Appendix 13.15-F SRK, Tenas Project Conceptual Report Memo

TELKWA COAL
LIMITED

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FINAL

Technical Memo

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To	Dan Farmer
From	Nadine Shatilla, Iozsef Miskolczi
Cc	Samantha Barnes
Subject	Telkwa Project – Scoping Level Closure Cover Assessment
Client	Telkwa Coal Limited
Project	1CT027.003

1 Introduction

1.1 Background

Telkwa Coal Ltd. (Telkwa) is considering the use of covers as a mitigation strategy at the Tenas Project site in British Columbia, Canada to ensure a positive water balance. A performance assessment of the proposed cover concepts based on the site-wide water balance model (SRK 2021a) and Baseline Hydrometeorological Report (SRK 2021b) was needed, to provide a rationale for how covers can best be designed for the Tenas Project, to perform as intended, under a range of conditions.

Mine materials at the Tenas Project includes both coarse and fine processed rock, potentially acid-generating (PAG) and non-acid generating (Non-PAG) rock as well as overburden. The current closure concept is reliant on the PAG rock being maintained saturated in perpetuity to prevent oxidation and resultant acid rock drainage. To this end the mined PAG rock will be deposited in purpose-built facilities (Management Ponds) which include a very low permeability liner.

1.2 Scope of Work

While it is understood that covers are one of many possible mitigation strategies that can be used to achieve site-wide closure objectives, the scope of this study was to specifically determine what cover concepts are most likely to be successful at the Tenas Project, and how best to implement them. This was done by evaluating site specific conditions that are most likely to affect cover performance, including climate, material availability, waste characterization, seismicity, etc.

Once the cover concepts that are most likely to be successful at Tenas were identified, appropriate cover functions were defined to specifically ensure overall site wide closure objectives would be met. Finally conceptual cover designs are presented that demonstrate potential implementation plans and meet Project objectives, which will be followed by a detailed level cover design for the Project.

1.3 Report Layout

An introduction to different cover types and whether they should be given consideration at the Tenas Project is provided in Section 2. Section 3 provides a generalized overview of the currently-stated closure objectives and outlines the criteria incorporated into a design specific to the Tenas Project. Specific water balance considerations used to determine the most appropriate cover design configuration are also described. Finally, different conceptual cover designs suitable for application at the Tenas Project are summarized. Conclusions and recommendations are presented in Section 4.

2 Generalized Cover Types

2.1 Water Covers

Water covers involve permanently submerging mine waste and maintaining a specific minimum water depth for the life of the facility. A water cover effectively shuts down oxygen ingress to the underlying waste, preventing oxidation. The water cover will provide a constant hydraulic head to encourage seepage, which may in turn provide a pathway for mobilizing soluble oxidation products present in the waste. Therefore, water covers work best if oxidation of the waste is prevented from occurring in the first place. If the waste has already undergone significant oxidation, exclusion of oxygen through a water cover to prevent further oxidation may not be warranted, or even desirable, given the inventory of oxidation products already present in the waste.

Water covers are best suited to net positive climatic water balance areas (*i.e.*, annual precipitation exceeds evaporation), since that implies a surplus supply of water to the cover. Water covers are less favourable when permanent engineered water retaining structures are required at a large scale, such as dams that may be subject to long-term integrity concerns.

Based on the diffusion coefficient of oxygen through water, it is accepted that under ideal conditions a minimum of 30 cm of water cover would be sufficient to prevent oxidation. In reality, waste disposal facilities are typically large, and are subject to wind induced wave action, counter-current flows, seiching, lake/pond turnover, lake/pond ice formation, etc. These physical actions result in water turbulence, which in turn, may result in resuspension of particles. Resuspended particles may undergo oxidation rendering the water cover ineffective. Rules-of-thumb state that a 1 m thick water cover would mitigate against these concerns; however, a review of current practice shows that typical water cover depths are between 2 and 5 m thick. A permanent water cover is not recommended for the Tenas Project due to increased evaporation from an open water surface and a preference for re-establishing vegetation as the final closure configuration.

2.2 Saturated Soil Cover

Saturated soil covers are an alternative method of ensuring isolation of wastes from exposure to oxygen, but by eliminating the need for large stretches of open water, the issues associated with resuspension of solids are eliminated. The concept entails using a coarse (ideally gravelly) material with significant void space for the primary cover layer and maintaining it in a perpetually saturated state. This saturated layer can be at surface or at depth, *i.e.*, providing opportunity for an upper cover layer that may sustain vegetation. This type of cover works best if the climatic water balance is positive, and just as with the water cover, may be ineffective if significant oxidation products are already present. This type of cover is recommended for the Tenas Project to ensure that the Non-PAG and PAG material remains perennially saturated.

