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MEMORANDUM

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Document Number:	J-NZ0233-009-M-Rev3
Document Title:	Engineered Landform Design Philosophy

Mine Waste Management Limited (MWM) has provided this engineered landform (ELF) design philosophy memorandum to Matakanui Gold Limited (MGL) for the management of waste rock associated with the proposed Bendigo-Ophir Gold Project (BOGP).

EXECUTIVE SUMMARY

Objectives of this Study

The objectives of this study are to:

- Summarise literature and provide industry proven methods for the design of engineered landforms for the storage of waste rock.
- Provide recommendations (design objectives) to prevent and minimise the potential risks associated with acid and metalliferous drainage (AMD) by the use of source control technologies.
- Provide preliminary recommendations (design objectives) on how waste rock could be managed within an ELF at the proposed BOGP.

Findings

Previous studies (e.g., MWM, 2025a,b,e) have indicated that a number of potential constituents of concern (PCOC) could be elevated at the BOGP including for instance, As, SO_4, Cu, Fe etc., which could have an effect on the downstream environment if not managed appropriately. One aspect of AMD management is source control to prevent sulfide mineral oxidation and the mobilisation of these oxidation products from landforms.

MGL has committed to proactive source control, using engineered landforms, which provides a foundation for sustainable waste rock management, aligning with INAP[1] (2024) principles for long-term environmental stewardship.

[1] *International Network for Acid Prevention: https://www.inap.com.au/acid-drainage*

Management

This report provides a design philosophy for the ELF to prevent the oxidation of sulfides and minimise the mobilisation of any oxidation products by water. Design objectives are incorporated into the ELF Management Plan (EGL, 2025a) and the Mine Impacted Water (MIW) Management Plan (MGL, 2025).

ELFs will use available industry proven methods (e.g., INAP, 2020, 2024) to minimise water and oxygen ingress and hence control the potential geochemical hazards at their source. The current proposed design objectives are explained in Table 1 and focus on minimising oxidation of sulfide minerals and mobilisation of oxidation products (e.g., water management).

Table 1. BOGP ELF Design Objectives

DESIGN FEATURE	ATTRIBUTE
Foundation Earthworks	• Clean water diversion to minimise water/rock interaction. • Inert – low sulfur basal materials (3 m thick) to minimise PCOC mobilisation due to basal seepage from natural springs etc. Note: Low sulfur materials (<0.02 wt% S) have been identified in drill holes near the surface of the RAS[2] deposit to approximately 10-15 m depth and these materials should be used for this basal layer where practicable (MWM, 2025a). • Basal underdrainage network to minimise water/rock interaction using the low sulfur (< 0.02 wt% S) materials where practicable. • ELF toe bund (or similar) to prevent advective oxygen ingress.
Clean Water Management	• Clean water diversion to minimise water/rock interaction. • ELF design to shed water as quickly as practicable. • Compaction to shed water.
Materials Management	• Development of a material classification management process. • Development of a material management process. • Minimise time between blasting and placement. • Maximise blasting opportunities to maximise grainsize of waste rock – e.g., reduce reactive surface area of higher risk materials (e.g., TZ4 / RSSZ[3]).
Lift Height	• Commence construction using a 4-6 m lift height. • Confirm grainsize segregation does not occur for lift heights of 4-6 m via test pitting or tip head inspections. • Maximise paddock dumping where possible. • Undertake studies to confirm whether higher lifts can be used (e.g., >4-6 m) yet advective oxygen ingress is prevented and diffusion of oxygen is limited to 20 m horizontal depth into the ELF. • Limit long term diffusive oxygen ingress to < 20 m horizontally and 15 m vertically. Confirm by performance monitoring.

[2] *Rise and Shine*
[3] *Textural Zone 4 and Rise and Shine Shear Zone materials*

DESIGN FEATURE	ATTRIBUTE
	• Validate oxygen flux rates (e.g., cover system trials) to confirm long term sulfide oxidation processes and geochemical model reliability.
Encapsulation	• Placement of RSSZ, TZ4, and high As TZ3 waste rock in the core of the ELF surrounded by lower risk TZ3 materials. • Development of perimeter bund (advective oxygen barrier) and lower permeability running surfaces constructed from TZ3 materials.
Cover System	• 0.2 m of topsoil/subsoil • 0.3 m of moderately weathered mine rock (commonly referred to as ‘Brown Rock’) • Develop a cover system to limit net percolation to <20% of annual rainfall and limit oxygen flux such that closure objectives can be achieved. Further work is required.
Progressive Rehabilitation	• Up-valley construction of the ELF where practicable, to provide immediate surfaces for rehabilitation (cover system installation). • Placement of compacted brown rock, soils, and vegetation to reduce net percolation of rainfall.
Performance Monitoring	• Geochemical characterisation and quality assurance / quality control (QA/QC) • Grainsize segregation and lift height • Oxygen ingress depth • Net percolation rates • Seepage water quality and quantity

BACKGROUND

MGL is proposing to establish the BOGP, which comprises gold mining operations, processing operations, ancillary facilities and environmental mitigation measures on Bendigo and Ardgour 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 key mine facilities are proposed:

- 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 SRE[4].
- 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 (Figure 1).

