removal. The information presented is preliminary, and test-work should be carried during the mining phase of the project (prior to active closure) to confirm design assumptions and prove final water qualities can be achieved for the flows required.

3 PROCESS OBJECTIVES AND ASSUMPTIONS

3.1 Reference Information

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- Young, C.A. and Jordan, T.S., 1995, Cyanide Remediation: Current and Past Technologies, Proceedings of the 10th Annual Conference of Hazardous Waste Research, Department of Metallurgical Engineering, Montana Tech, Butte, MT59701

3.2 Process Objectives

During the Active Closure Phase, water treatment is required by a water treatment plant (WTP) once the project switches from a process of internal water management for MIW (during operations) to discharge of MIW from site after closure of the mine. Model results indicate that the WTP can be replaced by a passive treatment system (PTS) within decades of mining cessation, which then defines the commencement of the Post Closure Phase.

3.3 Definition of Plant Flow Rates

This section summarises the long-term average flow rates for each mine domain that may require treatment during the Active Closure and Post Closure phases of the BOGP.

3.3.1 Average Flow Rates

Average flow rates are estimated from the Water and Load Balance Model. It is assumed that the use of average flow rates is suitable for the WTP OoM Study and the PTS Concept Study. Peak flows may require either a larger capacity plant or a surge pond prior to any treatment. Further work is required to advance the designs to a feasibility Study (FS) level including understanding the treatment requirements for peak flow rates.

Table 1 provides a summary of flow rates for the various mine domains that require treatment. These flow rates are preliminary and are intended to provide guidance for the OoM study on the WTP design. For the OoM WTP Study it is recommended that the design include suitable contingency for variable flow rates. Active treatment is not required for SRX Pit - It is expected that the water quality from this mine domain will be acceptable for release to the receiving environment (e.g., Rise and Shine Creek / Bendigo Creek) with passive treatment.

Table 1: Estimated average water quantity per mine domain.

MINE DOMAIN	WTP DESIGN CRITERIA (L/s)	PTS (L/s)	COMMENTS
Shepherds ELF	4	4	• 20% Net percolation
SRX ELF ^{1, 2}	-	1	• 20% Net percolation
West ELF ²	1	1	• 20% Net percolation
Shepherds TSF	13.4	3	• Flow is expected to be ~13.4 L/s decreasing to 3 L/s after 5 years
RAS Underground Portal	6	6	• Flow from the RAS Underground is not expected for 20-30 years after closure
CIT Pit Backfill	1.5	1.5	• Further details are available in MWM J-NZ0464-002-R-Rev1
SRX Pit	-	8	• Further details are available in MWM J-NZ0464-002-R-Rev1. It is assumed this water will not require active

MINE DOMAIN	WTP DESIGN CRITERIA (L/s)	PTS (L/s)	COMMENTS
			treatment. Passive treatment is required.
SCK Fill ²	1	1	20% Net percolation
Non-AMD impacted water	-	-	Managed for TSS separate to the active WTP. At closure rehabilitated surfaces are assumed to be suitable for discharge with TSS management.

1. Active treatment for SRX ELF and SRX Pit are not anticipated.

2. Flow rates rounded up to 1 L/s

Table sourced from MWM J-NZ0464-002-R-Rev1

This results in an active water treatment plant with the capacity to treat an average flow of 26.9 l/sec.

3.4 Definition of Mine Water Quality (Plant Feed Envelope)

This section summarises the water quality from the various mine domains that require treatment at closure of the BOGP by the active water treatment plant. Peak concentrations are provided for the following streams

- Shepherds ELF
- West ELF
- Shepherds TSF
- RAS Underground Portal
- CIT Pit Backfill
- SCK Fill

3.4.1 Shepherds TSF Water Quality

TSF seepage water quality at mine closure (Year 11) is presented in Table 2. Further details on how the water quality was derived are provided in MWM J-NZ0464-002-R-Rev1

Constant concentration is assumed.

Table 2: TSF seepage water quality (Closure).

PARAMETER	CLOSURE TSF SEEPAGE WATER QUALITY
Alkalinity (mg CaCO ₃ /L)	73.21
pH (pH units)	6.41
EC (µS/cm)	4,121
Ca	297
Cl	804
F	1.93
Mg	99
Na	847
K	50.8
TOC	-

PARAMETER	CLOSURE TSF SEEPAGE WATER QUALITY
Al	0.01
Ag	0.0068
As	2.05
B	0.825
Cd	0.0002
Co	0.053
Cr	0.0055
Cu	0.001
Fe	15.3
Mn	0.59
Mo	0.14
Ni	0.678
Pb	0.0275
Sb	0.18
Se	0.003
Sr	4.4
Tl	0.001
U	0.028
V	0.004
Zn	0.0296
Cyanide - WAD	0.35
Sulfate	954
Ammoniacal-N	2
Nitrate-N	0.005

Note: All units in mg/L unless otherwise stated. **Green data** are LOR and are included in the source term as '0' WAD – Weakly Acid Dissociable cyanide; If no data are provided these are identified by '- '.

3.4.2 ELF and CIT Backfill Water Quality

Water quality for the ELFs is provided in Table 3, (Table sourced from MWM J-NZ0464-002-R-Rev1) which shows the water quality for Year 27, when maximum loads are being derived from the Shepherds ELF to provide peak concentration data for the design of the WTP.

Constant concentrations are assumed for As (0.2 mg/L) and Fe (7.6 mg/L) based on empirical data for sub-oxic conditions (e.g., Globe Progress Waste Rock Stack, Hayton et al., 2022). These concentrations are above the proposed water quality reference limit (Ryder, 2025) and will require management. The SCK Fill assumes full oxidation, which results in low Fe concentrations.

