Appendix 1.0-Q SRK, Tenas Project PAG Management Alternatives Assessment Memo

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LIMITED

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Technical Memo

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To	Dan Farmer
From	Michael Dabiri
Cc	Samantha Barnes, Tom Sharp
Subject	PAG Management Alternatives Assessment
Client	Telkwa Coal Ltd
Project	1CT027.003

1 Introduction

This technical memorandum presents the processes and criteria used to select preferred alternatives, and “Alternative Means", for management of Potentially Acid Generating (PAG) materials, as well as potential Metal Leaching (ML) from non-PAG materials, at the Tenas Project (Project).

This alternatives assessment for the Project meets the information requirements as outlined in the British Columbia (BC) Environmental Assessment Office (EAO) Application Information Requirements (AIR) for the Project (EAO 2022). The assessment complies with the BC *Environmental Assessment Act* (GovBC 2002) and the EAO guidance for information requirements for tailings management (EAO 2015), and with the Operational Policy Statement Addressing “Purpose of” and “Alternative Means” under the *Canadian Environmental Assessment Act* (Canadian Environmental Assessment Agency [CEAA] 2012).

“Alternative means” are the various technically and economically feasible ways under consideration by the proponent that would allow the Project to be carried out. The proposed Project reflects the analysis of alternatives throughout the history of the mine site as information on coal resources was supplemented over time. This analysis of the alternative means considers the major decisions for the management of PAG materials.

The assessment presents and compares best practices and best available technologies for processed rock (tailings) and PAG rock management for the specific conditions of the Project. It takes into consideration safety (including dam safety), technical and financial aspects, and implications for environmental, health, social, heritage and economic values.

This memo presents background material on the history of the mine, geochemical material characterizations, the method for the review of alternative means, and an assessment of alternative means to manage mined and processed rock.

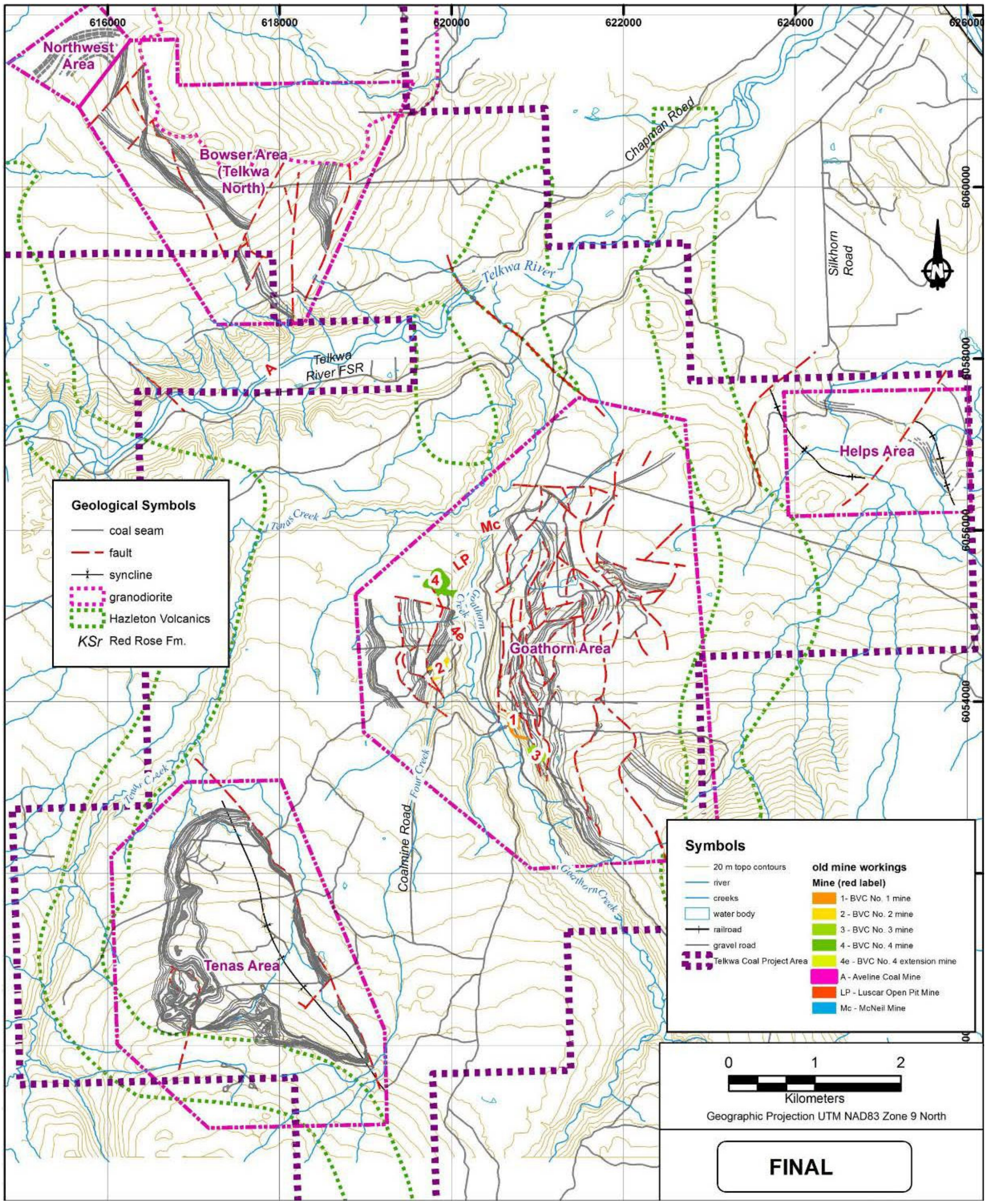
1.1 Background

Coal was discovered in the Telkwa area around the year 1900. Mining is reported to have begun as early as 1918, with small-scale operations supplying thermal coal locally for heating. Approximately 400,000 tonnes of coal were reportedly produced from 1918 to 1985. Through the 1980s and 1990s, the Telkwa property, which includes the Telkwa North, Tenas, and Goathorn Creek deposits (see **Figure 1-1**), changed hands several times with no coal production, before the coal licenses and property were acquired by Telkwa Coal Limited (TCL) in 2017 and 2018.

Geochemical characterization studies performed by previous owners of the project to support economic and environmental assessments in the 1990s showed that Metal Leaching/Acid Rock Drainage (ML/ARD) potential management needed to be considered for the project. The resulting management plans prescribed segregation of highly reactive rock components for subaqueous disposal in backfilled pits and blending of PAG and non-PAG components to create non-PAG mine rock dumps and backfilling of the open pit.

More recently, pre-feasibility studies were completed for large mine designs (encompassing the three (3) deposits, SRK 2017b) and small mine designs (encompassing only the Tenas deposit, SRK 2017a), which included initial expit non-PAG rock piles and in-pit disposal of PAG rock. Due to the requirement for long-term treatment of ARD, this configuration was abandoned for the subsequent Project feasibility study (SRK 2019a) in favour of subaqueous disposal of all PAG materials in purpose-built “PAG cells also known as management ponds”.

Figure 1-1: Telkwa Project Geology and Deposits



***Source**: SRK 2019a*

1.2 Environmental Assessment (EA) Mine Plan

The proposed Project will produce metallurgical coal at a planned annual production rate of between 775,000 and 825,000 tonnes over a life of mine of about 25 years at a maximum production rate of 2,500 tonnes of processed coal per day. Coal is processed by a dense medium cyclone (DMC)/flotation Coal Processing Plant (CPP) with a 145 tonnes per hour (tph) capacity, with fine processed rock (fine processed rock, defined as materials smaller than 0.5 millimetres [mm]) dewatered to 40 percent (%) solids content by a belt filter press, before being combined with the coarse reject and stockpiled for disposal. A schematic of the CPP is shown in **Figure 1-2.**

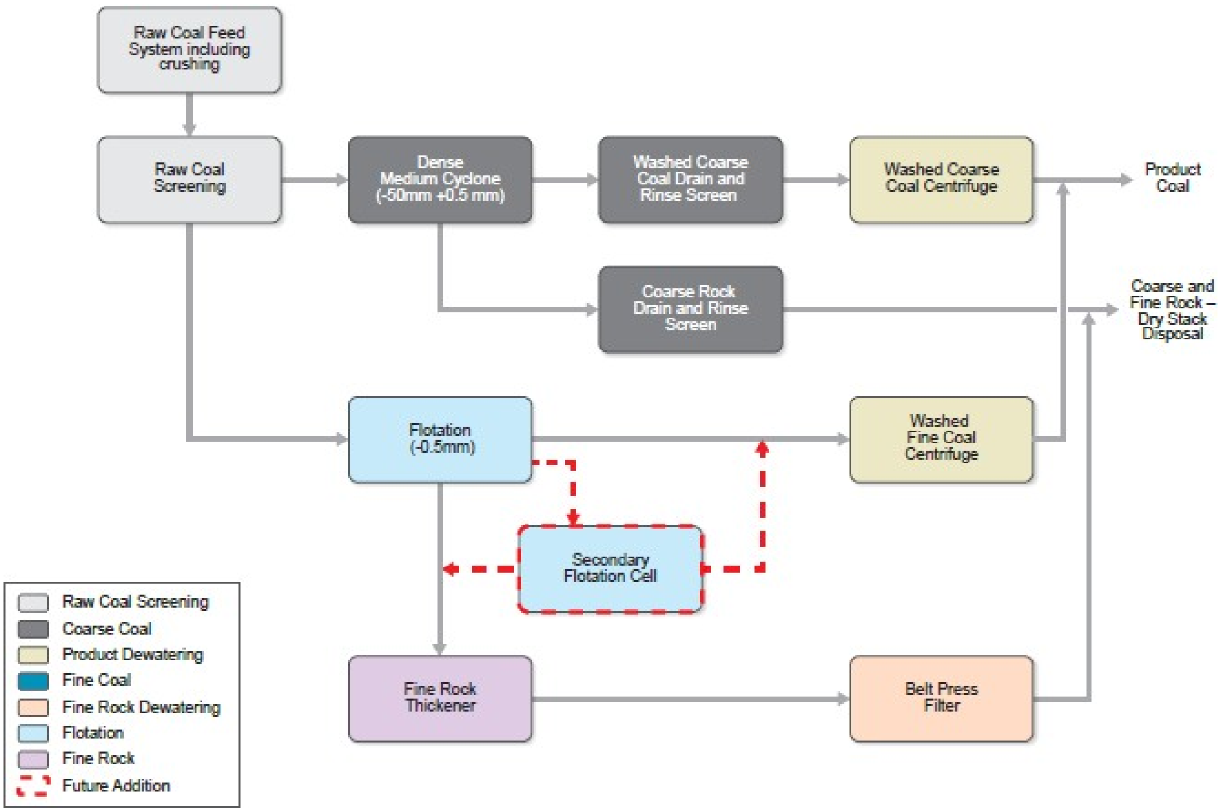
The Tenas Environmental Assessment (EA) Open Pit contains both PAG and non-PAG materials (see **Section 2**). The current mine plan involves separating mine rock based on its potential to generate acid, as it is extracted. A zone model has been developed for rock units within the open pit, and supplemental geochemical testing will be conducted during the Operation Phase to confirm mine rock properties. Non-economic materials from the project are expected to include:

- Non-PAG reclamation materials (surface soils) and overburden from open pit mining and haul road development (24.22 million banked cubic metres [MBCM]);
- PAG[1] mine rock from open pit mining (31.83 MBCM);
- Non-PAG rock from open pit mining including rehandle (29.52 MBCM); and
- Coarse and fine processed rock. These materials are also expected to be PAG (total 3.28 MBCM).