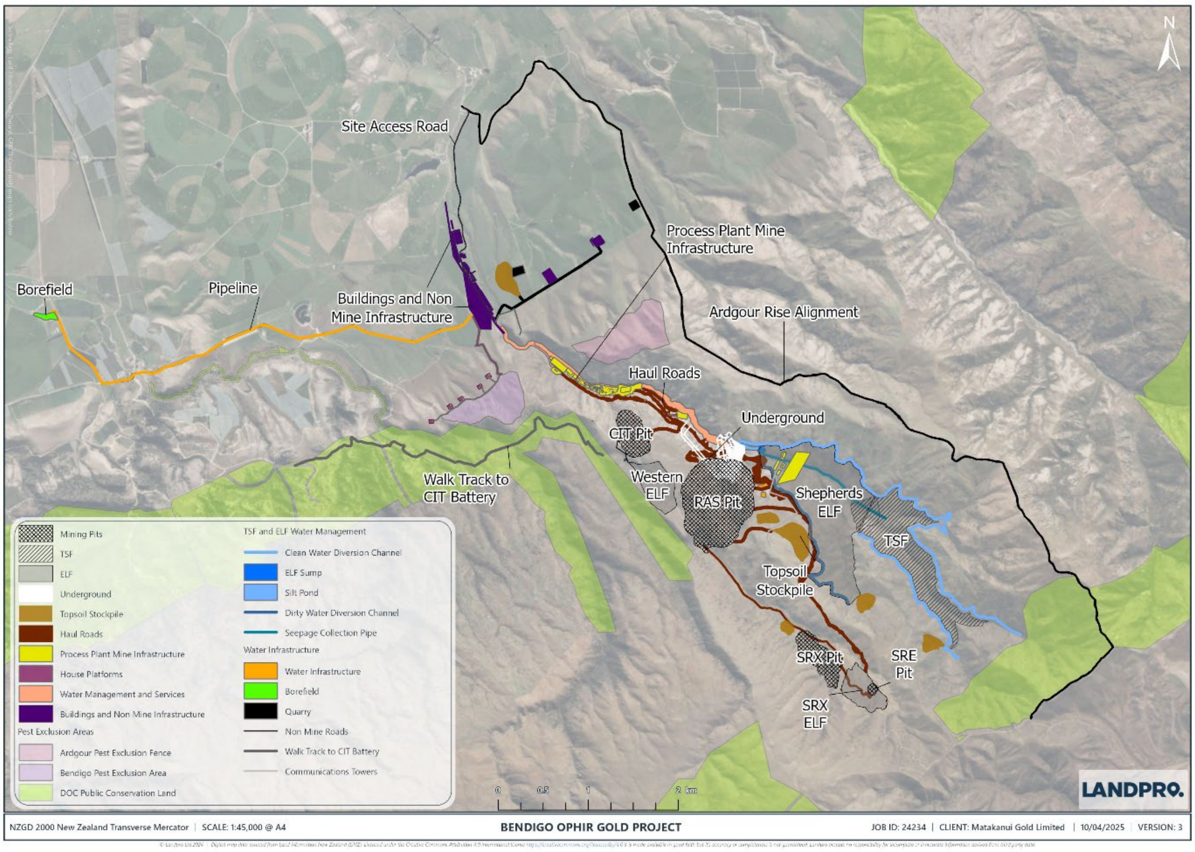

Figure 1. Bendigo-Ophir Gold Project Infrastructure.

Source: MGL (2025).

OBJECTIVES

The objectives of this study are to:

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[4] *Note: SRE Pit is backfilled by the SRX ELF.*

- Summarise literature and provide industry proven methods for the design of engineered landforms.
- Provide recommendations to prevent and minimise the potential risks associated with acid and metalliferous drainage (AMD) by the use of source control technologies.
- Provide preliminary recommendations on how waste rock could be managed within an ELF at the proposed BOGP.

GEOENVIRONMENTAL HAZARD CHARACTERISATION

The geoenvironmental hazards associated with the BOGP have been assessed (MWM, 2025a,b,e).

Studies indicate that the rocks associated with the project (TZ3, TZ4, and RSSZ) will not generate acid rock drainage with >350 samples tested by industry accepted acid base accounting (ABA) techniques (e.g., AMIRA, 2002). This is a function of the high acid neutralisation capacity (ANC) of the rocks associated with carbonate minerals (e.g., dolomite) and a low sulfide mineral content (e.g., arsenopyrite, pyrite) that can generate lesser acidity. The overall ABA assessment indicates that the rocks are classified as non-acid forming (NAF).

Rocks associated with the BOGP will generate neutral metalliferous drainage (NMD) elevated in PCOC such as As, Cu, Fe, SO_4 etc. Minimising sulfide mineral oxidation (e.g., arsenopyrite) and the mobilisation of oxidation products will minimise the potential effects to receiving waters.

Nitrogenous compounds such as nitrate are also expected to be elevated in seepage from blasted rock due to the use of ANFO, an ammonium-nitrate fuel oil explosive. This is not an uncommon issue in the mining industry.

It is expected that mining of the BOGP will affect waters within the project area and these effects will include:

- Neutral metalliferous drainage (NMD) with elevated sulfate and the other constituents of concern (see MWM, 2025b).
- Nitrate-rich drainage due to the use of ANFO.
- Cyanide using in mineral processing and gold recovery.

Collectively these waters are referred to as mine impacted water (MIW) to acknowledge the different contributions to poor water quality within the project area.

BOGP ENGINEERED LANDFORM - OVERVIEW

This section summarises the primary landforms for the storage of waste rock including the engineered landforms and backfill

Engineered Landform Summary: Shepherd ELF, West ELF, and SRX ELF

Overburden waste rock from the RAS deposit will be stored in the Shepherds ELF (Figure 2) and the West ELF (Figure 3) and the overburden from the SRX Pit will be stored in the SRX ELF (Figure 4).

MGL (2024) note that an ELF with a total design capacity of 103.6 million loose cubic metres (LCM) has been designed for the Shepherds Creek catchment (Figure 2). The design quantity has a contingency of roughly 12% which would account for possible changes in the swell factor or the compaction ratio following further analysis on the actual site-specific parameters.

Waste landform sequencing has been undertaken based on the assumption that arsenic concentrations are higher in the ore host rock (TZ4 and RSSZ) and for precautionary reasons it is planned to be encapsulated and capped with lower arsenic waste rock (TZ3).

A base layer and encapsulating layer of inert material is typically required, with a core of non-inert material. For this reason, the ELF has a base layer of 3 metres of TZ3 material. Low sulfur materials (<0.02 wt% S) have been identified in drill holes near the surface of the RAS deposit to approximately 10-15 m depth (MWM, 2025a) and these materials should be used for this basal layer where practicable.

The TSF dam embankment will also consist of TZ3 material. MGL (2024) propose that a minimum 20 m thick capping layer of TZ3 materials will encapsulate the ELF and higher sulfur TZ4 and RSSZ waste rock.

Backfill

Waste rock (TZ3) will be placed as backfill in the CIT Pit to return the ground to its pre-mining topography (or similar). The CIT Backfill is shown in Figure 5 and indicates that the long-term groundwater level will be equivalent to the spill point of 503 m. Waste rock will be constructed as an ELF to minimise long term risks to water quality. The volume of the CIT Pit has been estimated at ~923,000 m^3.