Table 3. Water Quality Data (Year 27) for WTP design – 20 m Oxygen Exclusion Model

STATION	TSF SEEPAGE	SHEPHERDS ELF SEEPAGE	WELF SEEPAGE	CIT PIT BACKFILL	SCK FILL SEEPAGE	MIW COMBINED*
Acidity	0.01	0	0	0	0	0.03
Al	0.011	0.003	0.003	0.005	0.003	0.013
Alkalinity	73	189	183	190	158	160
As	2.06	0.20	0.20	0.08	0.20	0.61

STATION	TSF SEEPAGE	SHEPHERDS ELF SEEPAGE	WELF SEEPAGE	CIT PIT BACKFILL	SCK FILL SEEPAGE	MIW COMBINED*
B	0.83	0.87	0.10	0.09	0.01	0.59
Ca	297	51	51	39	36	107
Cd	0.0002	0	0	0.0001	0	0.0001
Cl	806	63	37	12	8	223
Co	0.053	0.109	0.023	0.004	0.003	0.061
Cr	0.00636	0.00020	0.00019	0.00040	0.00007	0.00170
Cu	0.00100	0	0	0.00021	0	0.00049
DOC	0	0	0	0.206	0	0.038
F	1.94	6.30	6.12	1.39	2.37	3.90
Fe	15.3	7.6	7.6	2.4	7.6	8.7
Hg	0	0	0	0.00014	0.00000	0.00003
K	51	683	672	84	159	372
Mg	100	38	37	20	24	49
Mn	0.594	0.819	0.774	0.103	0.182	0.567
Mo	0.140	1.005	0.672	0.119	0.157	0.535
NO3-N	2.01	49.64	9.54	0.73	1.33	22.89
Na	848	922	734	127	170	673
Ni	0.6784	0.0121	0.0010	0.0013	0.0001	0.1652
Pb	0.0276	0.0001	0.0001	0.0002	0.0000	0.0068
Sb	0.1802	2.9986	3.2208	0.3622	0.7601	1.6317
Se	0.0030	0.1544	0.1649	0.0196	0.0388	0.0826
SO4	954	957	888	110	208	730
Sr	4.40	16.15	15.91	3.77	10.89	10.12
Tl	0	0	0	0.00021	0.00000	0.00005
CN	0.35	0	0	0	0	0.08238724
U	0.0280	0.2751	0.2225	0.0299	0.0515	0.1468
V	0.0040	0.1200	0.1155	0.0135	0.0269	0.0633
Zn	0.0296	0.0098	0.0021	0.0014	0.0003	0.0117
pH (pH unit)	6.41	7.93	7.92	8.03	7.92	6.72
Hardness	1,151	285	280	179	190	469

Units in mg/L *MIW Combined - This is a weighted average

3.4.3 RAS Underground Water Quality

As discussed in MWM J-NZ0464-002-R-Rev1 seepage from the RAS Underground will be comparable to the RAS Pit Lake. The RAS Underground is not expected to commence discharge until Year 26. Water Quality for Year 26 is provided in Table 4.

Table 4 RAS Underground water quality (Year 27)

PARAMETER	RAS UNDERGROUND
Acidity	0.44
Al	0.100
Alkalinity	182
As	0.09
B	0.05
Ca	59
Cd	0.0001
Cl	14
Co	0.000
Cr	0.00058
Cu	0.00302
DOC	0.090
F	0.23
Fe	7.9
Hg	0.00006
K	34
Mg	37
Mn	0.014
Mo	0.020
NO ₃ -N	4.35
Na	42
Ni	0.0009
Pb	0.0035
Sb	0.0234
Se	0.0008
SO ₄	141
Sr	0.79
TI	0.00031
CN	0
U	0.0094
V	0.0006
Zn	0.0022
pH (pH unit)	5.91
Hardness	299

Units in mg/L

3.5 Discharge Water Requirements

PCOC that have been identified for the BOGP based on baseline water quality studies, environmental geochemistry studies, and proposed water quality compliance limits are shown in Table 3. Limits are based on:

- Ecotoxicity assessments developed by Ryder (2025) for the proposed surface water compliance sites
- Groundwater limits are based on New Zealand Drinking Water Standards (MoH, 2022).

The proposed compliance monitoring locations are shown in Figure 2 for surface waters and groundwaters.

For conceptual desk-top studies, it is proposed that the WTP and PTS design should be based on the more stringent water quality criteria (i.e., the lower compliance value) for surface and groundwaters to ensure that treated waters comply with both criteria.

These proposed water quality criteria for the BOGP (Ryder, 2025) are summarised in Table 5.

Table 5. Proposed Water Quality Compliance Limits for the BOGP

PARAMETER (UNITS ARE mg/L UNLESS STATED OTHERWISE)	SURFACE WATER RECOMMENDED COMPLIANCE LIMIT(S)	GROUNDWATER RECOMMENDED COMPLIANCE LIMIT(S)
pH (unitless)	6.5 - 9.0	-
Turbidity (NTU)	5 (over a 5-year rolling period, 80% of samples, when flows are at or below median flow, are to meet the limit)	-
Ammoniacal-nitrogen (NH ₃ -N)	≤0.24 (annual median) <0.4 (annual 95 th %) ¹	-
Nitrate-nitrogen (NO ₃ -N)	<2.4 (annual median) <3.5 (annual 95 th %)	11.3 (MAV) ²
Cyanide (CN ⁻)	0.011 (un-ionised HCN, measured as [CN], ANZG 2018) ¹	0.6 (MAV)
Sulfate (SO ₄ ²⁻)	• If hardness is <100 mg/L (CaCO₃), the sulfate compliance limit = 500 mg/L. • If chloride is <5 mg/L, the sulfate compliance limit = 500 mg/L. • If the hardness is 100–500 mg/L AND if chloride is 5–<25 mg/L, the sulfate compliance limit is (in mg/L): $[-57.478 + 5.79 * (\text{hardness mg/L CaCO}_3) + 54.163 * (\text{chloride mg/L})] * 0.65$ • If hardness is between 100 and 500 mg/L AND if chloride is between ≥25 and ≤500 mg/L, the sulfate limit is (in mg/L): $[1276.7 + 5.508 * (\text{hardness mg/L CaCO}_3) + 1.457 * (\text{chloride mg/L})] * 0.65$ A minimum of 12 samples must be collected over any rolling 12-month period.	≤250 (taste threshold)