In addition, portions of the open pit walls are expected to be PAG. The mine production schedule is summarized in **Figure 1-3**. The risk of neutral ML from non-PAG rock is also considered in this assessment.

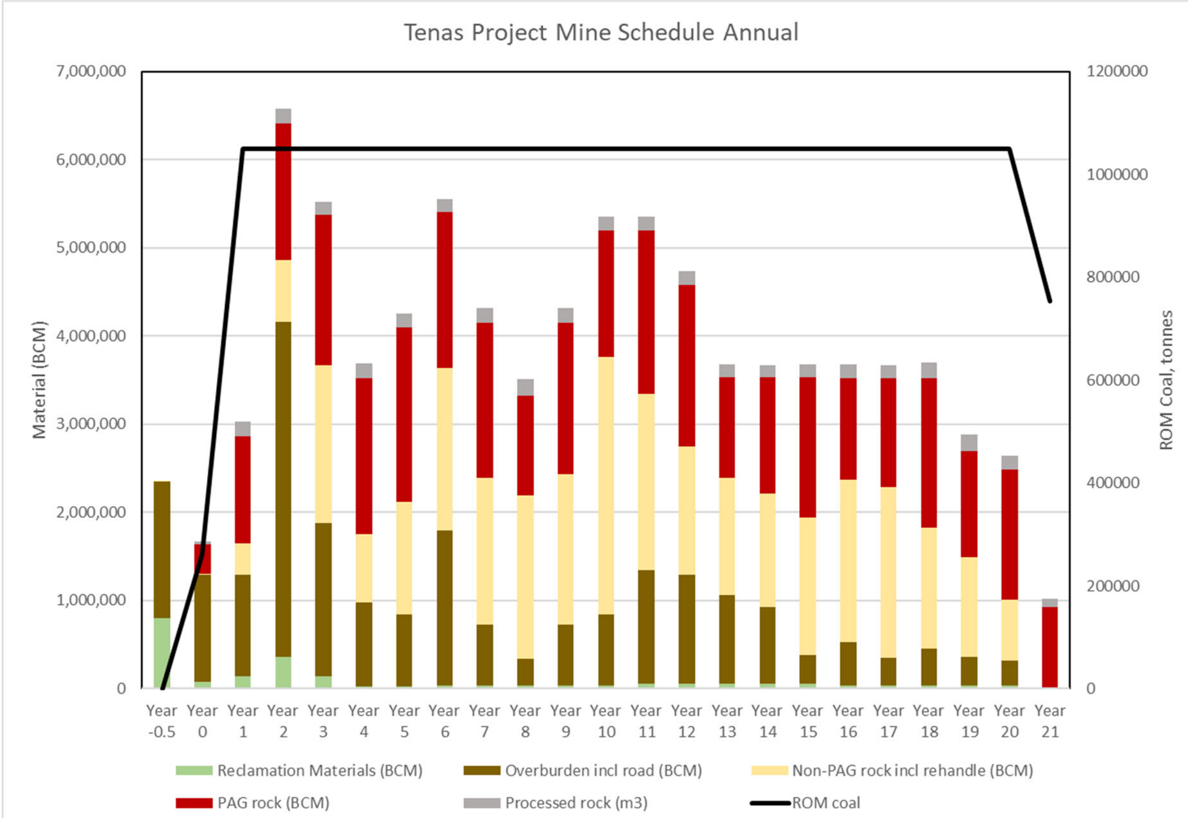
[1] PAG defined as rock with a neutralization potential ratio (NPR) less than 2, see **Section 2.**

Figure 1-2: DMC/Flotation CPP Schematic



***Sources**: SRK 2019a*

Figure 1-3: Tenas Project Annual Production Schedule



2 Geochemical Material Characterization

2.1 Background

A comprehensive historical geochemical characterization program was completed for the Telkwa Project (Norecol Dames and Moore 1999) which included geochemical testing of over 700 samples. A supplemental geochemical characterization program was conducted in 2019 (SRK 2019b) which included additional testing of 173 selected samples from the 1999 program, as well as collection and testing of 19 additional samples of processed rock, overburden, and construction rockfill.

Based on these characterizations, mine rock for the Project is characterized as non-PAG or PAG by acid base accounting (ABA), which measures the ratio of the Neutralization Potential (NP) to the Acid Potential (AP) of the material (i.e., the Neutralization Potential Ratio [NPR]). When the mineralogical contributors to NP and AP are well understood (i.e., NP is like that provided by calcite, AP is from oxidation of pyrite and these minerals have the same availability), regulatory guidance allows that NPR of 2 can be used to define PAG versus non-PAG (MEND 2009). The results of the supplemental mine rock geochemical characterization for the Project showed a strong positive relationship between modified-NP and presence of calcium plus magnesium, which provides confidence in the ABA calculations (SRK 2019b). In addition, there was a strong correlation based on modified-NP and NP calculated based on minerology NP-XRD (SRK 2022). Based on this relationship, an NPR of 2 is selected to identify rock as PAG or non-PAG, consistent with the guidelines.

The results of geochemical characterization are summarized for the different mine rock types in **Table 2-1**, and described in the following sections.

Table 2-1: Non-Economic Material Geochemical Characterization

Material Type	Geochemical Characterization
Mine Rock	Ten (10) zones: 3 non-PAG, 7 PAG, 2 of which are not mined by the EA open pit (zones 7 and 8)
Processed rock (coarse and fine)	PAG
Reclamation materials (surface soils) and Overburden	non-PAG
Open Pit Walls	8 zones: 3 non-PAG, 6 PAG

Sources: *Compiled in text.*

Notes: *EA=environmental assessment; PAG=potentially acid generating; PAG distinction based on NPR ≤2*

2.2 Mine Rock

Seven (7) non-economic rock zones were defined in the 1990s by reference to the coal seams, with four (4) added (0, 1a, 7, and 8) to represent the entire Tenas Deposit and reflecting EA zone geochemical model, as summarized by **Table 2-2** and shown in **Figure 2-1**.

Table 2-2: Acid Rock Drainage (ARD) Management Zone Definitions (Potentially Acid Generating (PAG) Material Highlighted in Yellow)

Zone	Stratigraphic Location	Average Weighted NPR
0	Till and overburden – topography to bedrock surface	17.5
1	Bedrock surface to top of Seam e (minus Zone 1a)	3.5
1a	Select area above Seam e to bottom of Seam e	0.8
2 & 3	Bottom of Seam e to bottom of Seam c	0.9
4	Bottom of Seam c to top of Seam b	2.7
5	Top of Seam b to top of Seam 1U	1.4
55	Top of Seam 1U to bottom of Seam 1L	2.3
6	Bottom of Seam 1L to bottom of Seam 1Lc	1.4
7**	Below Seam 1Lc to the bottom of Seam 1Ld	1.7
8**	Below Seam 1Ld	5.5

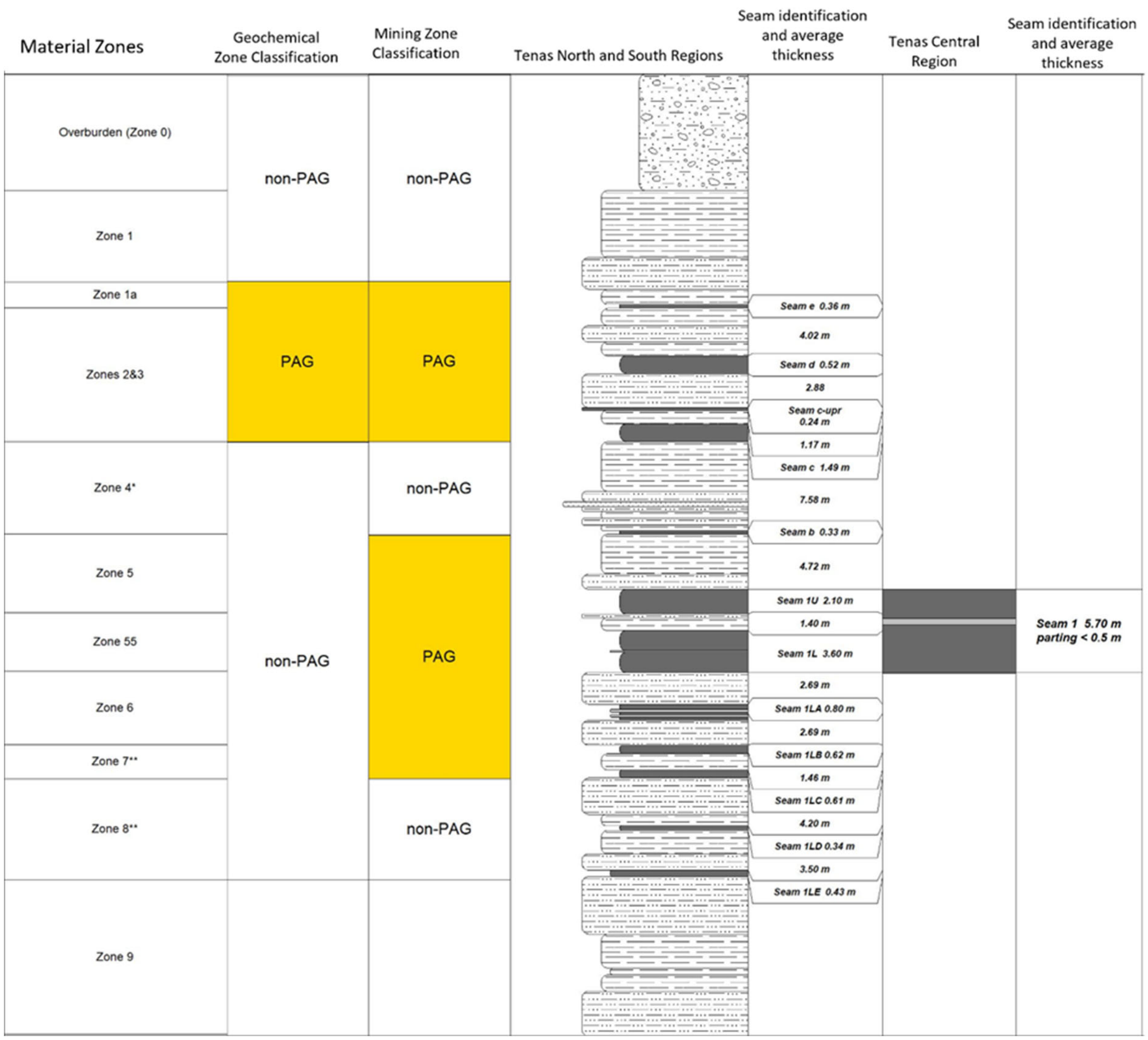
Sources: SRK 2019b)