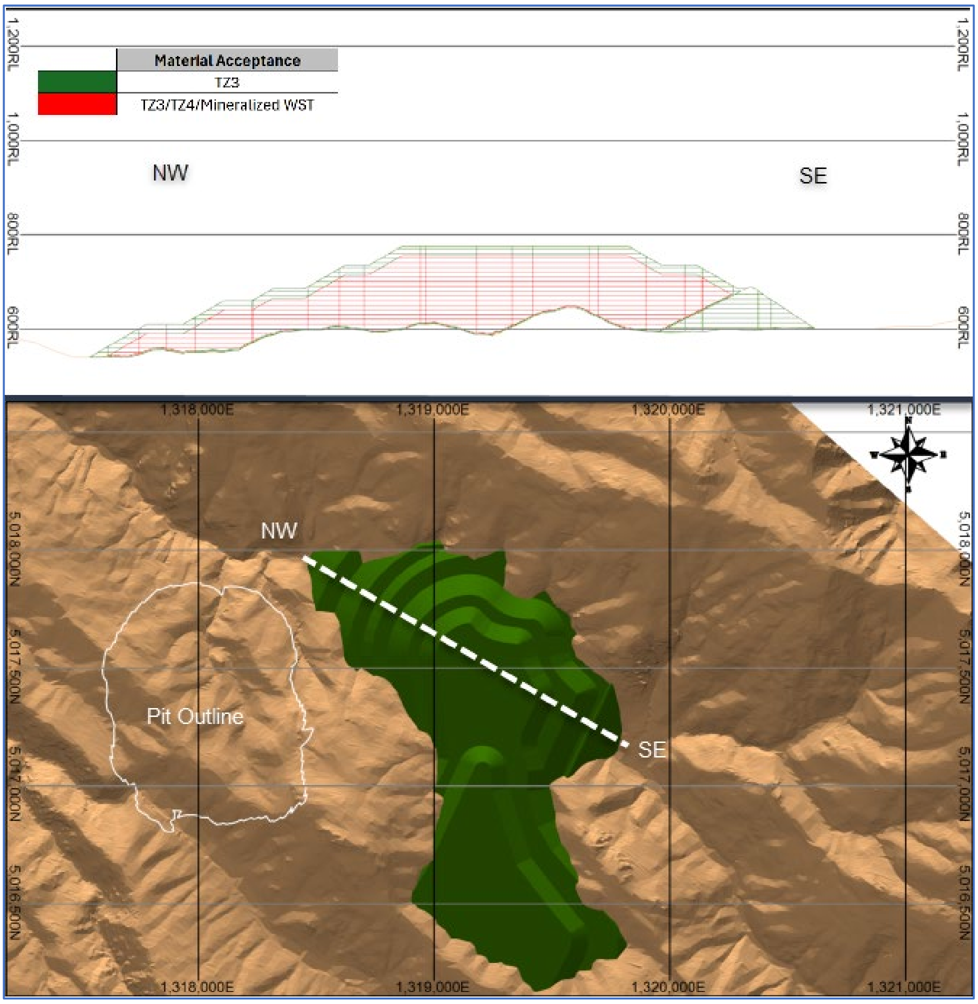

Figure 2. Shepherds ELF.

Source: MGL (2024).

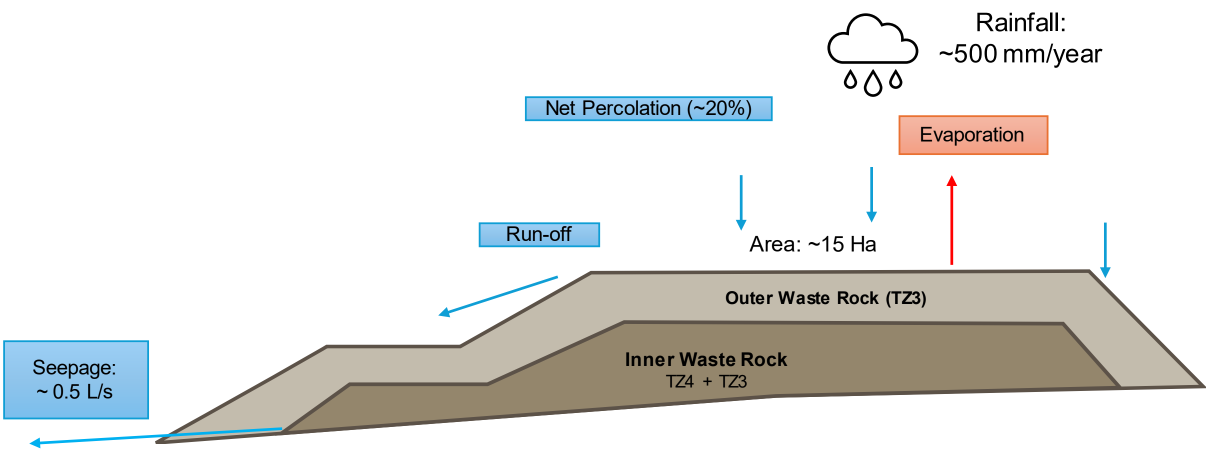

Figure 3. Conceptual (and schematic) water balance and material distribution for the WELF.

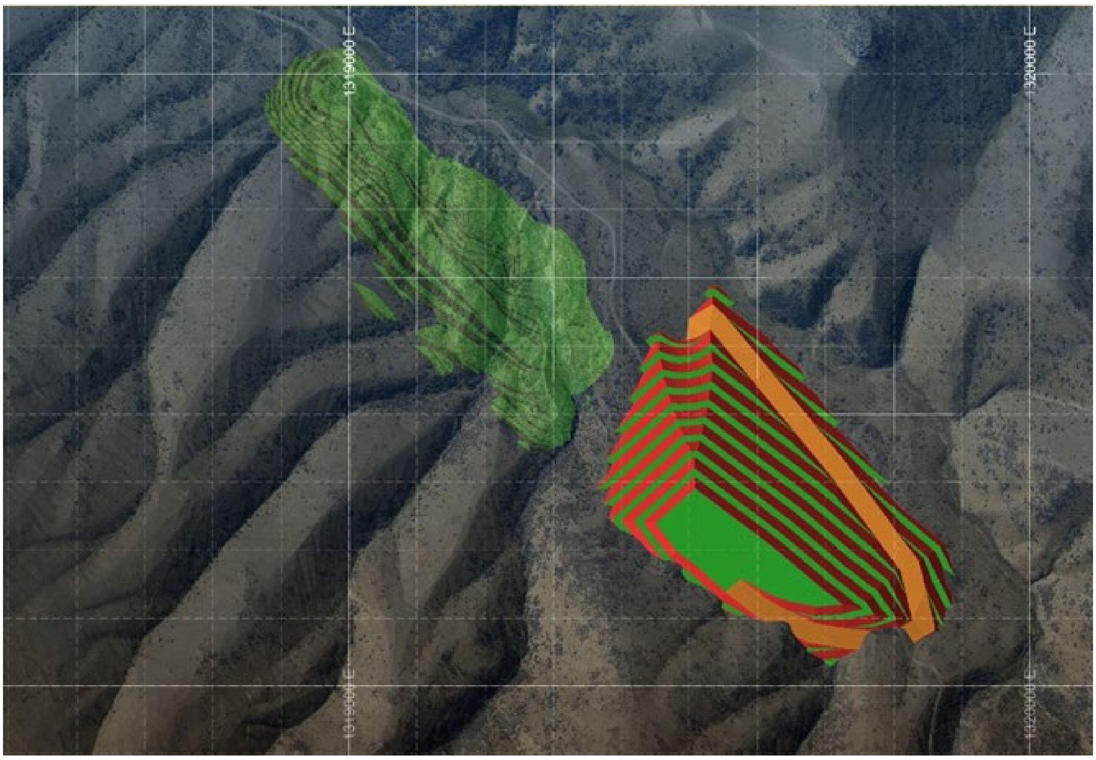

Figure 4. SRX Pit and SRX ELF

Source: MGL (2024)

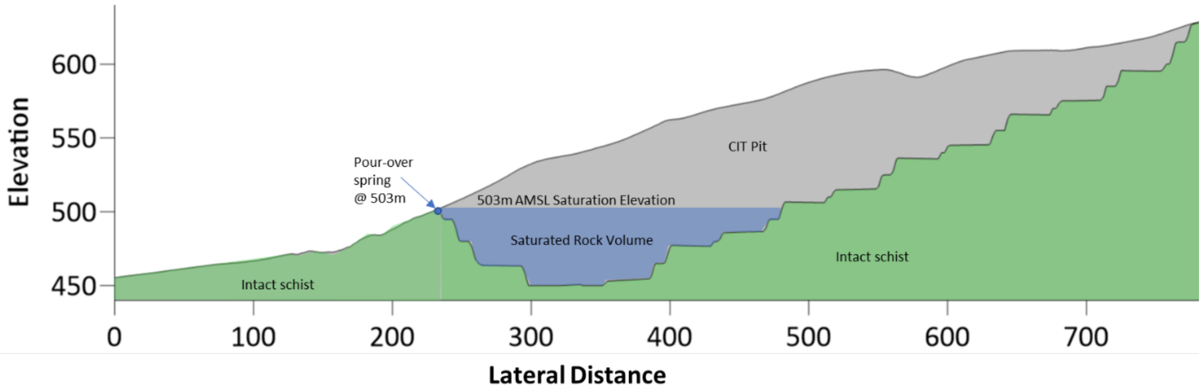

Figure 5. CIT Backfill.