PARAMETER (UNITS ARE mg/L UNLESS STATED OTHERWISE)	SURFACE WATER RECOMMENDED COMPLIANCE LIMIT(S)	GROUNDWATER RECOMMENDED COMPLIANCE LIMIT(S)
For compliance limits in the points above, no more than 20% of samples collected over a rolling 12-month period may exceed the relevant compliance limit. An acute compliance limit = 1,000 mg/L averaged over 4 days and not to be exceeded more than once in a one-year period, OR in more than 10% of samples over a one-year period.		
Aluminium (Al)	≤0.08	1 (MAV)
Antimony (Sb) (total)	0.074 (chronic) 0.250 (acute)	0.02 (MAV)
Arsenic (As(V))	≤0.042	0.01 (MAV)
Cadmium (Cd)	≤0.0004 ³	0.004 (MAV)
Chromium (Cr)	≤0.0033 (Cr(III)) ⁴ ≤0.006 (Cr(VI)) ⁴	≤0.05(MAV, Total Cr)
Cobalt (Co)	0.001 (chronic) ⁵ 0.11 (acute, not to exceed) ⁵	<1 (livestock drinking water)
Copper (Cu)	≤0.0018	≤0.5
Iron (Fe) (total)	-	≤0.3
Lead (Pb)	-	0.01 (MAV)
Manganese (Mn)	-	0.4 (MAV)
Molybdenum (Mo)	≤0.034	<0.01
Selenium (Se)	-	0.02
Strontium (Sr) (total)	-	4
Uranium (U)	-	0.03 (MAV)
Zinc (Zn)	≤0.015 ⁶	≤1.5

All limits are dissolved unless noted as total

"-" = no limit recommended.

¹ = refer to Ryder (2025), for concentration adjustments.

² MAV = Maximum acceptable value – From the NZ drinking water standards.

³ Cd (dissolved) is adjusted by the following algorithm: $HMTV = TV * (H/30) * 0.89$, where hardness-modified trigger value (HMTV) = (µg/L), trigger value (TV) (µg/L) at a hardness of 30 mg/L as CaCO₃; H, measured hardness (mg/L as CaCO₃) of a fresh surface water.

⁴ = Cr (dissolved) is adjusted by the following algorithm: Chromium (mg/L) = Toxicity value (mg/L) * $(H (mg/L)/30)^{0.82}$

⁵ = Co (dissolved) is adjusted by the following algorithm: Cobalt (µg/L) = $\exp \{ [0.414 \ln(\text{hardness CaCO}_3 \text{ mg/L})] - 1.887 \}$

⁶ = Zn (dissolved) is adjusted by the following algorithm: Zinc (mg/L) = Toxicity value (mg/L) * $(H (mg/L)/30)^{0.85}$

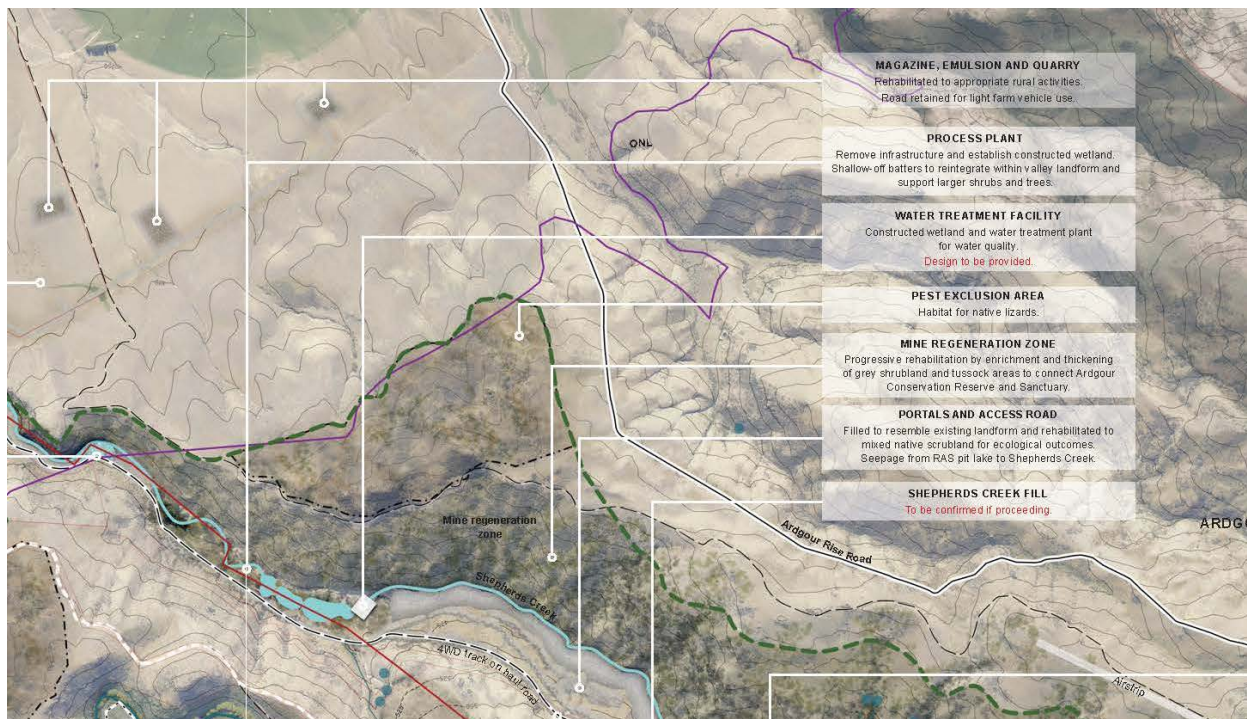
The PCOC presented in section 3.4 were identified from the baseline studies, source hazard assessment, geochemical modelling, and the water and load balance modelling to understand potential effects of the BOGP.

3.6 Plant Location and Footprint

The proposed location for the Active WTP is located on Shepherds creek near the mine regeneration zone (area labelled “Water Treatment Plant” on the image shown below).

The size and footprint requirements for the WTP and Surge and Treated water ponds is as follows.

- WTP Footprint – An area approximately 100 m x 60 m TBA is recommended to be located near the surge and treated water ponds.
- WTP Surge Pond – 14,000 m³ (see section 4.4 for detail and sizing philosophy)
- WTP Treated Water Pond – 2,000 m³ (see section 4.6 for detail and sizing philosophy)



4 PRELIMINARY PROCESS DESIGN

The following is a description of the preliminary level process design which has been developed for the purpose of selecting plant options. This description should be read in conjunction with the preliminary design process flow diagrams PFL-2426-PRO-PFD-00001 to 00003 (Sheets 1 to 3) included in Appendix A of this report.

The selected process is based on known water treatment process technologies for primarily sulphate and metals removal as described in the following sections. It should be noted that the design selection is preliminary, and test-work should be carried during the mining phase of the project (prior to active closure) to confirm design assumptions and prove final water qualities can be achieved.