2.3 Barrier Covers

Barrier covers (also known as water shedding or infiltration controlling covers) work on the principle of physically limiting meteoric infiltration and in some cases oxygen ingress. SRK's current understanding is that PAG rock and processed rock are to be dumped sub-aqueously or else are to be covered by water within several months post dumping to ensure that oxidation does not occur.

Physical barriers can come in many different forms, including natural low permeability soil or impermeable synthetic barriers such as high-density polyethylene (HDPE), low linear density polyethylene (LLDPE), bituminous, or geosynthetic clay liners (GCL). A barrier cover can also be constructed by amending the surface layer of mine waste to achieve a low permeability layer. This type of cover is not consistent with the desired outcomes for the Tenas Project.

2.4 Store and Release Cover

An alternative method of reducing infiltration is to make use of the inherent soil moisture storage capacity of the soil. Meteoric infiltration is not prevented as with a barrier cover, but rather promoted, such that the moisture is stored in the cover soil. This moisture is returned to the atmosphere via evapotranspiration before is has the opportunity to drain through the cover and enter the underlying waste. These covers are referred to as "store-and-release" covers (also called "water retention" or "alternative" covers), and work most effectively in dominantly net negative climates, *i.e.*, the potential evaporation greatly exceeds the mean annual precipitation (typically at least two or three times greater).

Ideal store-and-release cover soils are well-graded soils that have sufficient fines to allow capillarity to be high whilst not compromising too much of the material porosity. Store-and-release covers are less susceptible to site preparation and quality control since compaction of the soil cover is generally not required (or in fact, not recommended) and the cover is of sufficient thickness to mask minor undulations on the waste surface. Settlement of the waste will also not affect the cover as much. Direct re-vegetation of the store-and-release cover is generally undertaken, unless the soil has a nutrient deficiency. The successful establishment of vegetation on a store-and-release cover is crucial towards its success since the enhanced evapotranspiration will ensure long-term cover performance. This type of cover is not recommended for the Tenas Project since water must infiltrate through the cover into the PAG materials to replace water losses through the base of the facility into the groundwater system. Specifically, infiltration must be facilitated to meet the goal of perennial saturation and avoid water table fluctuations that facilitate oxidation and chemical transport.

2.5 Reactive Cover

Reactive covers normally refer to covers that include chemically active components. Broadly speaking, two types of such reactive covers are referred to: (1) Covers where the reaction leads to consumption of oxygen, and (2) covers where the reaction leads to formation of low permeability layers and/or barriers to oxygen diffusion. It is not expected that a reactive cover will be required or put forward for the Tenas Project closure plan.

3 Conceptual Cover Design

3.1 Site Wide Closure Objectives

The site wide closure objectives are as follows:

- Protect people from safety risks when they are pursuing traditional activities including hunting, fishing, trapping, camping and collection of plants for food, medicinal, cultural or recreational purposes;
- Protect the environment (including land, air, water, plants, animals, fish and other environmental components and their interrelationships) from long-term effects caused by the mine activities and facilities;
- Return the mine site and affected areas to a state similar to the surrounding landscape;
- Ensure the long-term chemical and physical stability of residual mining components and minimize their effects on water quality in the receiving environment;
- Ensure the long-term physical stability of key structures such as the Management Ponds, collection channels and spillways; and
- Work towards a passive closure scenario for most or all mine components.

3.2 Possible Cover Functions

Covers are one of many possible mitigation strategies that can be used to achieve site wide closure objectives. Two other common strategies include material relocation and water treatment, neither of which are considered for the Tenas Project at this time. If conditions are such that covers are a suitable mitigation strategy, then the specific function that the cover needs to perform in order to meet the closure objective must be explicitly stated.

The following cover functions are recommended for the Tenas Project based on the current understanding of future site conditions:

- Increase infiltration to a specific target that would ensure an adequate water table level is maintained to maintain saturated conditions in Non-PAG and PAG material with minimal erosion;
- Maintain a positive water balance that ensures that a minimum of 1 m water cover is maintained above PAG material to prevent oxidation and achieve downstream water quality objectives;
- Isolate the mine materials to avoid direct contact by human or other terrestrial animals; and
- Provide a stable landform that is aesthetically pleasing.

3.3 Preliminary Cover Design Criteria

Cover functions consistent with the desired closure outcomes were detailed in Section 3.2. However, a rigorous evaluation of cover alternatives based on their technical merits requires a specific set of measurable criteria. One example of such criteria set is provided in Table 3-1. As the closure planning process advances, it is expected that these criteria will be updated or revised to reflect site specific data.