Source: Rekker and Dumont, 2025

AMD MANAGEMENT APPROACH

This section describes the general approach to how AMD is managed.

Background

AMD needs to be managed to reduce health and safety risks for on-site staff and communities, reduce deleterious effects to the environment, and ensure that appropriate closure of the site is achieved at the end of mining activities. This requires six AMD management steps to be undertaken as a holistic approach to AMD management, which is based on international industry guidance (e.g., International Network for Acid Prevention (INAP), 2014; DFAT, 2016). The six AMD management steps include:

1. Set Closure Goals
2. Predict
3. Prevent
4. Minimise
5. Control and Treat
6. Monitor Performance

These steps form the basis for any comprehensive AMD Management Plan, which is often supported by a risk assessment process and the development of site-specific operational controls to manage these risks and/or uncertainties. The AMD risk assessment process is based on data obtained from AMD prediction activities and determines the engineering control requirements for the project (e.g., prevention, minimisation, control and treat).

AMD Management Approach

This section provides a high-level summary of the six steps of AMD management.

Table 2. AMD Management Steps

AMD MANAGEMENT STEP	EXPLANATION	RELATED DOCUMENTS FOR THE BOGP
Set Closure Goals	• Closure goals are set in order to minimise legacy issues associated with potential AMD sources and any in-perpetuity uncontrolled AMD from mine domains containing AMD generating materials. • These goals are revaluated throughout the mine life against performance monitoring results.	• Closure objectives for water quality have been established (Ryder, 2025). • Baseline Water Quality (MWM, 2025c).
Predict	• Prediction is critical to understanding the potential, severity, and longevity of AMD. • Prediction is facilitated by geochemical analysis and interpretations. • A key prediction objective is to estimate water quality generated by various materials and mine domains that have the potential to generate AMD.	• Geoenvironmental Hazards Report (MWM, 2024a). • Leach testing to determine PCOC (MWM, 2025b,e).
Prevent	• Prevention of sulfide mineral oxidation, where practicable, is a key management step for AMD. • The prevention of AMD relates to reducing sulfide mineral oxidation as much as practicable by limiting the ingress of oxygen into a mine domain where it can oxidise sulfide minerals Prevention strategies are implemented during operations to manage a future risk.	• This memorandum.
Minimise	• Where prevention is not practicable, or has already occurred, the next management step involves minimising the contaminant load reporting to the receiving environment. • This often involves progressive reclamation strategies focused on minimising ongoing sulfide oxidation (potential oxidation products) and the mobilization of oxidation products with net percolation through the waste rock.	• This memorandum.

Control and Treat	• Although the objective is to prevent and minimise AMD, control and treat measures are an important step in managing the effects of AMD to the receiving environment.	• Water Management / Treatment Study (MWM, 2024d). • Process Flow (2025).
Monitor Performance	• Performance Monitoring should be conducted to regularly evaluate how AMD management techniques are performing openly and objectively against closure goals and success criteria (ICMM, 2019).	• MIW Management Plan (MGL, 2025).

SOURCE CONTROL

Prevention and minimisation of AMD can be considered engineering controls to manage the AMD source hazard. This section discusses source control technologies for the proposed engineered landforms that would contain waste rock at the BOGP.

Overview

Source control involves the prevention of sulfide mineral oxidation (where possible) and minimisation of contact water to reduce the mobilisation of oxidation products. Source control can be considered the a best practice approach to AMD management and reduces the risks of long-term AMD management by tempering the maximum potential AMD risk at closure that requires mitigation / management.

Generally waste rock dumps represent 60 - 80% of a site's AMD contaminant load (INAP, 2020) if the AMD source hazard is not managed appropriately. International case studies are available (e.g., Weber et al., 2017) to demonstrate the high proportion of AMD associated with waste rock domains. Hence there is a strong driver to incorporate waste rock into engineered landforms that address the key principles of AMD source control: Prevention and Minimisation.

Many examples of successful source control for engineered landforms are from New Zealand. INAP (2020) notes the following sites as examples:

- Cypress Coal Mine, Stockton.
- Stockton Coal Mine.
- Reddale Coal Mine.
- Escarpment Coal Mine.
- Waihi Gold Mine (Martha Mine).

Other New Zealand sites that have utilised engineered landforms include:

- Macraes Gold Mine (Coronation North Landform).
- Canterbury Coal Mine.

Prevention of Sulfide Mineral Oxidation

Waste rock that is end dumped in high lifts (>4-6 m in height) and the associated kinetic energy can result in grainsize segregation and the development of alternating coarse-textured and fine-textured bedding planes of poorly graded and well sorted material with high vertical airflow capacity (e.g., Fala et al., 2003; Wilson, 2008). This also results in an overall downward coarser grading providing higher airflow capacity deeper in the facility. In addition, the fall of rocks / cobbles from the end-tipped / dozer pushed material results in the development of a coarse basal layer with high lateral airflow capacity that provides oxygen ingress pathways into the core of the waste rock dump (WRD) as shown in Figure 6.

The dominant process for oxygen flux is by the advective and convective flow of oxygen (temperature differences, barometric pressure differences) along coarser waste rock layers that form within poorly constructed WRD. Work completed by Brown et al. (2014) has demonstrated that in a poorly constructed WRD, advection accounts for ~90% of oxygen ingress, and that diffusion of oxygen accounts for 10%.

Hence, a key control to prevent sulfide mineral oxidation and minimise the effects on seepage waters from WRD is to prevent the advective ingress of oxygen.

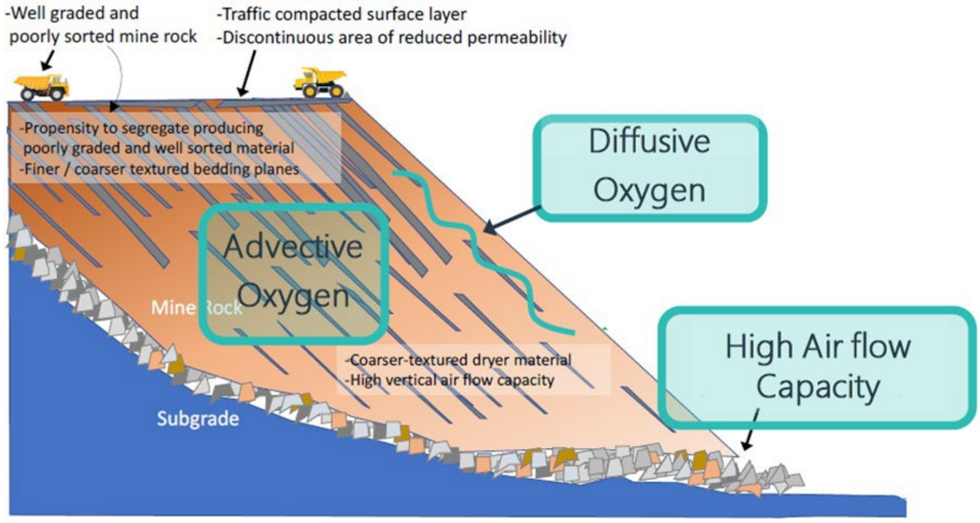

Figure 6. Advective air flow driven by grainsize segregation.