The process selected involves the following unit processes.

- Surge Sump
- Pontoon mounted pumps for plant feed
- Metal hydroxide precipitation and settling
- Gypsum precipitation and settling
- Ettringite precipitation and settling
- Carbonation and pH trimming
- Treated Water Sump
- Sludge Management

Other processes that will likely be needed in addition to the active WTP are:

- Cyanide Destruct on the Shepherds TSF influent stream
- Potential additional nitrate removal after the WTP via biological processes

4.1 Treatment Literature Review

A range of Active Treatment technologies for sulphate and metals removal exist, including Ettringite Precipitation, Biological Sulphate Removal, Ion Exchange, Reverse Osmosis, Electrocoagulation, Treatment and Extraction of Rare Earth Metals. This section is a review of the processes currently available at bench and pilot trial and full plant scale for sulphate and metals removal.

4.1.1 Active Treatment Processes reviewed

The following active treatment processes were reviewed for suitability for sulphate and metals removal:

- Biological processes
- Membrane treatment including Reverse Osmosis
- Ion exchange
- Electrocoagulation
- Treatment and extraction of rare earth elements
- Chemical Treatment and Mineral Precipitation (Lime addition, Barium Salts addition, CESR, Savmin, Outotec/Metso, (GARD, 2021; Lorax, 2023))

The processes that are still only under bench scale and research and development stage are:

- Electrocoagulation (developed to bench scale)
- Treatment and extraction of rare earth elements (This is under research and development only (GARD, 2021))

With the passage of time, these treatment options may become viable however at this stage they are not considered a proven technology suitable for full scale plant application for this BOGP project.

Reverse Osmosis, Ion exchange and Biological Processes have been discounted for this project as active treatment options.

Reverse Osmosis may be appropriate if sulphate concentration was lower than the sum of all metals and chloride (if operational and capital consideration allowed).

Reverse Osmosis and membrane processes generally produce large quantities of membrane reject waters (brine) which requires reprocessing and disposal. Capital and operating costs for membranes are high, with RO operating pressures high, and chemical use for fouling removal has potential to be high (Lorax, 2023). Operational issues associated with RO and Membranes include high fouling and cleaning rates with membrane longevity is shown to be reduced in these applications (Lorax, 2023).

Ion exchange processes do not have long track record for this application at full plant size, although information about trials at pilot scale are available (Lorax, 2023). Ion exchange processes produce quantities of gypsum sludges, and high amounts of brine which need further processing. They are not widespread in use for this application (Bratty et al, 2014). One ion exchange technology, the GYP-CIX process is suitable for treated mine waters with high levels of TDS, sulphate and calcium (up to 2000mg/l). It uses calcium hydroxide and sulphuric acid to regenerate the ion exchange resins. Costing of resins would have to be done to compare lime and other chemical costs to see if this process would be viable. For this BOGP project it has been discounted due to insufficient information on its long-term use at full scale for this application.

Biological Processes can be limited by sufficient organic carbon and nutrients in mine influence waters and the presence of heavy metals limiting growth. (Lorax 2023, Bratty et al, 2014)

Biological treatment with sulphate-reducing bacteria is suitable to low or moderate sulphate loadings (Qian et al., 2015; Silva et al., 2012), but its application is usually hindered by the shortage of organics, the inhibition of high salinity and metal ions in the wastewater (Mothe et al., 2017), and the generation of hydrogen sulphide (Runtti et al., 2016). (Dou. W, 2017)

There has been limited application of Biological Treatment in Active Water Treatment systems and is more successful used in Passive Treatment systems. (Bratty et al, 2014)

Sulphate removal using chemical precipitation include processes of lime addition, barium salts addition and proprietary processes such as the CESR (Cost Effective Sulphate Removal process), Savmin, Oututec/(Metso) processes (GARD, 2021; Lorax, 2023).

(It is noted in literature that Barium Sulphate is highly insoluble and as an alternative to Calcium Hydroxide, the addition of Barium Hydroxide is extremely effective at removing sulphate. Barium Hydroxide is however, an expensive, corrosive and toxic treatment chemical and this rarely represents a cost-effective treatment option to use this as a hydroxide for this stage of the process. (Gard, 2021).)

For mine water that is net acidic, where low residual metal and sulphate concentrations are needed in the treated discharge water, and the sulphate concentration is higher than the sum of metals and chloride, where carbon sources (crude or refined) are not available or are expensive, then the Savmin process is recommended as an appropriate technology (Younger et al 2002).

Ettringite Precipitation (addition of Lime and $\text{Al}(\text{OH})_3$ can be used to remove sulphate and heavy metals. Ettringite ($3\text{CaO} \cdot 2\text{CaSO}_4 \cdot \text{Al}_2\text{O}_3 \cdot 31\text{H}_2\text{O}$) has very low solubility and therefore sulphate concentrations are low in treated water after precipitation and settling.

The Main unit operations for known processes for sulphate removal with Ettringite precipitation involve:

1. Metals Precipitation - pH lift with Lime to the range of 11.5 to 12 (Calcium Hydroxide, rather than barium), this enables Al dissolution
2. Gypsum Precipitation
3. Ettringite Precipitation - Al^{3+} addition to remove sulphate as precipitated ettringite
4. pH reduction of the treated water with CO_2 to meet effluent discharge criteria and precipitate CaCO_3

Ettringite sludge must be separated by gravitation separation and or filtration (Reinsel 1999, Lorax Environmental 2003, Outotec 2014).

Known commercial chemical precipitation sulphate removal processes include the SAVMIN process, the CESR (Cost effective Sulphate removal Process) and the Outotec (now Metso) Ettringite process. All commercial processes follow similar principles:

SAVMIN uses aluminium oxide (aluminium trihydroxide in amorphous or gibbsite form) to create ettringite, with recovery. CESR uses a proprieter Al containing chemical from cement production, without recovery of aluminium source. The Outotec process does not contain a separate lime addition step. (Lorax Environmental 2003, Outotec 2014).