Notes: *EA=environmental assessment; NPR=neutralization potential ratio; PAG=potentially acid generating*

(1) Zone 4 is spatially segregated as non-PAG and PAG, with the larger portion of the zone (75%) being non-PAG,

***these two zones are currently not being excavated by the EA Open Pit*

Figure 2-1: Tenas Project Lithology



According to SRK (2019b), seven (7) (Zones 1a, 2/3, 5, 55, 6 and 7) out of the 11 zones have average NPRs less than 2 and are classified as PAG, even though all zones, except for Zone 1a, have a component of non-PAG rock (i.e., the non-PAG rock is included in the PAG estimates as part of the mine plan). Zones 1 and 8 are classified as non-PAG. Zone 4 contains quantities of both PAG and non-PAG mine rock but is classified as non-PAG based on the overall weighted average of the Zone, however in mine planning the portions of this zone identified as PAG were managed as other PAG rock zones.

In summary, the following zones were identified to be PAG and non-PAG:

- **Non-PAG** – Zones 0 (includes overburden and reclamation materials/surface soils), 1, 4 and 8 (not excavated in EA mine plan); and
- **PAG** – Zones 1a, 2/3, 5, 55, 6 and 7 (not excavate in the EA mine plan).

The sulfide oxidation rates in the humidity cell samples were used to estimate the lag time for acid generation (SRK 2019b). The evaluation indicated that for the bulk properties of PAG rock, the lag time varies from 2 to 12 years for the different zones. A minimum lag time of 0.6 years was estimated for PAG rock units with minimum NPRs in Zone 4 under laboratory conditions. Note that field conditions are expected to result in longer lag times due to temperature, and material size corrections.

Geochemical testing has indicated elevated concentrations of aluminum, cadmium, nitrite, cobalt, and selenium may be present in leachate at both acidic and neutral/alkaline pH. Aluminum is projected to have high concentrations in suspended form. Note that sediment control for the project is outside of the scope of this assessment.

2.3 Processed Rock

Processed rock samples tested were generally found to be PAG and contained more sulphur than interburden mine rock. Depletion calculations on the humidity cell tests (SRK 2019b) indicate that NP will be consumed prior to sulfide in all samples, with the NP predicted to be depleted after 1.3 years based on laboratory conditions. Note that field conditions are expected to result in longer lag times due to temperature, and material size corrections.

2.4 Reclamation Materials (Surface Soils) and Overburden

All the overburden and reclamation material (surface soil) samples tested had NPRs greater than 2 and were classified as non-PAG (SRK 2019b).

2.5 Open Pit Walls

At Post-closure, an end-pit lake will form in portions of the backfilled open pit. However, unsubmerged open pit walls (highwall and footwall) will remain above the end-pit lake composed mainly of PAG Zone 6 rock. While loading rates are expected to be lower than those of PAG mine rock or processed rock due to the lower reaction surface areas, these exposed surfaces should be expected to become acid-generating within 2 to 12 years based on laboratory conditions and contribute ML/ARD to the end-pit lakes if not management plan is provided. Note that field conditions are expected to result in longer lag times due to temperature, and material size corrections.

3 Methods

As defined in the AIR (EAO 2022), this framework constitutes an assessment of alternative means for material management, that are technically and economically feasible, of both PAG and non-PAG materials. PAG materials include processed rock (coarse coal rejects, fine coal rejects, and tailings) and mine generated PAG material (EAO 2015).

The following four (4) steps, consistent with CEAA (2012), were adopted to determine the preferred PAG management alternative for the Project:

1. Identify technically and economically feasible alternatives.
2. Characterize the options, including their potential effectiveness at reducing ML/ARD and expected effects on the environment and communities.
3. Select the approach for the analysis of alternatives means.
4. Assess the environmental effects of the preferred alternative, or alternatives if multiple are being carried forward.

Potential alternatives were first screened for cost effectiveness and technical applicability. Alternatives that met the screening criteria are further assessed based on their environmental and community effects. This assessment is carried out qualitatively, at a level sufficient to distinguish the relative merits of the different alternatives based on consideration for the advantages and disadvantages of each.

4 Performance Objectives and Criteria

PAG management alternatives are evaluated with respect to their effectiveness in mitigating long-term project risks and their potential effects on VCs. Feedback obtained from community outreach and consultations were considered in defining the VCs and establishing these objectives. The following criteria are considered for this assessment:

- Cost effectiveness;
- Technically applicability, including system integrity and reliability;
- Effects on the natural environment;
- Community effects and input including human health; and

These criteria are discussed further in the following subsections.

4.1 Cost Effectiveness

The cost effectiveness performance objective compares the relative capital and life cycle (including Post-closure) costs of each alternative, relative to the corresponding long-term benefits. Cost considerations include pre-mining (capital) construction, operating and sustaining costs, closure, and Post-closure operations, maintenance, and surveillance costs, as well as amenability for financing and financial risk.

Preference is given to lower-maintenance alternatives and alternatives that enable deferral of construction costs into cash-flow positive periods of the mine life.

4.2 Technical Applicability, System Integrity, and Reliability

The technical performance objective addresses the following technical risks associated with the alternative:

- Suitability for the proposed mine plan, climate, terrain, and design;
- Precedence of successful implementation in similar conditions;
- Risk of long-term degradation or failure of the system;
- Feasibility and ease of implementing contingency measures should the system degrade or fail; and
- Reliance on long-term operations, surveillance, and maintenance.

4.3 Effects on the Natural Environment

This performance objective describes the expected effectiveness of the alternative in reducing impacts to the natural environment, and primarily refers to water quality in effluent and the receiving environment, and the resulting effects on aquatic life.

However, additional considerations include effects on natural hydrological regimes, footprint area, post-reclamation land use, air quality, and terrestrial fauna and flora.

4.4 Community Effects and Input Including Human Health

This performance objective evaluates the effects of the alternative on the local communities and considers feedback from ongoing engagement activities with the community of Telkwa and the Wet'suwet'en First Nation.

Community effects include aspects of cultural heritage as well as Aboriginal and treaty rights, and includes traditional land use, access to quality resources, community well-being (including access to education, infrastructure, and services), archaeological resources, outdoor recreation, noise and vibration, and human health.

5 Metal Leaching/Acid Rock Drainage (ML/ARD) Alternatives Assessment

This section describes the alternatives assessment for ML/ARD management for the following materials:

- Processed rock (coarse and fine);
- Open pit walls; and
- Mine rock (non-PAG and PAG).

Sulphide oxidation occurs when minerals containing sulphide and elemental sulphur are exposed to the weathering effects of oxygen and water. ARD results from premature depletion of acid neutralizing minerals and results in elevated metal solubility and faster sulphide weathering rates under acidic conditions, however, ML can also occur at circum-neutral pH. “Metal” in this context includes any constituents of potential concern (COPC) and is not limited to elements or parameters classified as metals. Measures to reduce ML/ARD generally require one or more of the following mechanisms shown in **Table 5-1**.

Table 5-1: Metal Leaching/Acid Rock Drainage (ML/ARD) Mitigation Mechanisms

Mechanism	Examples
Limiting oxygen availability	Subaqueous deposition, saturation covers, oxygen diffusion barriers
Limiting water availability(1)	Dry (shedding) covers
Neutralization of PAG materials(2)	PAG/non-PAG blending (“ideal blend”), tailings de-sulphurization
Neutralization of ARD after onset	Active treatment, passive treatment (bioreactors), “non-ideal” PAG/non-PAG blending
Removal of neutral metals after onset	Active treatment, passive treatment (bioreactors, wetlands)

Sources: *Modified from the GARD guide (2010)*

Notes: *ARD=acid rock drainage; PAG=potentially acid generating*

[1] *Water is both a reactant and a transport mechanism for ML/ARD*

[2] *Neutralization of PAG materials may be achieved by removing or isolating sulphide materials, maximizing the availability of alkaline materials or porewater, or controlling bacteria and/or biogeochemical processes.*

5.1 Alternative Characterization and Screening

Proposed alternative means for mitigating ML/ARD from PAG materials (processed rock, mine rock, and open pits), as well as non-PAG mine rock, evaluated for the Project are described in the following subsections and summarized in **Table 5-2**. These alternatives were screened for technical applicability and economic feasibility, as summarized in **Table 5-3**. Where more than one (1) alternative was technically feasible, the alternatives were evaluated with the environmental and social criteria to determine a final preferred alternative, as summarized in **Table 5-4**.

5.1.1 Fine Processed Rock (Tailings)

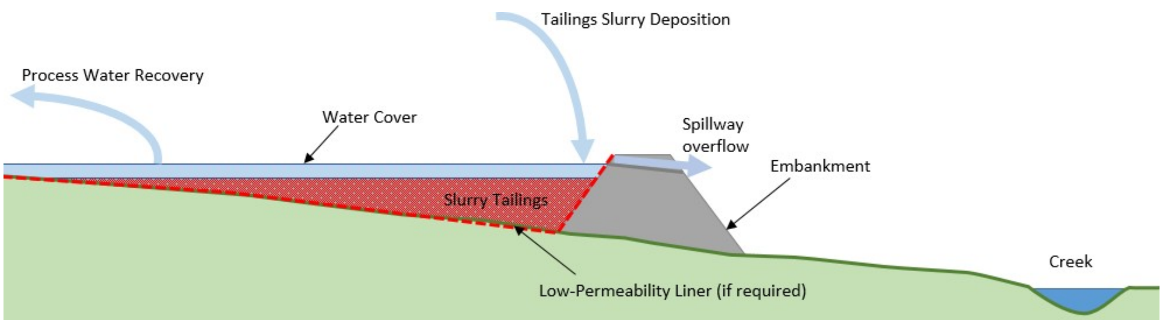
Processed rock storage (both fine and coarse) was discussed in each of the PAG management alternatives above and is discussed in further detail below. Note that total processed rock (coarse and fine) represents 8% of the total PAG materials, and 4% of the total mine rock (excluding overburden and reclamation materials (surface soils)), with fine processed rock making up a small percentage of project materials (2% of total PAG materials and 1% of total mine rock). The following alternatives for fine processed rock are considered:

- Slurry, deposited in a conventional tailings impoundment, or
- Dewatered, and either stacked on-surface or co-disposed with coarse processed rock and/or mine rock (disposal options are discussed further in **Section 5.1.2**)

5.1.2 Conventional Tailings Impoundment

The mine plan described in the Manalta Telkwa Project Environmental Assessment (Manalta 1998) included a separate impoundment to store tailings. In this alternative, tailings are deposited subaqueously in a lined impoundment to prevent the onset of ARD. Water reclaimed from this facility supplies the coal processing plant process. This is shown schematically in **Figure 5-1**.