Source: Meiers (2020).

The flux of oxygen into a poorly constructed WRD is typically higher than the flux of oxygen into a tailings storage facility (TSF).

- Within a TSF the oxygen flux is driven by diffusion due to the chemical gradient (no oxygen at depth versus atmospheric oxygen concentrations at the surface).
- Within a WRD the oxygen flux is often driven by the advective flow of oxygen (temperature differences, barometric pressure differences, etc) along coarser waste rock layers that form within poorly constructed WRD.

The oxygen flux (as evidenced by oxidation products) is shown in Figure 7. Hence, for the BOGP, control of oxidation is focused on the ELF rather than the TSF.

Figure 7. Diffusion of oxygen into a TSF as shown by Fe oxidation products, and advection pathways within a WRD as shown by oxidation at angle of response tipheads.

Source: Miller et al., 2003: ICARD 2003 ARD Prediction Short Course.

International research (INAP, 2020; 2024) has demonstrated that one of the most effective methods to minimise advective ingress of oxygen into WRDs is to minimise the height of the tiphead to <4 - 6 m and ensure that each lift has a compacted engineered surface, which reduces the size of the advective cell (both vertically and horizontally into the WRD; Figure 8 and Figure 9). Reducing oxygen ingress reduces sulfide mineral oxidation and hence the risks associated with AMD.

The establishment of multiple traffic compacted lifts also reduces the height of advective oxygen ingress to these cells. Further detailed design work is required to confirm that traffic air-entry layers can be achieved at BOGP, or whether additional materials / material management is required.

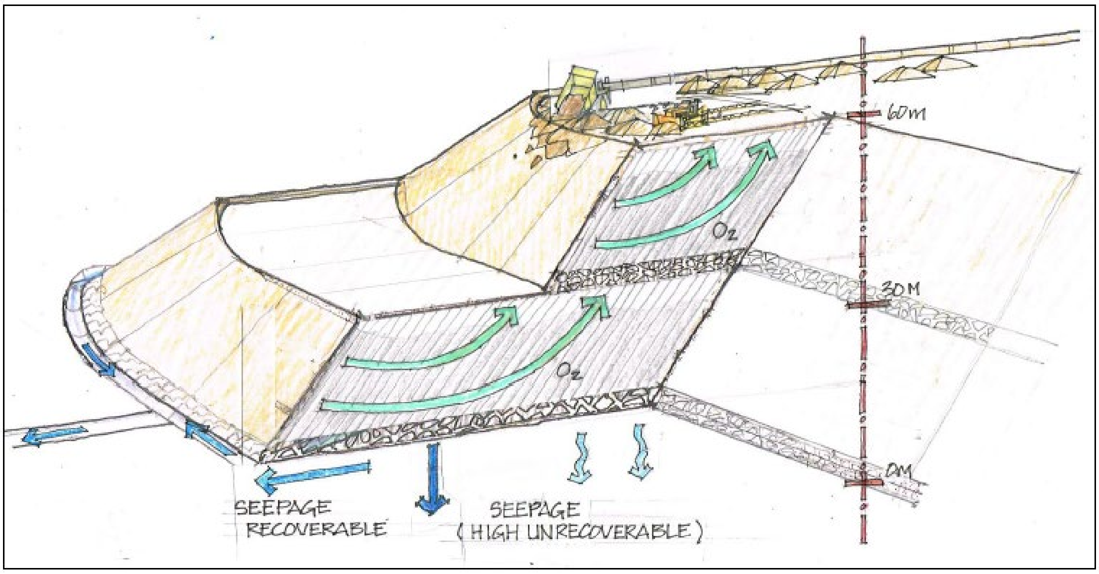

Figure 8. Conceptual gas transport regime in a WRD with no engineering controls.

Source: INAP (2024): Significant horizontal ingress along the basal chimney zone and significant vertical rise upwards along chimney zones.

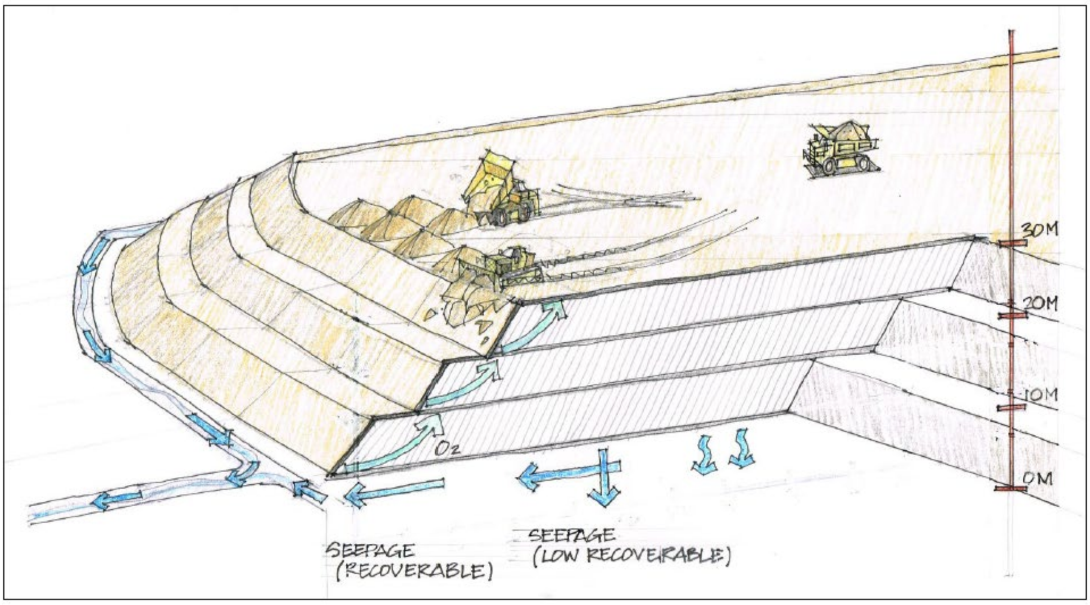

Figure 9. Conceptual gas transport regime into an ELF with trafficked air-entry disrupting running surfaces.

Source: INAP (2024): Limited oxygen ingress horizontally due to a lack of a basal rubble layer; limited vertical oxygen rise due to lower permeability running surfaces.

INAP (2024) note that an "Engineered Fill' approach "*allows for the ability to more accurately model and predict O_2 ingress and the volume and quality of recoverable seepage requiring treatment over time*" and that "this approach focuses on prevention, rather than a cure. This 'Engineered Fill' approach manages AMD "risks through implementation of source control, progressive reclamation, and cover systems, which allows for opportunities to move from active to passive water treatment over time thereby reducing asset liability, and likelihood of in-perpetuity management".