The processes have been developed for Sulphate concentrations above 2000mg/l, with performance levels providing removal of sulphate to 200-100mg/l. Ettringite formation can also provide a polishing effect, allowing precipitation of metals, Ni, Cd, Cu, Zn, Cr, As, Se, Cd, Boron, fluoride and chlorite and nitrate, in waste up to 30% have been removed (Reinsel 1999, Outotec 2014)

4.1.2 Design Considerations

Operating costs for the SAVMIN process depend on reagent use which depends on levels of sulphate and univalent cations (Na, K, NH_4 etc present in the feed water (Smit, 1999)).

Typically, there are low settling rates for the liquid/solid separation phases (Smit 1999). For this reason, conventional high-flow thickeners are preferred for the solid-liquid separation phases in the treatment process (Lorax, 2023). Mixing times for each phase varies from 30-60 minutes but will depend on site specific water quality.

Magnesium ions can interfere with sulphate removal by inhibiting the formation of ettringite (Zahedi et al, 2022).

It is reported that Mg^{2+} has adverse effects on the formation of ettringite in cement paste (De Weerd et al., 2014), and prevents sulphate removal as gypsum (Tolonen et al., 2015). However, the effects of Mg^{2+} on ettringite, precipitation are scarcely reported, and it should be essential for process design and very useful for understanding the precipitation behaviour in real wastewater rich in Mg^{2+} and sulphate. (Dou. W, 2017), also

The study by Dou. W, et al shows that Mg^{2+} has a significant inhibitory effect on sulphate removal by ettringite precipitation and that an additional precipitation step prior to ettringite precipitation is needed to remove magnesium hydroxide as a settled precipitate (as well as metal hydroxides). Dou.W, 2017 et al found in their study that High Caustic alkalinity (using Sodium Hydroxide) and low Mg are the most suitable conditions to precipitate ettringite.

Others have found that using calcium hydroxide as the initial step is effective in reducing magnesium concentration by conversion to insoluble magnesium hydroxide precipitate at pH 12. (Zahedi et al, 2022, Smit, 1999 and Lorax, 2023)

The operating parameters such as molar ratios of SO_4^{2-}/Ca^{2+} and SO_4^{2-}/Al^{3+} , and pH value have a significant effect on the sulphate removal process efficiency (Aygun et al. 2018, as cited in Zahedi 2022).

4.1.3 Treatment Process Site Specific Testing

The sulphate removal process is not commonly used in New Zealand and elsewhere there are limited full size treatment plant sites with available design data to reference.

The ability to test the on-site mine influenced water, or a laboratory formed mimic water, similar to the BOGP proposed water quality and then simulate each of these precipitation steps would give real data to present and reference for final water quality. This would also give more certainty about the effectiveness of the treatment process on the BOGP proposed mine water quality and assurance that the water treatment system will achieve the final water quality. It is proposed that during the detailed design phase that this level of bench scale and pilot scale testing be performed.

4.2 Treatment Plant Process

Of the chemical precipitation processes, a process like the SAVMIN process is proposed for this project.

4.2.1 Savmin Process Summary

The Savmin process uses precipitation reactions to remove sulphates from minewater. This process also removes heavy metals and calcium. The first stage is addition of lime to raise pH and precipitate out metals and magnesium as hydroxides.

After separating out the hydroxides, the resulting supersaturated calcium sulphate solution is contacted with gypsum crystals, which catalyse the precipitation of calcium sulphate (gypsum). Due to the slow settling rate of the precipitates, the most cost-effective equipment for the solid-liquid separation stages of the process are parallel-plate cone clarifiers.

In the third stage of the process, aluminium hydroxide is added to the solution which causes formation of the insoluble salt ettringite, which removes calcium and sulphate from solution.

The solution is then treated with carbon dioxide to lower the pH (process pH values in the first and third stages of the process need to be maintained at 11.6 to 12). The lower pH causes the precipitation of pure calcium carbonate which is separated from the water by filtration.

The final stage of the process is the recycling of ettringite, in which the ettringite slurry is which is treated with sulphuric acid to regenerate aluminium hydroxide.

Reported removal rates are: Heavy metals removed to below drinking water levels; 99% of calcium; 100% of magnesium and 98% of Sulphate. Sodium, chloride, potassium and fluoride are not removed. (Brown. et al, 2002)

4.2.2 Metal Hydroxide precipitation and settling

The metal hydroxide precipitation step is part of both the Savmin and CESR (Cost Effective Sulphate removal process) and generally consists of addition of Hydrated lime (Calcium Hydroxide) to a pH of 10.5-11, mixing from 30- 60 minutes (Reinsel.M,1999). Levels of pH of up to 12-12.5 have been documented and mixing time up to 3 hours.

Settling of the precipitated metals and magnesium as hydroxides occurs and this sludge will need further processing via thickening, dewatering and disposal.

With respect to the BOGP project, during the closure phase in the 50 years when the active treatment system will be used, if Chemical precipitation processes are chosen, large volumes of sludge will be produced (as a byproduct of water treatment) will be created.

Further studies need to be completed to determine the quantity and quality of the water treatment residues (including sludge) for both active and passive treatment systems and identify appropriate disposal options and locations. The sludge should be disposed of at a suitable facility or studies should be undertaken to confirm onsite management options.

4.2.3 Gypsum precipitation and settling

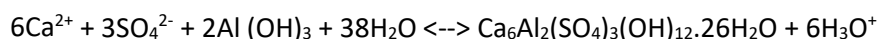
Following removal of the settled metal hydroxides, the liquid is contacted with gypsum to provide active surfaces and catalyse the precipitation of the supersaturated gypsum (Smit, 1999). This precipitated gypsum is then thickened and filtered with some leaving the process and some recycled to the mixing tank as the seed gypsum. It is noted that the sulphate content of the water leaving this stage is dependent on the pH. Higher pH will result in lower sulphate concentrations. The pH in this stage is determined by the settling of the metal hydroxides from the previous stage (at high pH, poor settling occurs).

As gypsum interferes with the precipitation reaction of ettringite, it is important that all gypsum is removed from the feed water before the ettringite formation process steps. (Lorax, 2023).

4.2.4 Ettringite precipitation and settling

Following the precipitation and removal of gypsum, Aluminium Hydroxide is added to the liquid phase. This allows the insoluble salt ettringite to precipitate which results in the removal of both sulphate and calcium from the solution (Smit, 1999).