Figure 5-1: Processed Rock (Tailings) Impoundment Schematic



Notes: *Schematic. Not to scale.*

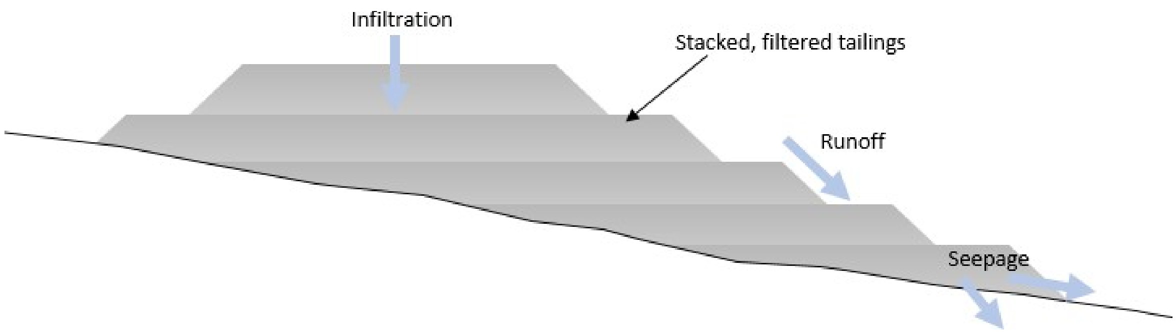
Dewatered Tailings Stack (Filter Press)

A dewatered processed rock (tailings) stack, separate from the PAG rock storage facility, was proposed as part of the Project feasibility study (SRK 2019a). Fine processed rock is dewatered to 40% solids by weight as part of the process, combined with the coarse processed rock, and trucked and placed in compacted lifts in a dedicated storage facility. Dewatering the fine processed rock allows the fine processed rock to be placed and stacked in a compacted pile without the need for an impoundment. It also increases the volume of water recovered, reducing freshwater makeup demands from either onsite or offsite sources.

Oxygen flux in fine materials is more likely to occur by diffusion rather than advection thereby significantly reducing oxygen availability for oxidation of sulphide minerals compared to coarser mine rock. In addition, fine materials can be partially saturated to a level at which the rate of air entry is the same as if the material were fully saturated with water. The moisture content at which this typically occurs is about 60%. Therefore, if the materials are sufficiently fine and well-compacted, the moisture content of the pile may be sufficient to prevent ML/ARD from occurring. Moisture content in the near surface would not be expected to be this high, and as such some ML/ARD should be expected to occur unless additional measures are implemented (e.g., soil cover, blending with neutralizing material).

For filtered tailings, a separate water management facility is typically required for site water management and to provide a source of process water supply.

Figure 5-2: Dry Stack Fine Processed Rock – Schematic



Notes: *Schematic. Not to scale.*

5.1.3 Coarse Processed Rock

The following alternatives were considered for coarse processed rock:

- Surface disposal (stack), in segregated coarse and fine processed rock piles;
- Surface disposal (stack), in blended coarse and fine processed rock piles; and
- Blended coarse and fine processed rock, co-disposed with mine rock underwater.

Segregated Processed Rock Piles

Both coarse processed rock and dewatered fine processed rock generally lend themselves to surface disposal. If dewatering of fine processed rock is selected for other reasons (e.g., water recycling in the process), the lowest effort option may be segregated surface piles. These piles would be placed on surface, likely near the process facility to reduce transportation requirements, and though have favorable geotechnical properties and may be effective in limiting ARD by limiting oxygen advection and seepage to deeper parts of the piles, they are likely to be susceptible to ML/ARD near surface. This alternative also requires drainage management from multiple sources, which increases risk and complexity.

Blended Fine/Coarse Processed Rock Piles

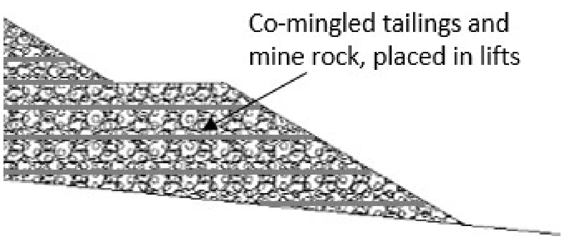
Blending dewatered fine and coarse processed rock can be done at the CPP, prior to transportation, to reduce the footprint and number of drainage management locations. Blending also has the benefit of further reducing oxygen advection and seepage compared to segregated piles.

Blended and Co-Disposal with Mine Rock

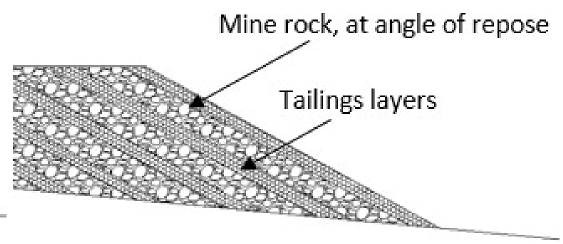
In this alternative, processed rock is co-mingled with PAG rock and deposited in the same facility. If the materials are going to be deposited subaqueously, fine processed rock may be dewatered or not, however dewatering simplifies transportation logistics and reduces freshwater demands. If the materials are going to be deposited in a surface pile, fine processed rock should be dewatered for stability and water management purposes, and co-mingled and/or placed in lifts to prevent segregation during placement. If the material will be submerged or disposed with non-PAG mine rock, end-dumping of different materials without specific co-mingling would provide similar results.

The two (2) configurations are shown schematically in **Figure 5-3**, though it is noted that the ratio of processed rock to mine rock is insufficient to allow effective layering for the Project.

Figure 5-3: Co-Disposal of Processed Rock with Mine rock – Schematic Options



(a) Co-mingled and placed in lifts



(b) End-dumped

Notes: *Schematic. Not to scale.*

5.1.4 Open Pit Walls

Although planned the mine plan involves staging and backfilling of open pits with mine rock, open pit development will result in progressive and sustained exposure of PAG rock walls throughout the life of mine and, without mitigation, post-closure. The following alternatives to mitigate open pit wall ARD were considered:

- Do nothing;
- Partial end-pit lake established based on natural topography and staging;
- Total submergence end-pit lake established via construction of embankments; and
- Open is backfilled with non-PAG rock, overburden, and reclaimed materials.

Do Nothing

In this alternative, open pits are exploited sequentially per the mine plan, but no measures are taken to promote ponding and no material is placed on the exposed open pit walls. Inflows are allowed to drain by gravity and open pit walls remain exposed.

Partial End-Pit Lake

In this alternative, open pits are exploited sequentially per the mine plan and open pit development and sequencing is done to promote ponding within the open pits, resulting in formation of (relatively shallow) end-pit lakes. Inflows are allowed to drain by gravity and pit highwalls remain exposed. No material is placed on the exposed open pit walls.

Total Submergence End-Pit Lake

This alternative promotes total submergence of exposed open pit walls by the construction of embankments to impound water within and outside of the open pits once they are exhausted. No materials is placed on the exposed open pit walls.

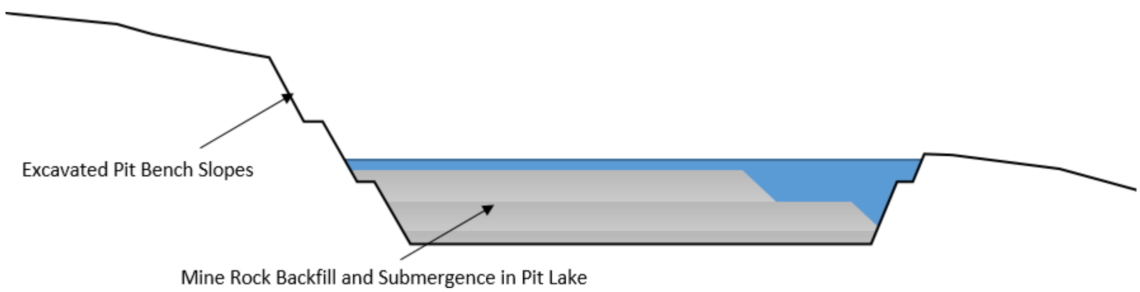
Backfill with Mine Rock and Overburden and Partial End-Pit Lake Submergence

In this alternative, open pit development will be staged in a way that facilitates progressive backfill with mine rock, and partial submergence during the Operation Phase with final end-pit lake elevations reached in the Decommissioning and Reclamation, and Post-closure phases. Upon decommissioning, remaining exposed open pit walls will be covered with excess overburden and non-PAG rock present in the backfill, embankments and buttresses, placed in lifts and reshaped to a final slope of 2.5H:1V. See **Figure 5-4**.

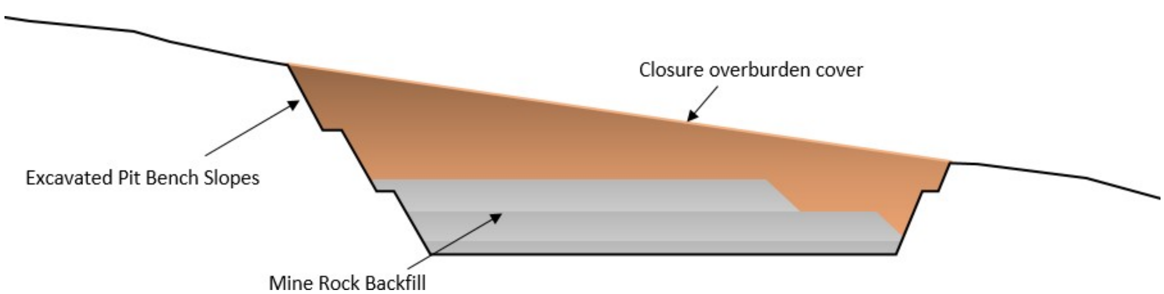
This approach is consistent with the mine development plan, as well as mine rock management objectives and the decommissioning and reclamation plan. The alternative approaches discussed above were not considered in detail in this assessment (see **Table 5-3** for selection rationale).