Figure 10 shows the impact of various grain-sized materials on the gas flux rate and acidity generation (i.e., sulfide mineral oxidation). Employing techniques like short lifts and paddock dumping effectively reduces oxygen ingress, leading to reduced sulfide mineral oxidation and, consequently, mitigating the potential risks associated with AMD.

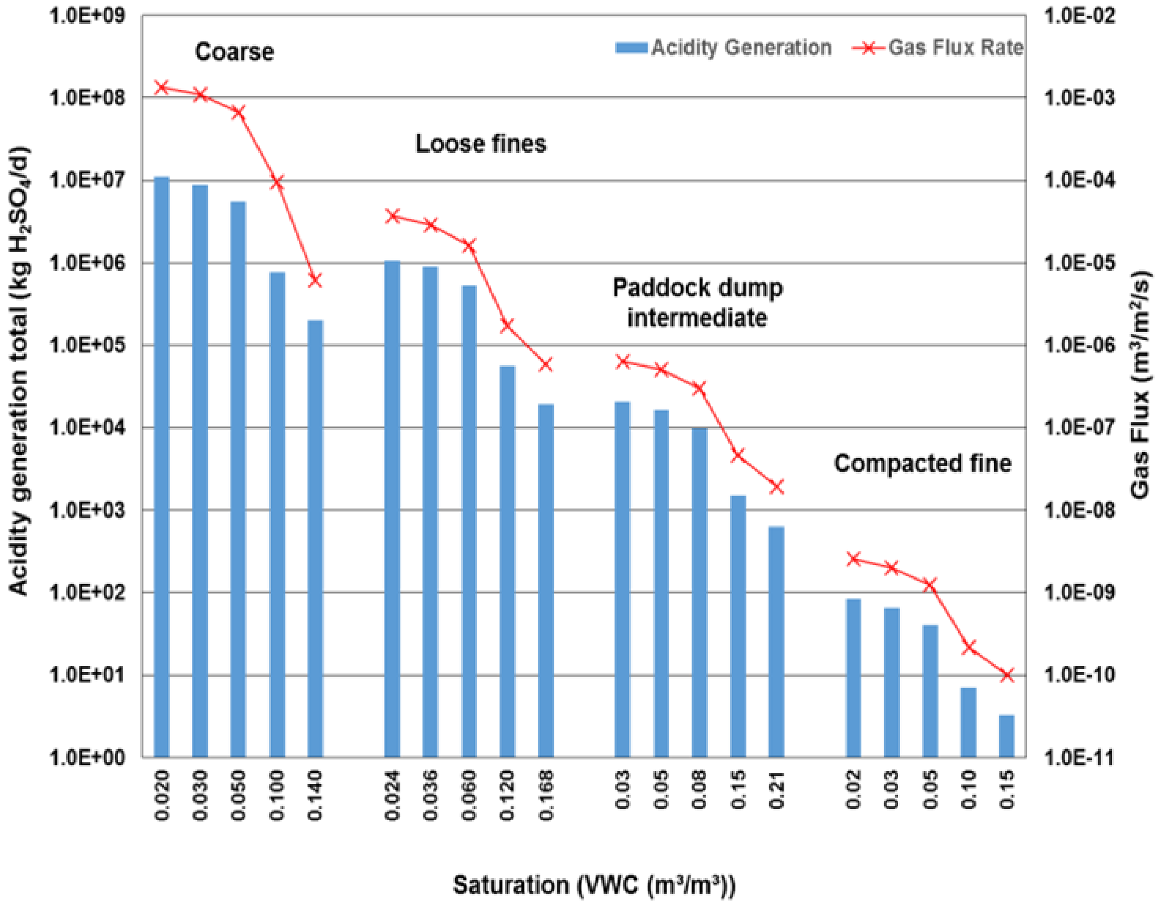

Figure 10. Grainsize segregation: high tipheads.

Source: Pearce et al (2016).

<u>Water Management</u>

Water flow through materials that contain sulfide oxidation products is the primary pathway for mobilisation of contaminants and the generation of AMD impacted waters. Diversion of run-on water and reducing infiltration of water into materials containing sulfide minerals, or sulfide mineral oxidation products, is a key management step for the management of AMD. Often this is site specific and is dependent on climate, topography, location of mine domains, etc.

<u>ELF SOURCE CONTROL OPTIONS FOR THE BOGP</u>

The following section reviews source control opportunities for the BOGP. Appropriate design objectives can then be integrated into the mine schedule and the ELF Basis of Design report (which will be developed prior to mining). Note: the guidance provided needs to be considered by a competent geotechnical engineer as being appropriate for geotechnical risks.

Foundation Earthworks

The following is recommended for the starter lift:

- Clean water upstream of the ELF could be piped through the facility as a management option during the operational phase of the mine to minimise water/rock interactions.

- Basal lift materials are likely to be in contact with topographic surface level seeps. Such materials should be inert, low sulfur, low arsenic, TZ3 materials. MGL (2024) have indicated this will be 3 m thick. Low sulfur materials (<0.02 wt% S) have been identified in drill holes near the surface of the RAS deposit to approximately 10-15 m depth (MWM, 2025a) and should be used for this basal layer where practicable.
- Prior to construction of the first starter lift, ensure a drainage pathway (underdrain) is created so that any seepage from the ELF is directed to one location. For the BOGP, seepage is likely to collect on the natural stream/topographic floor. Engineering Geology Limited (EGL) have designed this underdrainage system for Shepherds ELF and SRX ELF (EGL, 2025b).
- Materials used for the underdrain should be inert, low sulfur, low arsenic, TZ3 materials. The low sulfur (<0.02 wt% S) materials near the RAS surface (MWM, 2024a) should be used as construction materials for the underdrains where practicable.
- The underdrain will be connected to a HDPE pipe that will take seepage water from the ELF to the Shepherds Sediment Pond.
- An ELF toe bund will be constructed within the ELF. This will act as a barrier to advective oxygen flow. Underdrain pipes will be placed through this ELF toe bund in a manner that prevents oxygen ingress. The design of this is discussed by EGL (2025b).
- An ELF Sediment Pond should be constructed at the base of the starter lift to capture seepage from the ELF. The design of the ELF Sediment Pond should consider repurposing as a passive treatment system for ELF seepage at mine closure. This should include suitable maintenance access for removing sediment accumulation and potentially decant structures.

Clean Water Management

Studies have indicated that the BOGP materials are elevated in sulfate (SO_4) minerals that can be mobilised by water (MWM, 2025e). This means water flow through these materials within the ELF will mobilise this contaminant load. The following is recommended for ELF water management:

- Diversion of clean run-on water from upslope areas away from the ELF.
- Design of the ELF (batter slopes and running surfaces) to shed water as quickly as possible.
- Where practicable, avoid ponding of water on waste rock (e.g., avoid sediment sumps on ELF surfaces).
- Compaction, to design specifications, of the ELF running surfaces during operations to shed water and minimise infiltration of rainwater thus reducing the volume of seepage water and extending the wetting up time period and onset to basal and toe seepage.
- Flattening out paddock dumped materials (ideally wheel rolled or compacted) to shed water before significant rainfall events.

Materials Management

MGL (2024) state that waste rock disposal will be carried out by haul trucks approaching the Shepherds ELF from the west at various elevation levels. Track dozers will be used to push the material to form the batter slopes.