Table 3-1. Proposed Cover Design Criteria

Component	Criteria
Design Life	500 years with monitoring and maintenance
Oxygen Reduction	This is the fundamental requirement for the covers considered. It is proposed to be achieved through saturated cover layer.
Infiltration Reduction	Not required.
Differential Settlement	No specific criteria. Minimal differential settlement expected with appropriate waste deposition controls.
Seismicity	1 in 2,475 year recurrence interval (10% probability of exceeding in 50 years).
Physical Exposure	Saturated cover layer must extend over the entire waste surface, and therefore waste exposure is completely eliminated.
Slope Stability	Overall factor of safety of at least 1.3 under static conditions and 1.1 under seismic loading.
Wind Erosion	No visible dust up to and including wind speeds with a recurrence interval of 1:10 years, for any given duration.
Overland Surface Runoff	Capable of withstanding 1:200 year, 24 hour duration storm with no damage.
Evapo-Concentration	No salt recrystallization or evapo-concentration of contaminated porewater on any of the cover surface.
Root Uptake of Contaminants	Not required.
Vegetation	Self-sustaining vegetation cover endemic to the region within 5 years after cover construction (foreign species and fertilizers during early years acceptable if it supports the final objective).
Land Use	General vegetated area. Terrestrial animals, birds and aquatic life will be present. Humans may travel through the area infrequently. Specific measures to preclude damage to the covers due to human and/or animal use may be required.
Landform	Conform to final closure configuration of Management Ponds. Provide for variability on cover thicknesses and landscaping to promote establishment of microclimates and variability

3.3.1 Specific Cover Design Considerations

Cover Design Life

SRK does not believe that engineered soil covers can be expected to continue to perform in accordance with their original design intent for an infinite lifetime after construction (*i.e.*, in perpetuity), especially if there is no monitoring and maintenance plan in effect. Therefore, it is appropriate to design soil covers and associated monitoring and maintenance plans with a finite lifespan in mind. The length of that time period should dictate to what standard the cover must be designed and constructed, and also what level of monitoring and maintenance would be required.

There are no specific guidelines or standards in Canada that specify the lifespan for covers, leaving the design decision to the discretion of the mine operator. Internationally, there are also no fixed criteria for cover lifespan; however, some mining companies explicitly adopt life spans of 100, 200 or even 500 year periods during which the cover is expected to perform in accordance with the original design intent (Rykaart *et al*. 2006).

The design life of a cover is complicated by the fact that some cover failure modes require inherently different approaches. For example, if the Tenas Project was to adopt a design life for the conceptual cover designs presented in this report of 500 years, then it would be assumed that these covers would continue to perform the functions listed in Table 3-1 for this lifespan. However, portions of the cover design may have different design criteria; for example, surface water conveyance channels may be designed to withstand 1:200 year storm events with an understanding that the necessary maintenance and repair would be carried out for the 200 year design life of the cover.

It would be premature for SRK to recommend a design life for the Tenas Project covers in isolation of the overall closure design, as well as input from stakeholders. A risk assessment approach can be used during detailed design to evaluate the consequences of the different cover failure modes and what the optimal cover design life should be.

Site Climate

Site specific climate is one of the primary drivers that define what the most appropriate and sustainable cover may be for any given Project area. The three dominating climatic parameters include the climatic water balance, air temperature, and solar radiation (based on latitude).

Site-specific climate data is available with records from one onsite weather station. The Tenas Deposit Station (54.59° N, 127.19° W) has an available dataset spanning 29 September 2017 to December 2019; however, the dataset is generally too short to be directly applied within a scoping level cover assessment. Regional climate data is available from six regional weather stations, managed by Meteorological Services Canada (Environment Canada). The Smithers Airport station is located approximately 25 km away from the Project area and was used as the primary source of regional longer-term meteorological data (SRK 2021b). Due to differences between the location and elevation of the Tenas Project area and the Smithers Airport station, the long-term meteorological record was used in conjunction with other records (*i.e.*, reanalysis products). For this analysis, meteorological parameters on a monthly timestep for the Pacific Region of Canada and the northwestern USA from the PRISM reanalysis dataset were used (PCIC). Given a strong correlation between the Tenas Deposit Station and Smithers Airport, PRISM data was obtained and monthly correction factors for the Tenas Project area relative to the Smithers Airport station were developed to account for orographic gradients and temperature inversion effects.

Once gap-filled and corrected for orographic gradients, the Tenas Project mean annual precipitation (MAP) was estimated to be 608 mm. Approximately 59 % of this precipitation falls as rain, with the remainder being the snow water equivalent of the annual snowpack. However, comparison between the patched Smithers precipitation and the climate normal suggests that the two years recorded at the Tenas Deposit Station were drier than average, which introduces the possibility that the synthetic record generated for the Tenas Project area may underestimate precipitation.