Figure 5-4: Open Pit Mine Rock Backfill and Submergence – Schematic

(a) Open Pit Backfill During Operation



(b) Open Pit Backfill Decommissioning and Reclamation Cover of Overburden and Reclamation Materials and Partial Submergence of Mine Rock with Water



Notes: *Schematic. Not to scale.*

5.1.5 Mine Rock

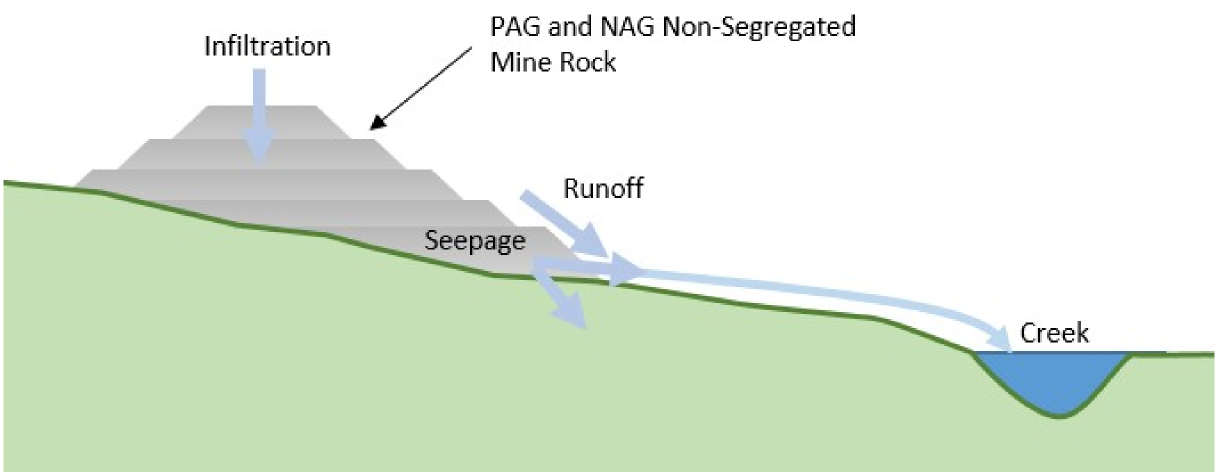
Do Nothing

In the “do nothing” scenario, mine rock generated from the open pit would be placed on surface without management of segregated PAG and non-PAG mine rock. The total mine rock volume is 60 MBMC plus an estimated 30% bulking, of which 52% is expected to be PAG. Depending on the timing and configuration of the mine rock deposition, some natural blending and neutralization may occur, however, pockets of PAG rock should be expected. The onset of acid generation would be expected to occur within 4 to 12 years (see **Section 2**), with some sections (Zone 4 NPR of 0.3) going acid in as little as 0.3 years under laboratory conditions.

Processed rock may be deposited in a separate storage facility (as per the Manalta project [1997]) or dewatered and deposited with the mine rock.

In this alternative, the effects of ML/ARD would be managed by the assimilative capacity of the site and dilution in receiving waterbodies. This alternative is shown schematically in **Figure 5-5**.

Figure 5-5: Do Nothing Option Schematic



Notes: *Schematic. Not to scale.*

Active Water Treatment

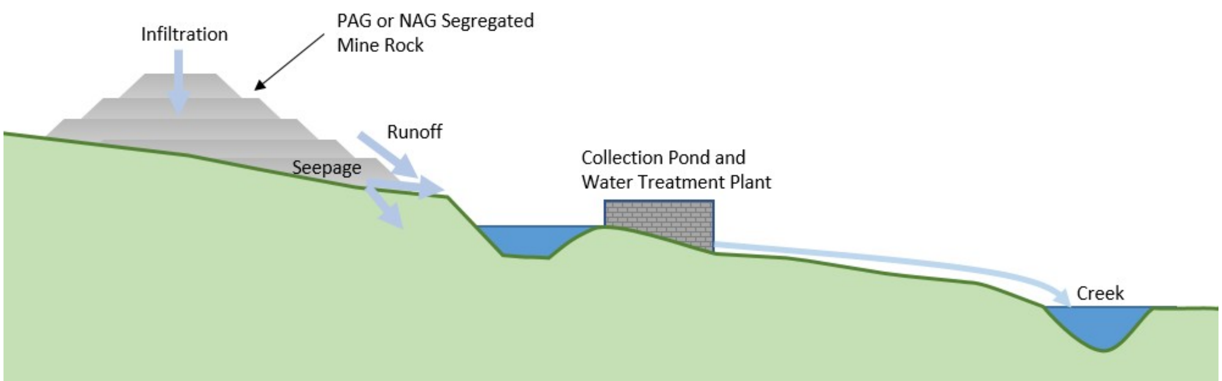
Active water treatment of ARD with lime was considered for the pre-feasibility study (SRK 2017a and 2017b) but was dismissed for the feasibility study (SRK 2019a) due to the risks associated with long-term operation of the water treatment plant, including management of sludges and maintenance of structures (ditches and ponds) to ensure strongly acidic waters are not accidentally discharged.

Active water treatment of neutral metal drainage has not been identified as a requirement based on water quality results.

In this alternative, PAG and non-PAG mine rock are separated at source, and PAG mine rock is co-disposed with filtered processed rock in a dry storage pile, separate from the non-PAG and overburden storage facilities. Surface runoff and infiltration from this facility are collected and directed to a treatment plant consisting of lime-based neutralization, precipitation, solid/liquid separation and including a high-density sludge (HDS) system to optimize lime demand and reduce residual sludge volumes, consistent with the pre-feasibility study (SRK 2017a). The water treatment system would operate on a seasonal basis for 5 months per year from May through September, with excess water stored in winter months in collection ponds and/or depleted open pits and would discharge to Telkwa River. A schematic of the system is shown in **Figure 5-6.**

Lime treatment is expected to be effective at reducing effluent metal loads to acceptable levels. However, localized ML/ARD seeps and acidic pond water may impact local flora and fauna, and long-term operation of the facility and management of sludge presents operational and environmental risks.

Figure 5-6: Active Water Treatment Option Schematic



Notes: *Schematic. Not to scale.*

Passive Water Treatment

Passive water treatment has not previously been proposed for the project. Passive treatment systems exist for ARD neutralization and metal and nutrient removal from neutral drainage. This scenario evaluates a gravel bed bioreactor to remove nitrate and selenium, and potentially other parameters of concern, from the overflow from the sub-aqueous (PAG) and/or sub-aerial (non-PAG) mine rock storage areas during the Operation Phase. Design of passive treatment systems are highly dependent onsite conditions, including influent geochemistry, and site climate and hydrology. Detailed design of a passive treatment system has not been completed for the Project due to the significant challenges imposed by the site climate and geochemistry and significant retention times, water flow volumes, metal loading under ARD conditions, and areas expected to be required, and the inherent unpredictability of the systems at achieving water quality outcomes. See **Figure 5-7.**

Figure 5-7: Active Water Treatment Option Schematic

Notes: *Schematic. Not to scale.*

Potentially Acid Generating (PAG)/Non-PAG Blending

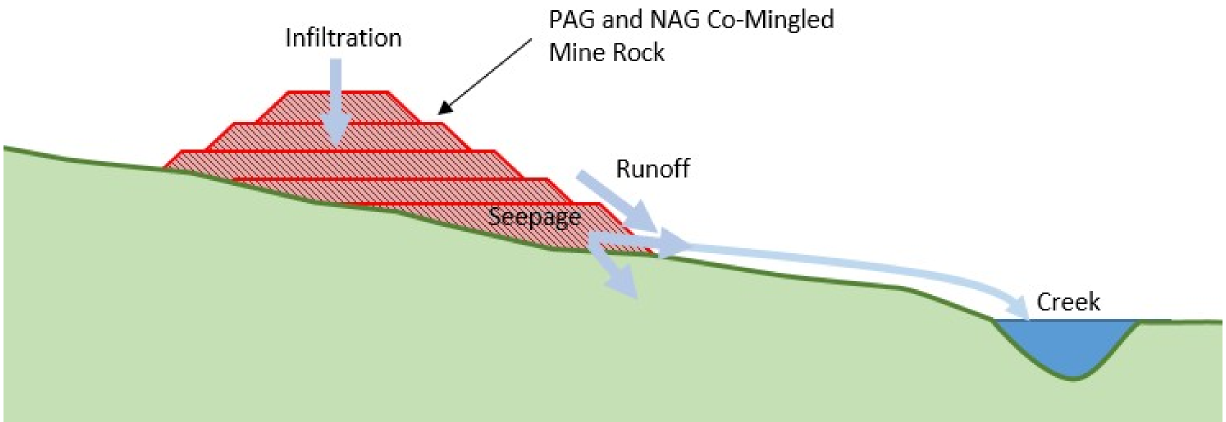
PAG/Non-PAG blending is achieved by co-mingling sufficient neutralizing alkaline materials with PAG materials, such that ML/ARD in the resulting seepage is avoided. An "ideal blend" occurs when, due to the availability and degree of blending of alkaline materials is sufficient that acidification and accelerated oxidation does not occur except at the grain scale. A "non-ideal" blend occurs when acidification and the resulting accelerated oxidation occurs at larger scales but is neutralized by alkaline materials along the flow path. In non-ideal blends, high concentrations of certain elements can persist in solution after neutralization, therefore these blends are less effective than ideal blends. The degree of mixing required to achieve an ideal blend is calculated in the form of a flow path length, based on the infiltration rate, degree of alkalinity and rate of acid generation. This alternative is shown schematically in **Figure 5-8.**

PAG/Non-PAG blending was initially proposed as part of the Manalta project in the 1990s (Manalta 1997, Piteau 1998), and was evaluated for the Project as part of the feasibility study (SRK 2017a, 2017b). The evaluation concluded that conventional blending will be challenging for the Project due to the lack of distinctive PAG and non-PAG layers, elevated sulphide content and high geochemical reactivity. Furthermore, due to the low NPR of PAG materials the lift thicknesses would need to be relatively thin (e.g., in the range of 150 mm) to achieve adequate blending. Lastly to ensure the blend was robust enough a NPR of in the range of 3 to 1 or greater would need to be achieved and there is simply not enough non-PAG rock to blend with PAG materials.

An important consideration for operational mine rock management is that as the stratigraphic average NP/AP_{blend} approaches the target NP/AP_{blend}, the need for rigorous operational control increases to ensure effective blending (SRK 2017b).