The following materials management processes need to be considered:

- Development of a materials schedule (and quantities) to ensure the correct materials are available and are placed in the correct location. This will be completed for the BOGP as part of the detailed design. This will include topsoil scheduling.
- Minimise the time between blasting and placement of mineralised waste, TZ4, RSSZ, high As TZ3 waste in the ELF. This will reduce the oxidation of sulfide materials.
- Manage the ore stockpiles as higher-risk mineralised waste, which is likely to contribute to poor water quality.
- Investigate blasting practices to increase particle size in TZ4 and RSSZ waste rock (to minimise mineral surface area exposure to oxygen (and AMD generation)). Conversely an assessment should be undertaken to look at decreasing the particle size of TZ3 materials for encapsulation purposes, although the risks of nitrogenous compounds and elevated SO_4 should also be considered for blasting to generate finer materials.
- TZ3 materials are weaker than the TZ4 materials with an UCS[5] of ~20 MPa compared to TZ4 materials that ~ 70 MPa (EGL, 2025b). It is expected TZ3 will break down with trafficking to form a lower permeability surface compared to TZ4 materials. This may have benefits for limiting advective oxygen ingress within the proposed ELFs.
- Blasting of TZ4 / RSSZ materials may generate waste rock that has a greater proportion of clast supported materials compared to TZ3 materials, which is a higher risk for oxygen ingress (Table 3). This is another benefit for having the TZ4 /RSSZ placement zones towards the rear of the ELF.
- Develop a traffic management plan to ensure the running surfaces are thoroughly compacted to minimise vertical rise of oxygen by advective processes.

Lift Height

It is recommended that the construction process and the height of end-tips is designed to prevent grainsize segregation and minimise advective flux of oxygen. Research has shown that tipheads <4 – 6 m do not generate grainsize segregation (Fala et al., 2003; Wilson, 2008), which reduces the risk of advective oxygen flux. However, tiphead height will be specific to the project materials and further work is required to confirm that advective oxygen ingress is prevented. The following approach is proposed:

- Commence construction using a lift height of 4 - 6 m and confirm that no segregation of materials occurs at this height.

[5] *Unconfined compressive strength*

- Higher lift heights might be possible. Undertake studies to confirm whether higher lifts can be used (e.g., 4-6 m) yet advective oxygen ingress is prevented and diffusion of oxygen is limited to ~20 m horizontal depth into the ELF.
- Confirm that segregation does not occur for different materials at different tiphead heights (e.g., TZ3 versus TZ4). Table 3 provides a high-level summary for the clast supported vs matrix supported ELF due to segregation processes.
- Where practicable, paddock dumping should be undertaken.
- Undertake performance monitoring to confirm depth of oxygen ingress aligns with geochemical model estimates of 20 m (MWM, 2025f), which was used to support the design objectives for the ELF (MGL, 2024).

Table 3. Clast vs matrix supported ELF.

ELF MATRIX	PROPERTIES	COMMENTS
Clast Supported	Greater porosity Greater air voids Lower density	End-tipping results in the separation of coarser and finer particles creating a material that tends to be clast supported with higher overall porosity
Matrix Supported	Lower porosity Less air voids High density	Paddock dumping and low-lift heights prevents material segregation such that the coarser materials are supported by a matrix of miner materials leading to lower porosity.

Encapsulation

The encapsulation of reactive sulfide-rich materials with low-risk materials is a proven source control technology to reduce sulfide mineral oxidation. The greater the thickness of low sulfide-bearing encapsulating material, the less oxygen diffusion from the atmosphere to the reactive materials (e.g., Figure 11), assuming that advective and convective airflow is minimised by material placement strategies.

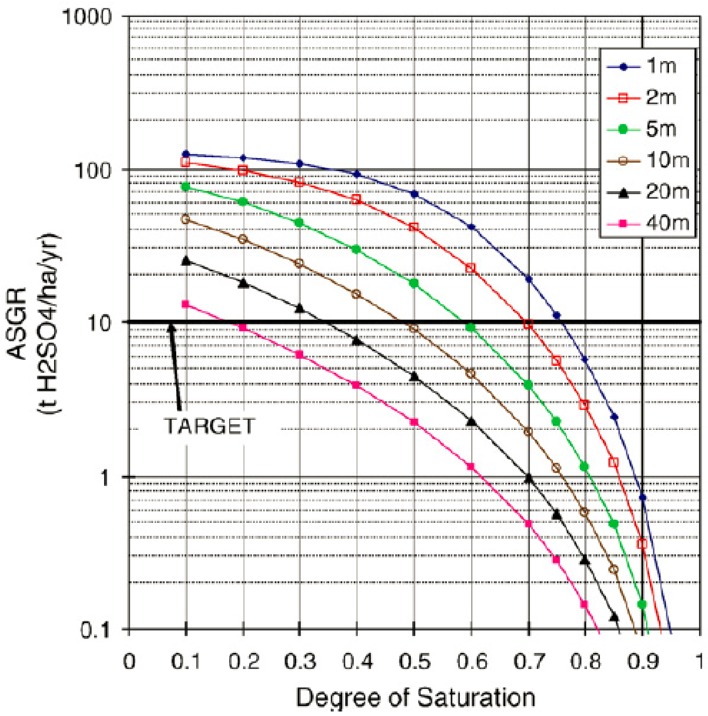

Figure 11. Acid generation rate (due to oxygen diffusion) as a function of cover thickness.

Source: Miller et al., 2010; ASGR = acid sulfate generation rate

For the BOGP the following encapsulation options should be undertaken:

- Placement of higher sulfur waste rock (TZ4, RSSZ) towards the back of each lift in a zone of limited airflow. As shown in Figure 9, this prevents higher-risk material from being within the zone of higher oxygen movement (e.g., the advective cell) near the front batter slopes of an ELF. The size of these zones and the number of individual zones will be a function of the materials schedule and 20 m is proposed as the set-back.
- Development of a perimeter bund of paddock dumped waste rock (lower sulfur TZ3 and or brown rock) at the start of each lift at the outer edge of the ELF. This can then be compacted as a toe barrier (~ 2 m high). Toe barriers have been proposed for other projects to limit oxygen ingress due to grainsize segregation (e.g., Figure 12). Further work is required to confirm the height and width of any advective toe barrier. This will be part of the detailed design.

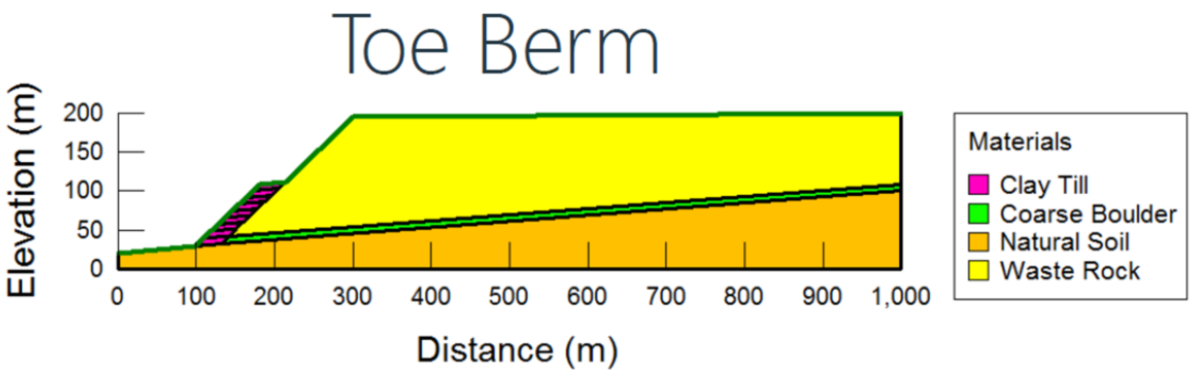

Figure 12. Advective toe barrier.