The stoichiometry of the formation of ettringite with the addition of aluminium is:



The optimal pH range for the formation of ettringite is 11.6-12.0. The pH is maintained in this range by the addition of lime. Literature suggests that for efficient sulphate removal, a multistage reactor is required to produce an ettringite product with good liquid solid separation characteristics (Smit 1999). The ettringite is removed from the process using thickening, filtration.

Long mixing phases for the aluminium hydroxide/ettringite formation were reported in some instances, up to 61h mixing (Zahedi et al, 2022).

4.2.5 Carbonation and pH trimming

At this stage the waste water stream, with a pH 11-12 and dissolved $\text{SO}_4 < 200\text{mg/L}$ is treated with carbon dioxide gas to lower the pH and to prevent scaling. The reduction of pH is prior to discharge to the receiving environment such as surface water or to the nitrate removal system. Relatively pure CaCO_3 is precipitated and removed by filtration or settling. Alternatively, pH can be adjusted to precipitate $\text{Ca}(\text{HCO}_3)_2$. (Lorax, 2023)

If treated water will be used again in the process, as service water, (for mixing, dosing chemical makeup water and washing), then reduction of pH and stabilisation to prevent deposition of hard carbonate scale on filters and distribution piping is required.

4.2.6 Recycling of Aluminium Hydroxide

Aluminium hydroxide is recovered by thickening and filtration and reused in the third stage as the ettringite formation catalyst (Lorax, 2023).

This recovery is achieved by taking the ettringite slurry from the Ettringite Precipitation phase, adding sulphuric acid to lower the pH and decompose the ettringite. This decomposition takes place in gypsum saturated water at a liquid to solid ratio that allows the calcium and sulphate ions to remain in solution as supersaturated calcium sulphate (Smit 1999). The stoichiometry is the reverse of the ettringite formation reaction.

Instead of sulphuric acid, CO_2 can be used, however it converts half of the calcium from the ettringite forms solid calcium carbonate. Some of the regenerated aluminium hydroxide then has to be removed from the circuit as a bleed to control the buildup of calcium carbonate (Smit 1999).

4.3 Treatment Process Equipment

The SAVMIN process contains precipitation reactions in conventional stirred reactors at ambient pressure and temperature. The reactors will be mixing tanks, with mechanical agitators, and settling/clarification vessels in the most part and associated slurry and sludge pumps.

During settling phases of this treatment, settling rates potentially will be lower than conventional thickeners, but sludge volumes may be high, so allowance should be made on site for tall deep cone settlers. The Wren Parallel Cone clarifiers are mentioned in literature. These either have no moving parts for the settling phase or have rotating flocculator in the centre cylinder. Parallel settlers are also mentioned in literature, as an option for a smaller site footprint, but scale removal provisions for maintenance in design would have to be paramount and a less restricted settling vessel may be preferable if site space allows.

Most of the vessels will contain water to pH 12 or thereabouts. There will also be chemical dosing of strong acids such as sulphuric acid and acid coagulants (Aluminium Sulphate and Aluminium Hydroxide). Durability of vessels, piping and pumps will be paramount in design, as will chemical safety during maintenance.

Most of the pipelines and pumping and vessels will involve materials in liquid, slurry or sludge form with the propensity for scale formation from calcium carbonate, gypsum and ettringite, so allowance should be made for scale removal maintenance and redundancy for all equipment in case of blockage and scale removal maintenance downtime.

EQUIPMENT DESCRIPTION	PROCESSES USED
Mixing Vessels	Stage 1, 2 and 3 plus lime saturation and Ettringite decomposition
Settling Clarifiers	Stage 1, 2 and 3
Chemical Dosing systems	Lime, Aluminium Hydroxide, Aluminium Sulphate, Carbon Dioxide Sulphuric Acid
Sludge Handling, Dewatering and disposal systems	Metal Hydroxide, Gypsum, Ettringite, Calcium Carbonate

4.4 Surge Sump

A surge sump located adjacent to plant has been included in the design. Primarily this is to allow a pumped (fixed speed) feed to the plant. Recommended sump/pond sizing is based seven days storage at average flow.

PLANT FEED RATE	DURATION/RETENTION	RECOMMENDED SUMP VOLUME
Average Flow Rate (26.9 l/sec) 96.84 m ³ /hr	7 Days	16,269 m ³

4.5 Pontoon Mounted Pumps

A pontoon mounted pump system with duty/standby pumps is recommended to reclaim MIW from the surge sump for plant feed. Therefore, two centrifugal pumps are recommended (each capable of feeding the plant at full flow. The required pump specification is as follows.

PUMP DETAILS	TECHNICAL DATA
Actual Calculated Flow	(30 l/sec) 108 m ³ /hr each (VSD Driven)

4.6 Treated Water Sump

A treated water surge sump located adjacent to plant has been included in the design. Primarily this is to allow retention time on treated water prior to discharge. Additional residence time post treatment is recommended as a polishing pond to allow for any carry over of final impurities to settle before discharge. Recommended sump/pond sizing is based on 24 hours storage at maximum flow.

PLANT FEED RATE	DURATION/RETENTION	RECOMMENDED SUMP VOLUME
Average Flow Rate (26.9 l/sec) 96.84 m ³ /hr	24 Hours	2,324 m ³

4.7 Sludge Management

From the water quality and literature review, the proposed sulphate and metals removal processes will have several sludge management streams with different product outputs, some which will need disposal either on site or off site and some that could be recycled or form a product for export off site.

1. Metal hydroxide sludge will need to be thickened and dewatered prior to transport to disposal in an appropriate landfill off site. There may be potential to process this further to recover certain metal if this was desired.
2. Gypsum sludge will be collected, processed and mainly be recycled on site, but there may be the need to export some gypsum product off site or to on-site disposal.
3. Ettringite sludge will partially be recycled and again disposal will be required in an appropriate landfill off site.
4. Calcium Carbonate Sludge, which may contain impurities will also have to be thickened, dewatered and disposed in an appropriate landfill off site.

Theoretical maximum TSS and metals quantities predicted will give a total precipitated solids amount of in g/m³ (% solids w/v) of influent to the WTP. Preliminary theoretical design suggests that a range of 5-10% of the total flows from the various processes will be required to report to the settlement column underflow. Further design will require test work on mimic waters to confirm proposed sludge volumes and dry weight percentages expected.

Preliminary theoretical sludge volumes based on 5-10% range of total underflows, with dry weight percentage of 0.5-1% would give the following sludge qualities. Note that not all the total underflows need disposal as some will be recycled, but this represents the total sludge processing capacity needed, not total disposal.