In addition, the NP/AP target for a blend mixture needs to be greater than that used to define ARD potential for individual samples ($NP/AP_{blend}>2$, as described in **Section 2**) to provide a factor of safety for inefficiencies of mixing. According to the mine plan, 52% of the mine rock to be produced from the Project is expected to be PAG, though all the PAG zones, except for Zone 1a, contained a component of non-PAG rock (SRK 2019b). Based on these proportions, heterogeneity of the zones, and relatively low NPRs of many of the zones (see **Table 2-2**), it is unlikely that sufficient neutralizing material will be produced over the course of mining activities to offset the PAG materials.

Figure 5-8: Potentially Acid Generating (PAG)/non-PAG Blending Option Schematic



Notes: *Schematic. Not to scale.*

Dry Covers

Dry covers were proposed for post-closure for the pre-feasibility study (SRK 2017a and 2017b) though, as noted above, they conservatively were assumed to not be sufficiently effective to preclude the need for water treatment of ML/ARD in the long term.

The objectives of the dry cover are to:

1. Reduce the supply of oxygen, to slow or prevent the sulphide oxidation reaction (acidification).
2. Reduce the supply of water available for ML/ARD.
3. Provide a surface for post-mining land-use reclamation and revegetation.

In this alternative, PAG and non-PAG mine rock are separated at source, and PAG mine rock is co-disposed with dewatered processed rock in a dry storage pile, separate from the non-PAG and overburden storage facilities. Co-disposal of fine processed rock with mine rock reduces the available pore space within the PAG mine rock, reducing the rate of infiltration and oxygen ingress to the mine rock pile.

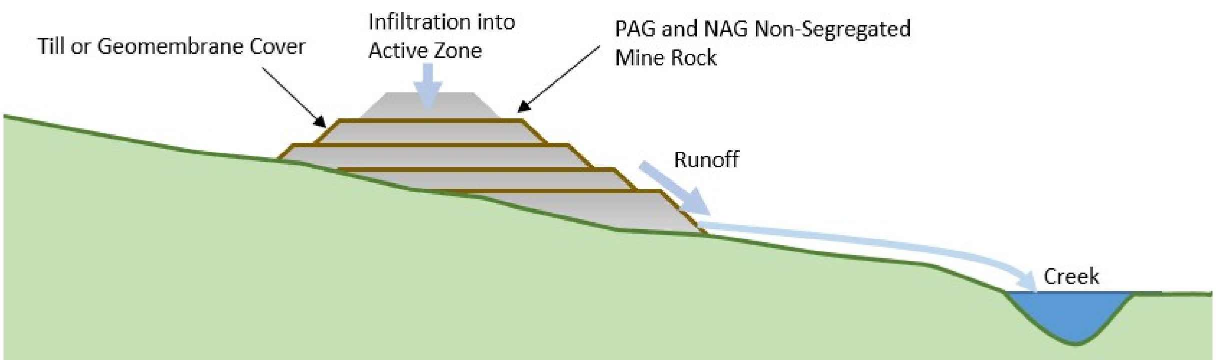
The mine rock piles are constructed in phases, and a dry cover is constructed progressively as shown in **Figure 5-9**. Based on geochemical characterization, the onset of acid generation of the PAG mine rock is expected to occur within 4 to 12 years (see **Section 2**), with some Zone 4 sections going acid in as little as 0.3 years. Onset of acid generation for processed rock is 6 years. Therefore, Zone 4 PAG materials should be segregated and stored separately and covered immediately (likely subaqueously). Progressive reclamation of the remaining PAG materials should be done with sufficient frequency to prevent the onset of acid generation (i.e., covers should be in place within 4 years of extraction). For the non-PAG rock piles, ML is expected to occur immediately but at relatively low concentrations. Progressive covering would be designed primarily to reduce mine rock infiltration and impacted seepage rates.

Areas of uncertainty regarding dry covers are generally related to long-term performance and the degree of effectiveness in reducing oxygen supply and infiltration (MEND 2009) and are related in large part to site climatic conditions and to the availability and properties of high-fines granular materials (glacial tills and clays) at the site. Due to the relatively wet climatic conditions at the

Project, some infiltration should be expected to occur through most covers. Addition of geosynthetic liners can further reduce rates of infiltration and oxygen advection but require additional cost and detailed Quality Assurance/Quality Control (QA/QC) during installation and operation.

For PAG rock piles, water treatment and/or other ML/ARD mitigation may be required during progressive operation of the PAG piles as they are progressively covered due to local variability in mine rock properties, and after closure due to imperfections in the cover system. However, water treatment rates would be expected to be significantly reduced compared to the active water treatment only case. For non-PAG rock piles, progressive cover is considered a conservative measure to further reduce effluent loadings to receiving water bodies.

Figure 5-9: Progressive Dry Cover Option Schematic



Notes: *Schematic. Not to scale.*

Wet Covers and Saturation Covers

Submergence or saturation of PAG materials has been demonstrated as being the most effective means of preventing ARD and reducing ML and has wide-ranging application in BC (MEND 2009). Due to the low solubility of oxygen in water, the rate of sulphide oxidation is controlled by mass transfer.

Key considerations for saturation covers are as follows:

- Submergence of weathered PAG materials can increase dissolution of soluble contaminants (e.g., from secondary oxidation reactions). Therefore, it is important to submerge PAG mine rock before onset of acid generation, or significant oxidation under non-acidic conditions;
- Saturation or water cover must be maintained in perpetuity, and design must account for natural and anthropogenic variations in hydrological regimes to prevent exposure of PAG materials to the atmosphere. However, finer materials can be partially saturated to a level at which the rate of oxygen ingress is the same as if the mine rock were fully saturated with water. The moisture content at which this typically occurs is about 60%. Therefore, if the PAG mine rock materials or (in the case of saturation cover, the cover materials) are sufficiently fine to maintain saturation in the pore spaces, temporary exposure should not result in oxidation reactions and ML/ARD; and
- Geotechnical risks increase with flooded impoundments. The potential consequence of impoundment failure must be considered, as well as the additional construction, maintenance,

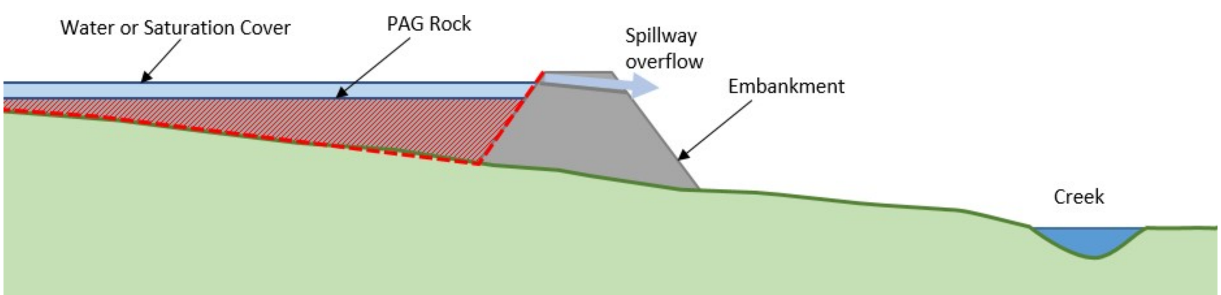
and surveillance requirements, in addition to the risk of ML/ARD.

In this alternative, PAG and non-PAG mine rock are separated at source, and PAG mine rock is co-disposed with dewatered processed rock in a lined and flooded impoundment, separate from the non-PAG and overburden storage facilities. The impoundment embankment is raised progressively over the life of mine to accommodate PAG storage and water cover requirements. Construction of saturation covers are not considered feasible for operations because mine rock is continuously deposited in the PAG cells (management ponds).

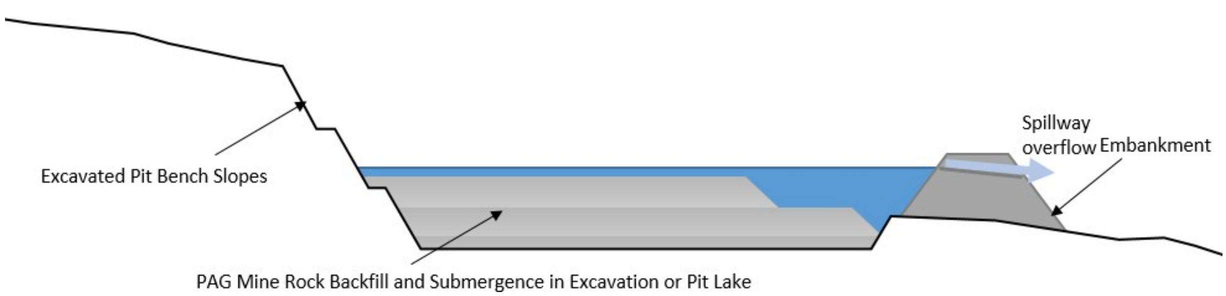
Co-disposal of fine processed rock with mine rock does not offer significant benefits to the PAG storage facility but eliminates the need for a separate PAG processed rock storage facility. An alternative configuration is considered in the feasibility study (2019a), in which PAG rock is deposited in excavated PAG cells (management ponds) with smaller impoundments. While this alternative reduces the overall embankment heights and thus geotechnical risks, it increases capital expenses (the entire facility must be excavated prior to PAG placement, rather than raised sequentially over the life of mine). Both alternatives are shown in **Figure 5-10**.

Figure 5-10: Wet Cover Option Schematic with Impoundment or Excavated Management Ponds (PAG cells)

a) Impoundment Disposal



b) Excavated PAG Cell (Management Pond) Disposal (shown as open pit)



Notes: *Schematic. Not to scale.*

5.1.6 Summary and Screening

Alternatives are summarized in **Table 5-2.** Initial screening of alternatives based on technical applicability and economic feasibility is presented in **Table 5-3.**

Technical applicability and economic feasibility selection criteria are defined as follows:

- **Unacceptable:** Contains an obvious critical flaw or does not meet required threshold criteria for further consideration (e.g., does not achieve objective of mitigating ML/ARD risks, or is obviously economically prohibitive). Alternatives that are either technically or economically unacceptable are discarded;
- **Challenging:** Does not contain an obvious critical flaw, but presents significant challenges for achieving stated objectives, or presents significant (though not obviously prohibitive) economic risk or liability. Alternatives that are either technically or economically challenging are discarded *if there is a more favorable alternative available*; and
- **Acceptable:** Is expected to achieve stated objectives without significant challenges or economic risk or liability.

Alternatives that are not discarded are either assessed further based on their effects on the natural environment and communities (**Section 5.2**) or selected if only one alternative is considered technically and economically feasible.