Source: Meiers (2020).

Cover System

A cover system can minimise the amount of oxygen and water flux into an ELF as well as providing a stable revegetation medium. A variety of systems are available including soil/rock covers, low permeability compacted clays barrier layers, capillary breaks, geosynthetic clay layers, and membrane technology such as polythene. A cover system should be considered one aspect of AMD management.

A cover system should be considered one aspect of AMD management. INAP (2017) notes that cover systems are designed to:

- Meet regulatory requirements
- Divert clean water and reduce the volume of impacted surface water managed on site
- Isolate chemically reactive waste material
- Limit upward movement of process-water constituents and oxidation products
- Limit influx of oxygen and oxidation of certain minerals
- Limit influx of meteoric water to limit oxidation of certain minerals, and limit leaching and dilution of oxidation products
- Control wind and water erosion of waste material as part of the overall landform stability
- Provide a growth medium as the “building blocks” for establishing vegetation and ecosystems.

Types of cover systems include (INAP, 2017):

- Erosion-protection systems
- Store-and-release systems
- Enhanced store-and-release systems
- Barrier-type systems
- Cover systems with engineered layers
- Saturated soil or rock cover systems

MWM (2025g) has provided guidance on the expected net percolation rates (i.e., % of rainfall that will enter the mine facilities) for the ELFs at the BOGP, which has been estimated at 30 – 50%. Data from Macraes (MWM, 2024) suggest lower NP may be possible, in the region of 10 to 20% of annual rainfall. Cover system design elements such as thicker layers and/or lower permeability layers at the base of the cover system could be considered to achieve NP towards the lower range (e.g., NP of 20% of annual rainfall). Further work is required to demonstrate this is achievable at the BOGP.

This flow will mobilise stored contaminants within the mine domain. For the BOGP the following is recommended:

- Utilisation of existing soils and subsoils as the growing medium.
- Brown rock and lower sulfur TZ3 materials need to be assessed for their geotechnical benefits as a cover system material to limit oxygen/water ingress.

- Further analysis is recommended as part of the ELF detailed design to understand the benefits of the cover system including a store and release system to reduce net percolation.

The long-term oxygen flux rate will determine the ongoing generation of PCOC from the ELFs. Hence, the cover system and ELF construction processes should also limit oxygen flux such that closure objectives can be achieved. Further work is required on confirm oxygen flux rates through cover system trials.

Progressive Rehabilitation

Progressive rehabilitation will be a key component of the ELF construction process. This will include:

- Grading down materials from the dump crest to the toe of the batter slope and compaction with a dozer.
- Spreading cover materials (e.g., brown rock, or inert finer grained lower sulfur TZ3 materials) to achieve the agreed design specification to limit oxygen ingress / water ingress.
- Topsoiling of the batter slope (or application of suitable brown rock), hydroseeding to control soil loss and the establishment of vegetation.

PERFORMANCE MONITORING

Performance monitoring is an important aspect of AMD management and should include leading and lagging performance monitoring programs to confirm design objectives are being achieved. Performance monitoring provides the data for trigger action response plans (TARPs) in case there is a variance from the expected case and further actions are required to minimise potential effects. Performance monitoring should be designed around demonstrating success criteria (primarily based on design objectives) are being achieved and that performance can be demonstrated openly and objectively. This report suggests that performance monitoring should include, for instance:

- Monitoring of water quality and quantity at the discharge of the ELF underdrain (e.g., Shepherds ELF, SRX ELF, West ELF, CIT backfill) to understand water quality effects and confirm net percolation rates.
- Monitoring of groundwater downgradient of ELF to confirm that basal seepage is not significant.
- Monitoring of oxygen flux into the ELF using oxygen probes and/or oxygen sensors to confirm the oxygen concentration and the depth of the oxidation is < 20 m (i.e., the design objectives)
- Installation of lysimeters soil monitoring (i.e., matric suction and water content sensors) to validate net percolation rates are acceptable (i.e., < 20%) and meet design expectations.

Construction QA/QC is also required during the construction of the ELF to ensure the facility has been constructed as per the basis of design. Construction QA/QC could include for instance:

- Geochemical characterisation of materials (pre-excavation and placement) for AMD risks and risks associated with nitrogenous compounds.
- Monitoring of tipheads to confirm that grainsize segregation is not occurring to ensure a matrix supported rock mass is achieved.

Performance monitoring and TARPs are a key aspect of adaptive management.

HEALTH AND SAFETY CONSIDERATIONS

Construction methodologies involving small lift heights introduce several health and safety benefits during the construction/operational phases:

- Eliminating many risks related to working on and around tipheads with significant vertical drops.
- Substituting less stabled wheeled plant with highly stable tracked machines when working close to the tiphead.
- A reduction in the likelihood and consequence severity of geotechnical failures at tipheads due to restricted height.
- Lesser risk of differential settlement and areas requiring active control and management.
- Lesser reliance on catch berms to control larger rocks at the toe of the tiphead.
- A reduction in point source dust emissions through smaller drop heights leading to improved air quality for operators within the immediate vicinity and a reduction to the cumulative particulate load released to receiving environments.
- A general decrease in potential AMD effects and risks in the longer term.

SUMMARY

INAP (2020) notes that "direct and indirect measurements of acidity load from various site domains at more than 40 sites over the past 25 years have revealed that mined sulfidic waste rock typically contributes to the majority of the total acidity load (60 to 80%) from most mine sites, with a further 20 to 30% of acidity load associated with TSFs, and relatively minor contributions from other sources (e.g., underground mine void wall-rock, open cuts, heap leach facilities and other stockpiles)". Hence the greatest long term source hazard for AMD is waste rock rather than tailings. For the BOGP, acidity and low pH are not considered an issue due to the high carbonate content, however, the risks associated with sulfide oxidation products (i.e., neutral metalliferous drainage) remain, hence the risks remain applicable for waste rock storage facilities.

To address this risk, MGL has committed to proactive source control, using engineered landforms, which provides a foundation for sustainable waste rock management, aligning with INAP (2024) principles for long-term environmental stewardship.

Several optioneering studies were completed to determine the most appropriate location for the ELF (MWM, 2025h) with consideration given to minimisation of oxygen ingress and water ingress as components of the optioneering study. The upper Shepherds Creek catchment was chosen for the Shepherds ELF, which minimised exposed surface area. ELFs will use available industry proven methods and acceptable solutions (e.g., INAP, 2020, 2024) to minimise water and oxygen ingress.

CLOSING REMARKS

Please do not hesitate to contact Paul Weber at +64 3 242 0221 or paul.weber@minewaste.com.au should you wish to discuss this memorandum in greater detail.

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