4.7.1 Total Sludge Processing Capacity – Theoretical

DESCRIPTION	DATA
Total Underflow 5-15% Plant flow	4.8 -15 m ³ /hr
Solids in Total Underflow (assume 0.5-1%)	5-10 kg/m ³
Dry Weight Solids (kg/Hr at average flow rate)	24-150 kg/hr

DESCRIPTION	DATA
Dry Weight Solids (T/Year at average flow rate)	210.2-1,314.0 kg/year (Assuming 24 WTP hour continuous operation)
Wet solids at spadable consistency 20% solids T/year	1051.2 T/yr – 6570.0 T/yr

There are number of methods/technologies for available for dewatering of the settler underflow sludge, these include.

- Mechanical dewatering – centrifuge, belt press filters etc
- Wet/dry stacking of tailings (tailings dam)
- Bag dewatering technologies – vertical bag, geo bags etc

4.8 Other Treatment Processes

Other processes that will likely be needed in addition to the active WTP are:

- Cyanide Destruct on the Shepherds TSF influent stream
- Potential additional nitrate removal after WTP via biological processes

4.8.1 Cyanide Destruct – Shepherds TSF Influent Stream

As part of baseline water quality studies and environmental geochemistry studies, (MWM, 2025). It is reported that the influent stream from Shepherds TSF will have low concentrations of Cyanide present. Modelling indicates that this could be approximately 0.35mg/L. Compliance limits allow 0.6 mg/L in ground water and 0.011 mg/L in surface water (Ryder, 2025). Therefore, treatment may be required for this influent stream. Cyanide is highly toxic even in very low concentrations.

Cyanide removal is required for the waste flows coming from the Shepherds TSF area. This is estimated to contain Cyanide at around 0.35 mg/L. The recommended compliance limits for Cyanide are: 0.011mg/L (Surface Water) and 0.6mg/l (MAV Groundwater).

To provide more efficient treatment, it is anticipated the cyanide treatment would be carried out on the Shepherds TSF Stream only, prior to combining this with flows from other areas of the mine. Information from BOGP PFS document for the Bendigo Mine states that an Air/SO₂ circuit has been chosen as the preferred form of Cyanide treatment for the process due to the amenability of the ore to this type of process and this is expected “to reduce the weakly acid dissociable cyanide to less than 30ppm at discharge” (30ppm=30mg/L).

Various forms of Cyanide treatment have been used in gold mines worldwide, including Alkaline Chlorination, Hydrogen Peroxide, SO₂/Air, Ferrous Sulphate Complexation, Ozonation, Caro’s Acid, Biological Treatment, Thermal destruction (SGS 2005, Palmer et al 1987) and UV Oxidation. Copper is used as a catalyst in some of these processes.

Of the cyanide removal processes, there are various advantages and disadvantages for each. A brief comment on some of the technologies is offered below.

Alkaline Chlorination is a very common process for cyanide removal and is reported to be inexpensive and effective. However, it has the potential to generate hazardous by-products and more recently is

considered to be undesirable due the potential for negative environmental effects including high discharge of chloride and hypochlorite anions (Young and Jordan, 1995). It is also unable to remove some cyanide metal complexes known as SADs (Strong Acid Dissociable Complexes).

In terms of performance, it was shown that the Ozonation process at a San Diego plating plant reduced cyanide from 1.02mg/L in the Influent to 0.08mg/L in the effluent (Palmer et al, 1987). Ozonation was reported to have high operating costs.

More recently, UV oxidation has also been shown to be effective.

Wet Air Oxidation was reported to remove 99% of cyanide at a waste treatment facility in California from influent concentrations of 110mg/L to 0.035mg/L in the effluent (Palmer et al, 1987). This technology is more commonly used in domestic wastewater applications but is also used in industrial waste treatment to lesser extent.

The SO₂/Air processes include a range of technologies. One such process called the INCO Process used at a Gold Mill site has been shown to reduce cyanide concentrations from around 40mg/L to 0.07mg/L in industrial applications (Palmer et al, 1987) however we have not established if this technology can achieve concentrations lower than this.

During the mining phase of the project, it is recommended that detailed testing of the BOGP water quality from Shepherds TSF take place to determine actual levels of Cyanide present prior to detailed design of a cyanide destruct process.

4.8.2 Nitrate Removal

Nitrate removal may be required but again this will need to be confirmed by test work.

Ettringite formation can also provide a polishing effect, allowing precipitation of metals, Ni, Cd, Cu, Zn, Cr, As and Se, often below their compliance and laboratory detection limits. Boron, fluoride and up to 30% of chloride and nitrate-nitrite in wastewater have also been removed (Reinsel 1999).

If required following test work, additional nitrate treatment systems can be added as a bolt on to the back end of the plant, depending on the amount of removal required. Options include the following.

- Fluidised bed reactors (FBR)
- Ion exchange
- Wetland (if polishing required)

Note that biological processes can be limited by sufficient organic carbon and nutrients in mine influence waters and the presence of heavy metals limiting growth. (Lorax 2023, Bratty et al, 2014)

4.8.2.1 Fluidised Bed Reactor

Fluidised bed reactors can be effective in removing nitrates from mine wastewater. They use a biological process where the wastewater flows upwards through a bed of granular materials, such as sand or activated carbon. This allows the growth of biofilm within the FBR using the denitrification process, converting nitrate to nitrogen gas in anoxic conditions. (Metcalf and Eddy, 2003).

Design would include the sizing appropriately of the following:

- Upflow velocities
- Bed depth
- Specific surface area
- Hydraulic retention times

A pilot size trial with similar water would provide more accurate sizing for a full-size plant.

4.8.2.2 Ion Exchange

As mentioned earlier in this document, any ion exchange processes will generate a brine waste stream which will have to be disposed of off-site.

4.8.2.3 Wetlands

There are three types of wetlands that differ in form, function and applicability:

- Aerobic wetlands (reed beds)
- Compost wetlands
- Reducing and Alkalinity Producing Systems (RAPS)

Aerobic wetlands can legitimately be regarded as proven technology when applied to ferruginous net alkaline waters. (Brown Barley and Wood, (2007)).

The two principle aims of mine water treatment in wetlands are.