Table 5-2: Management Alternatives for Potentially Acid Generating (PAG) and non-PAG Materials

Component	Management Option	Description	ML/ARD Management Mechanism	Key Considerations
Mine rock	Do nothing	Non-segregated surface piles for PAG and non-PAG materials.	None.	The remineralization of carbon in some coal materials can consume oxygen at a greater rate than metal mine materials. Placement of coarser materials reduces oxidation reaction rates by reduced surface areas. However, mine rock at Telkwa is generally expected to be relatively fine.
	Active water treatment	Segregated surface piles for PAG and non-PAG materials. ARD or neutral metal leachate is collected and treated.	Neutralization of ARD and removal of neutral metals after onset.	Long term operations and maintenance, including sludge management post-closure.
	Passive water treatment	Segregated surface piles for PAG and non-PAG materials. Leachate is passed through a bioreactor to remove selected parameters of concern.	Neutralization of ARD and removal of neutral metals after onset. Biochemical anaerobic-anoxic reactions to consume nutrients and attenuate metals.	Site-specific design of system to address key parameters of concern and nutrient loading. High flow rates and low temperatures are key challenges for bioreactor effectiveness. Reliability of systems at meeting end-of-pipe concentration requirements makes permitting challenging Post-closure operations and maintenance challenges. Long term operations and maintenance, including sludge management post-closure.
	PAG and non-PAG blending	Blended PAG and non-PAG surface piles to achieve NPR>2.	Neutralization of PAG materials at source (ideal blend) or ARD after onset (non-ideal blend) ML/ARD.	Effectiveness of co-mingling of PAG and non-PAG materials, influenced by structural formation and mineralization. Challenging for the Project due to the lack of distinctive PAG and non-PAG layers, elevated sulphide content and high geochemical reactivity.
	Dry cover	Segregated surface piles for PAG and non-PAG materials. Piles are progressively covered with low-permeability materials (high-fines granular materials or geosynthetics).	Limiting oxygen availability (by advection). Limiting water availability, by limiting seepage rates.	Availability and material properties of high-fines granular materials (e.g., clays or glacial tills). Long-term (post-closure) effectiveness of cover, potentially supported by oxygen consumption of coal mine rock.
	Wet cover	Segregated PAG or non-PAG storage facility with water cover.	Limiting oxygen availability (diffusion).	Water cover maintenance. Geotechnical risk of impounded water and saturated processed rock, including post-closure. Placement of finer materials decreases rate of diffusion even under partial saturation conditions.
	Saturation cover	Segregated PAG or non-PAG storage facility with saturated granular fill cover.	Limiting oxygen availability (diffusion).	Maintaining saturation. Geotechnical risk of saturated processed rock (e.g., liquefaction). Presents logistical challenges during operations due to difficulty maintaining cover saturation during active placement. Placement of finer materials decreases rate of diffusion even under partial saturation conditions.
Processed rock (tailings)	Conventional slurry tailings impoundment	Deposition as conventional slurry in a tailings' impoundment with a water cover.	Limiting oxygen availability (diffusion).	Water cover maintenance during operations and post-closure. Geotechnical risk of impounded water and liquifiable tailings.
	Dewatered tailings stack (filter press) and on-surface coarse processed rock pile	Filter press circuit to dewater tailings and allow storage as dry stack or co-disposal with processed rock and/or mine rock.	Limiting oxygen availability (by advection). Limiting water availability, by limiting seepage rates. Likely to require additional measures such as covers or active treatment if deposited on surface.	Placement of finer materials decreases oxygen ingress even under partial saturation conditions. Relatively small volumes to justify a separate disposal facility. Impact of the grain size distribution and water content of dewatered product on limiting oxygen advection and infiltration. Long-term geochemical weathering. Lower geotechnical risks compared to conventional slurry impoundments.
Coarse processed rock	Segregated processed rock piles	On-surface coarse reject pile and separate dewatered fine processed rock pile or impoundment (see Conventional slurry tailings impoundment).	None. Likely to require additional measures such as covers or active treatment.	Multiple PAG management facilities required, increasing cost, complexity, and post-closure risk. Oxidation near surface leading to ARD. Geotechnical stability and surface erosion. Relatively small volumes to justify a separate disposal facility.
	Blended fine/coarse processed rock piles	Processed rock and dewatered fine processed rock are blended and placed in dry surface stack.	Limiting oxygen availability (by advection). Limiting water availability, by limiting seepage rates. Likely to require additional measures such as covers or active treatment.	Multiple PAG management facilities required, increasing cost, complexity, and post-closure risk. Oxidation near surface leading to ARD. Geotechnical stability and surface erosion.
	Blended and co-disposal with mine rock (PAG, non-PAG or unsegregated)	Processed rock and dewatered tailings are blended and co-mingled with mine rock prior to placement. Could be blended with segregated non-PAG rock, or unsegregated (PAG/non-PAG) mine rock.	Limiting oxygen availability (by advection). Limiting water availability, by limiting seepage rates. Neutralization of PAG materials via blending (if option selected). May require additional measures such as covers or active treatment.	Geotechnical stability.

Component	Management Option	Description	ML/ARD Management Mechanism	Key Considerations
Open pit walls	Do nothing	Open pits are exploited sequentially. Inflow drains by gravity.	None.	Spatial constraints and haul distances for mine rock storage.
	Partial end-pit lake	Open pits are exploited sequentially, and open pit design and sequencing promotes formation of a partial end-pit lake in inactive open pits. Some of open pit walls remain exposed.	Limiting oxygen availability (diffusion).	Pit staging and geometry to promote ponding. Spatial constraints and haul distances for mine rock storage. Impact of exposed pit walls on pit lake geochemistry in the long term.
	Total submergence end-pit lake	Open pits are exploited sequentially, and embankments are constructed to promote formation of an end-pit lake in inactive open pits that completely submerges open pit walls.	Limiting oxygen availability (diffusion).	Embankment construction to promote ponding. Spatial constraints and haul distances for mine rock storage. Geotechnical risk of embankments during Operations and Post-closure phases.
	Backfill with mine rock and partial end-pit lake	Open pits are exploited sequentially, and embankments are constructed to promote formation of an end-pit lake in inactive open pits that partially submerges open pit walls.	Limiting oxygen availability (diffusion).	Embankment construction to promote ponding. Spatial constraints and haul distances for mine rock storage. Geotechnical risk of embankments during Operation, and Post-closure phases.

***Sources**: Compiled in report.*

***Notes**: ARD=acid rock drainage; ML=metal leaching; NPR=neutralization potential ratio; PAG=potentially acid generating*

Table 5-3: Initial Screening based on Technical and Economic Feasibility

Component	Management Option	Technical Applicability	Rationale	Economic Feasibility	Rationale	Screening Decision	Rationale
Fine processed rock (tailings)	Conventional slurry tailings impoundment	Acceptable	Conventional method which facilitates submergence of PAG materials, but results in requirement for a separate storage facility requiring long-term maintenance after closure.	Challenging	Lower initial capital and operating costs are offset by long-term costs of managing separate PAG facilities.	Discard	Lower initial cost and extensive precedence for effective management of PAG, however, creates additional technical challenges compared to other alternatives associated with managing multiple facilities, as well as geotechnical risk of impounded fine materials, without corresponding benefits.
	Dewatered fine processed rock (filter press)	Acceptable	Though more expensive, filter pressing is technically feasible and provides environmental benefits (e.g., increases process water recycling)	Challenging	Higher initial capital and operating costs due to process infrastructure requirements and transportation costs are offset by reduced long-term liability.	Select, in combination with other ML/ARD alternatives	Though higher cost initially, provides many benefits including reducing process water makeup demands, reducing geotechnical risk and project footprint, especially if paired with co-disposal with processed rock and mine rock. Does not, on its own, mitigate ML/ARD potential.
Coarse processed rock	Segregated coarse/fine processed rock piles	Challenging	Though surface coarse and dewatered processed rock disposal is well-established technology, it will present ML/ARD challenges in this application.	Challenging	Multiple PAG management facilities required, increasing cost and complexity.	Discard	Does not mitigate ML/ARD generation for PAG coal reject materials, and creates additional technical challenges associated with managing multiple facilities.
	Blended coarse/fine processed rock piles	Acceptable	Well established processed, that may help mitigate ML/ARD challenges.	Challenging	Multiple PAG management facilities required, increasing cost and complexity	Discard	Does not adequately mitigate ML/ARD generation for PAG coal reject materials, and creates additional technical challenges associated with managing multiple facilities. Does not offer benefits compared to co-disposal with mine rock.
	Blended and co-disposal with mine rock (non-PAG or unsegregated)	Acceptable	Well established technology, that may help mitigate ML/ARD challenges and reduces number of PAG management facilities.	Acceptable	Most economically viable method in the long-term, due to reduced number of separate PAG management facilities.	Select	Reduces technical complexity by providing a single PAG management location and provides additional benefits to geotechnical and geochemical performance of the mine rock pile.
Open pit walls	Do nothing	Unacceptable	Significant portions of the exposed pit wall area are expected to be acid generating, resulting in unacceptable water quality effects.	Challenging	Exposed PAG surfaces expected to require active dewatering and ARD water management.	Discard	Does not, on its own, adequately mitigate ML/ARD risk.
	Partial end-pit lake	Acceptable	Establishing end-pit lakes is feasible within the mine development staging plan and would reduce ARD as exposed open pit wall areas are relatively small compared to submerged open pit areas.	Acceptable	Establishing pit lakes is consistent with the mine plan and is expected to occur naturally due to the site hydrology, and therefore should not result in significant extra costs.	Discard	Provides adequate mitigation of ML/ARD risk due to reduction of exposed reactive surface areas, however, does not offer any corresponding benefits compared to the alternative with mine rock backfill.
	Total submergence end-pit lake	Challenging	Constructing embankments to submerge open pit walls is technically feasible, though introduces geotechnical risks without commensurate benefits of ARD risk reduction.	Challenging	Additional embankments introduce additional costs and long-term (post-closure) liabilities.	Discard	ARD-mitigation benefits offered by submerging pit walls during operations are offset by additional technical risk and long-term liability associated with the additional dams.
	Backfill with mine rock and partial end-pit lake	Acceptable	Backfilling open pits with mine rock and partial submerging is feasible within the mine development and has overall benefits of reducing the requirement for external PAG rock management and facilitating closure ARD management.	Acceptable	Backfilling with mine rock is complementary to the mine plan and reduces haul distances. Establishing end-pit lakes is consistent with the mine plan and is expected to occur naturally due to the site hydrology, and therefore should not result in significant extra costs	Select	Backfilling with mine rock is complementary to the mine plan and reduces haul distances, providing environmental, reclamation and economic benefits.
Mine rock	Do nothing	Unacceptable	Significant portions of the mine rock are expected to be acid generating, resulting in unacceptable water quality effects.	Unacceptable	Lack of ML/ARD management is expected to result in unacceptable long-term liability.	Discard	Does not, on its own, adequately mitigate ML/ARD risk.
	Active water treatment of PAG mine rock	Challenging	Lime treatment of ARD is a well-established technology, however, the ability to effectively capture ARD from sources presents potential challenges.	Challenging	Potential high capital costs, and requirement for long-term water treatment presents a significant long-term liability.	Assess further	Long-term active water treatment would prevent the mine from achieving reclamation objectives (i.e., passive closure conditions), and presents challenges associated with capturing ARD.
	Active water treatment of non-PAG mine rock	Challenging	Treatment methods of metals in neutral drainage are generally parameter specific, and multiple treatment methods would be required.	Unacceptable	Capital and operating cost of multiple treatment methods presents an unacceptable cost to the project.	Discard	Economic and technical challenges.
	Passive water treatment of non-PAG	Challenging	Passive water treatment systems have demonstrated effectiveness in reducing selected parameters of	Challenging	Significant areas and retention times are required for passive treatment in cold, wet climates, and challenges in	Discard	Economic and technical challenges.

Component	Management Option	Technical Applicability	Rationale	Economic Feasibility	Rationale	Screening Decision	Rationale
	mine rock		concern (notably selenium and nitrate), however, present challenges in cold, wet climates.		reliably predicting end-of-pipe compliance.		
	PAG/non-PAG blending	Unacceptable	PAG/non-PAG blending presents many challenges and has limited examples of successful application. In addition, PAG/non-PAG mass balance does not support this alternative.	Challenging	Significant logistical and construction effort is required to achieve effective blending.	Discard	Not likely to be achievable based on-site conditions.
	Dry cover over PAG (granular or geosynthetic)	Challenging	Dry covers are a well-established technology; however, it is generally agreed that they are effective at slowing, but not eliminating, processes for ARD in cold, wet BC climates.	Challenging	Significant construction effort and perpetual ongoing monitoring and maintenance required to ensure cover performance at limiting ARD reactions.	Discard	Unlikely to adequately mitigate ML/ARD from PAG materials.
	Dry cover over non-PAG (granular or geosynthetic)	Preferred	Dry covers are a well-established technology at limiting infiltration, which should be effective at limiting neutral metal leaching.	Acceptable	Significant construction effort and ongoing monitoring and maintenance required to ensure cover performance; however, lower performance measures are required to limit metal leaching than ARD reactions.	Assess further	Dry cover is an effective long-term risk mitigation method.
	Wet cover over PAG	Acceptable	Wet covers are a well-established technology for ML/ARD management in cold, wet BC climates.	Acceptable	Higher capital costs for impoundment construction are offset by lower long-term operating costs associated with preventing ARD.	Assess further	Most robust alternative and cost-effective alternative for mitigating ML/ARD from PAG materials in a humid environment. However, requires an impoundment which increases geotechnical risk.
	Wet cover over non-PAG	Acceptable	Wet covers are a well-established technology for ML/ARD management in cold, wet BC climates.	Unacceptable	The cost and effort required to maintain submergence of the full volume of both PAG and non-PAG materials is likely to be prohibitive.	Discard	Submerging both PAG and non-PAG material volumes would negatively affect project economics and create additional geotechnical risks without corresponding benefit of improving environmental outcomes.
	Saturation cover over PAG	Acceptable (closure)	Saturation covers offer similar benefits to wet covers but reduce risk of desaturation (reduced evaporation rates) and reduced geotechnical risk. Not feasible during operations due to the need for continual material placement.	Acceptable (closure)	Logistically challenging to place progressive saturated covers during active deposition. For closure, higher capital costs for impoundment and cover construction are offset by lower long-term costs associated with preventing ARD post-closure.	Assess further	Most robust alternative and cost-effective alternative for mitigating ML/ARD from PAG materials in a humid environment post-closure. Geotechnical risk of impoundment exists but is reduced compared to water cover.
	Saturation cover over non-PAG	Acceptable	Saturation covers offer similar benefits to wet covers but reduce risk of desaturation (reduced evaporation rates) and reduced geotechnical risk.	Unacceptable	The cost and effort required to construct and maintain saturated cover of the full volume of both PAG and non-PAG materials is likely to be prohibitive.	Discard	Submerging both PAG and non-PAG material volumes would negatively affect project economics and create additional geotechnical risks without corresponding benefit of improving environmental outcomes.

Sources: *Compiled in report.*

Notes*: ARD=acid rock drainage; ML=metal leaching; PAG=potentially acid generating*

Technical Applicability and Economic Feasibility selection criteria are defined as follows:

- *Unacceptable: Contains an obvious critical flaw or does not meet required threshold criteria for further consideration (e.g., does not achieve objective of mitigating ML/ARD risks, or is obviously economically prohibitive).*
- *Challenging: Does not contain an obvious critical flaw, but presents significant challenges for achieving stated objectives, or presents significant (though not obviously prohibitive) economic risk or liability.*
- *Acceptable: Is expected to achieve stated objectives without significant challenges or economic risk or liability.*

5.2 Environmental and Community Alternatives Assessment

Based on the pre-screening assessment detailed in **Table 5-3**, the alternative of blending dewatered fine rock and coarse processed rock and co-mingling with PAG mine rock is selected due to lack of technically and economically feasible alternatives. Similarly, ML/ARD from open pit walls will be managed by progressively backfilling with non-PAG rock and overburden and partially submerging as open pits become exhausted, and ML/ARD from non-PAG mine rock will be mitigated by progressive placement of overburden and reclamation material (surface soil) covers over the mine life.

Alternatives for PAG mine rock management (blended with processed rock) are evaluated against environmental and community effects criteria, as summarized in **Table 5-4.**

Table 5-4: Alternatives Assessment based on Effects on the Natural Environmental and Community Effects and Inputs including Human Health (Mine Rock)

Management Option	Environmental Effects	Rationale	Community Input	Rationale	Screening Decision	Rationale
Active water treatment of PAG mine rock	Challenging	Treating water will result in improved water quality outcomes in receiving environments but involves long-term management of water treatment sludge. Risk of not capturing ML/ARD seeps from the open pit and/or impoundments may result in environmental impacts.	Challenging	Long-term active water treatment would prevent the mine from achieving reclamation objectives (i.e., passive closure). Possibility of parameters of concern entering the downstream environment having a negative effect on human health.	Implement as contingency, in case of failure of other methods	Long-term active water treatment would prevent the mine from achieving reclamation objectives (i.e., passive closure conditions), and presents challenges associated with capturing ARD. However, water treatment is an effective mitigation technology in the case of failure of preferred ML/ARD prevention methods.
Wet cover over PAG	Acceptable	Wet covers are an effective method of effectively eliminating ML/ARD. Local climate lends itself to maintaining water cover, even under drought and climate change conditions. However, there is a risk of losing the wet cover due to evaporation and resultant ARD potential.	Challenging	Passive ML/ARD management option. However, presents long-term geotechnical risk associated with embankment failure	Select for operation phase	Effective at providing ML/ARD source control from PAG materials in a humid environment. However, requires an impoundment which increases geotechnical risk.
Saturation cover over PAG	Acceptable (closure)	Saturation covers offer similar benefits to wet covers but reduce risk of desaturation (reduced evaporation rates) and reduced geotechnical risk.	Acceptable (closure)	Passive ML/ARD option that allows re-establishment of vegetation. Geotechnical risk of impoundment exists but is reduced compared to wet cover.	Select for Decommissioning and Reclamation and Post-closure phases	Effective at providing ML/ARD source control from PAG materials in a humid environment, but not practical to implement during active material placement. Geotechnical risk of impoundment exists but is reduced compared to water cover.

Sources: *Compiled in report.*

Notes*: ARD=acid rock drainage; ML=metal leaching; PAG=potentially acid generating*

Technical Applicability and Economic Feasibility selection criteria are defined as follows:

- *Unacceptable: Contains an obvious critical flaw or does not meet required threshold criteria for further consideration (e.g., does not achieve objective of mitigating ML/ARD risks, or is obviously economically prohibitive).*
- *Challenging: Does not contain an obvious critical flaw, but presents significant challenges for achieving stated objectives, or presents significant (though not obviously prohibitive) economic risk or liability.*
- *Acceptable: Is expected to achieve stated objectives without significant challenges or economic risk or liability.*

6 Conclusions and Recommendations

ML/ARD mitigations for PAG and non-PAG mine rock, including fine processed rock and open pit walls, recommended based on this assessment, and their rationale, are as follows:

Fine processed rock (tailings) treated as PAG: Dewatered fine processed rock (tailings) blended with coarse processed rock (also treated as PAG), for co-disposal with PAG mine rock and placed underwater for permanent storage:

- Increased process water recycling leading to lower freshwater makeup requirements; and
- Reduced operational complexity and risk of managing a single PAG facility.

Open pit walls: covered with non-PAG rock and overburden and partially submerged to form an end-pit lake during operations. Any remaining exposed open pit walls will be covered with an overburden and reclamation materials (surface soils) cover during the Decommissioning and Reclamation Phase to meet Post-closure land use objectives:

- Reduction of infiltration of water and oxygen to the open pit walls;
- Prevention of ML/ARD during Operation, Decommissioning and Reclamation, and Post-closure phases by providing constant availability of NP materials and seepage to the open pit wall; and
- Amenable to Post-closure restoration of pre-mining landforms.

Non-PAG mine rock: progressively covered with overburden and finally reclamation materials (surface soils):

- Reduced infiltration and seepage to the receiving environment; and
- Promote vegetation and meet Post-closure land use objectives.

PAG mine rock: impounded, with a water cover:

- Demonstrated effectiveness of the method in managing ML/ARD in the long-term;
- Ability to incorporate design contingencies to mitigate risks of system failure; and
- Relatively low operational and maintenance requirements, post-closure.

It is recommended that the Project design incorporate the following considerations:

1. Design the saturation cover depth with consideration to be resilient to drought conditions, considering the potential long-term effects of climate change.
2. Incorporate design measures to reduce the likelihood and potential consequence of an embankment failure on the downstream environment (e.g., closure spillways designed for the probable maximum flood (PMF), saturated rockfill cover Post-closure).

Other materials such as **overburden**, **reclamation materials (surface soils, woody debris)** and surficial construction materials (gravel and rock quarry) are not expected to require any specific material management procedures beyond best practices for excavation and placement of these materials.

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Regards,

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