1. To neutralise acidity and
2. To precipitate out metals.

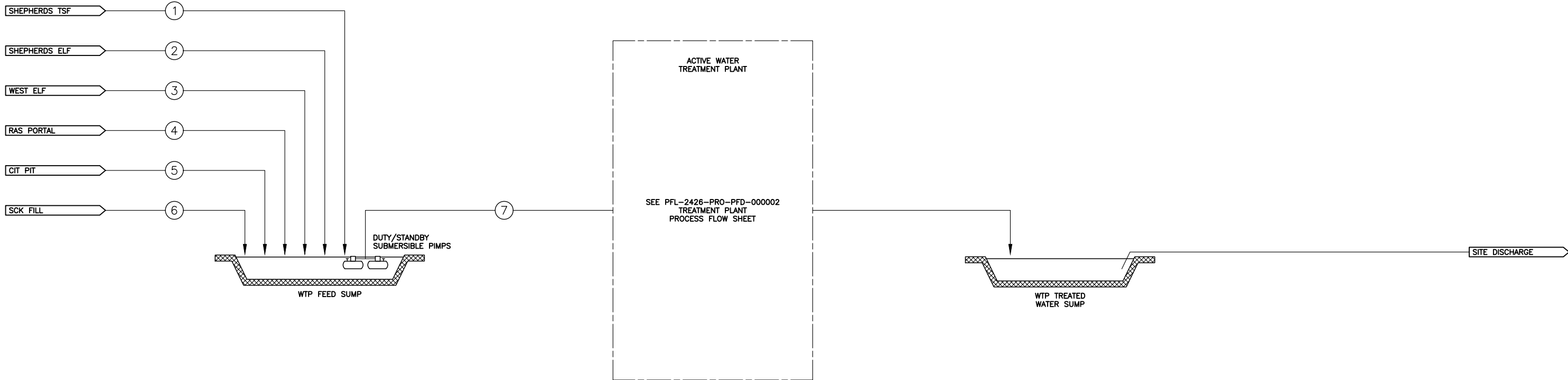
Constructed wetlands need to comprise the following five components:

1. Substrates (which may have widely varying rates of hydraulic conductivity)
2. Plants adapt to water saturated anaerobic conditions
3. Water column (water flowing in or above the substrate)
4. Vertebrates and invertebrates
5. Aerobic and microorganisms

Natural wetlands are biologically complex and cover large land areas. When designing constructed wetlands, care must be taken when reducing them to minimal components and treatment areas for minewater processing purposes. Such loss of biological complexity may prevent the achievement of a balanced self-sustaining ecosystem which is the aim of passive treatment. (Brown Barley and Wood, (2007))

At this stage it is not possible to quantify the amount of nitrate that would be removed by a wetland system prior to detailed design.

APPENDIX A - PROCESS FLOW SHEETS



Parameter	Units	Stream 1 TSF Seepage	Stream 2 Shepherds ELF Seepage	Stream 3 WELF Seepage	Stream 4 RAS Portal	Stream 5 CIT Pit Backfill	Stream 6 SCK Fill Seepage	Stream 7 MIW combined
Flow Rate	l/sec	13.4	4	1	6	1.5	1	26.9
Acidity	mg/L	0.01	0	0	0.44	0	0	0.03
Al	mg/L	0.011	0.003	0.003	0.1	0.005	0.003	0.013
Alkalinity	mg/L	73	189	183	182	190	158	160
As	mg/L	2.06	0.2	0.2	0.09	0.08	0.2	0.61
B	mg/L	0.83	0.87	0.1	0.05	0.09	0.01	0.59
Ca	mg/L	297	51	51	59	39	36	107
Cd	mg/L	0.0002	0	0	0.0001	0.0001	0	0.0001
Cl	mg/L	806	63	37	14	12	8	223
Co	mg/L	0.053	0.109	0.023	0	0.004	0.003	0.061
Cr	mg/L	0.00636	0.0002	0.00019	0.00058	0.0004	0.00007	0.0017
Cu	mg/L	0.001	0	0	0.00302	0.00021	0	0.00049
DOC	mg/L	0	0	0	0.09	0.206	0	0.038
F	mg/L	1.94	6.3	6.12	0.23	1.39	2.37	3.9
Fe	mg/L	15.3	7.6	7.6	7.9	2.4	7.6	8.7
Hg	mg/L	0	0	0	0.00006	0.00014	0	0.00003
K	mg/L	51	683	672	34	84	159	372
Mg	mg/L	100	38	37	37	20	24	49
Mn	mg/L	0.594	0.819	0.774	0.014	0.103	0.182	0.567
Mo	mg/L	0.14	1.005	0.672	0.02	0.119	0.157	0.535
NO3-N	mg/L	2.01	49.64	9.54	4.35	0.73	1.33	22.89
Na	mg/L	848	922	734	42	127	170	673
Ni	mg/L	0.6784	0.0121	0.001	0.0009	0.0013	0.0001	0.1652
Pb	mg/L	0.0276	0.0001	0.0001	0.0035	0.0002	0	0.0068
Sb	mg/L	0.1802	2.9986	3.2208	0.0234	0.3622	0.7601	1.6317
Se	mg/L	0.003	0.1544	0.1649	0.0008	0.0196	0.0388	0.0826
SO4	mg/L	954	957	888	141	110	208	730
Sr	mg/L	4.4	16.15	15.91	0.79	3.77	10.89	10.12
TI	mg/L	0	0	0	0.00031	0.00021	0	0.00005
CN	mg/L	0.35	0	0	0	0	0	0.082
U	mg/L	0.028	0.2751	0.2225	0.0094	0.0299	0.0515	0.1468
V	mg/L	0.004	0.12	0.1155	0.0006	0.0135	0.0269	0.0633
Zn	mg/L	0.0296	0.0098	0.0021	0.0022	0.0014	0.0003	0.0117
pH	mg/L	6.41	7.93	7.92	5.91	8.03	7.92	6.72
Hardness	mg/L	1151	285	280	299	179	190	469

© THESE PLANS AND THE DESIGNS SHOWN THEREIN REMAIN THE PROPERTY OF PROCESS FLOW LIMITED AND MAY NOT BE COPIED IN ANY FORM (INCLUDING THE MANUFACTURE OF ALL OR PART OF THE DESIGNS SHOWN) WITHOUT PRIOR PERMISSION IN WRITING.

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