Using the synthetic record generated for the Tenas Project area spanning 1942-2020, a snowmelt model was developed to calculate monthly available water, or excess water, which represents the monthly sum of rainfall and snowmelt. The annual sum of mean excess water is equal to the mean annual total precipitation value of 608 mm. Monthly excess water for the Project are presented in Table 3-2.

The only regional station with evaporation measurements is Topley Landing, located 71 km northeast of the Project at an elevation of 722 masl. Mean annual lake evaporation at Topley Landing was 401 mm based on the 1981-2010 Canadian Climate Normals published by Environment and Climate Change Canada (ECCC, 2021). Note that relative humidity and solar radiation are not measured at Topley Landing so a direct comparison of each calculation method results to observations could not be completed. Large and shallow water bodies such as the Management Ponds and other sedimentation and control ponds can experience direct water losses from evaporation. Lake surface evaporation for the Project was developed using the Morton CRWE shallow lake evaporation method (Morton, 1983). Based on the adjusted temperature record, modelled solar radiation and relative humidity and wind speeds from the Smithers Airport station, the estimated mean annual evaporation for the Project is 529 mm from open water bodies (SRK 2021b).

Table 3-2. Project Average Monthly Excess Water and Open Water Evaporation [mm]

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Excess water	1	2	9	122	219	46	47	44	52	56	9	2	608
Evaporation	0	0	0	60	97	108	116	99	50	0	0	0	529

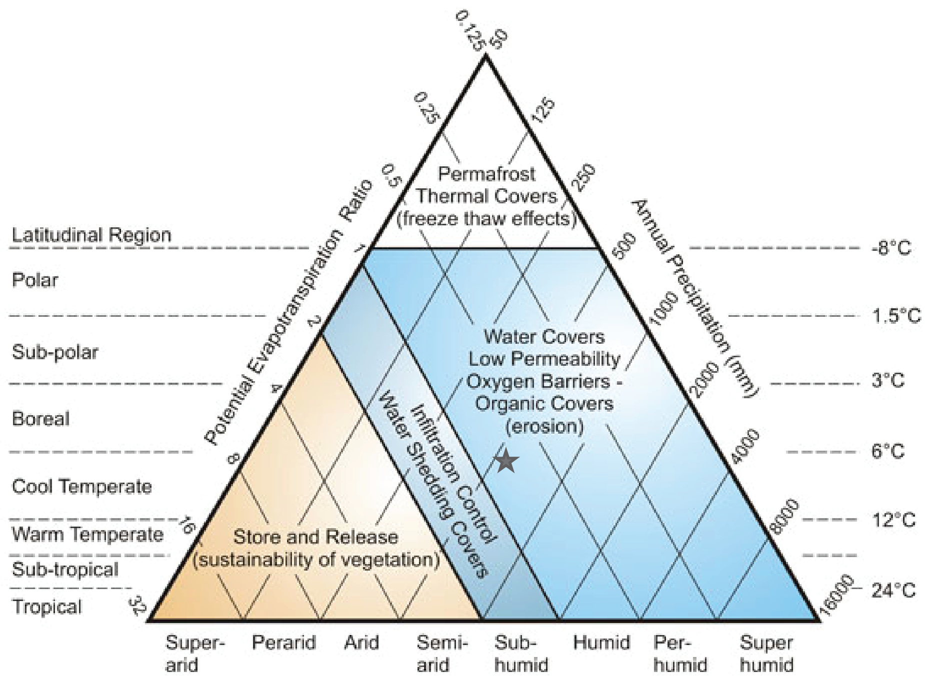
Source: SRK 2021b

In the short-term, the mean monthly climatic water balance based on this data shows that between May and August, the modelled water balance is net negative, *i.e.*, evaporation exceeds precipitation. This highly seasonal water balance deficit on a near neutral annual water balance makes it challenging to determine the most suitable cover type and a more in-depth analysis of the long-term meteorology is required. It is expected that evapotranspiration from a vegetated cover surface will be less than the potential evaporation estimated for open water bodies (Table 3-2). This assumption was investigated and the method is described in Section 3.3.2 with outcomes detailed in Section 3.4.2.

3.3.2 Water Balance Investigation

Additional climate data for the Tenas Project at the elevation of the Tenas Deposit Station was accessed from ClimateWNA for a period of 100+ years. The seasonal and annual water balance for direct precipitation and reference potential evapotranspiration was used to consider vegetation viability. ClimateWNA data was initially generated using historical weather station data produced for western North America and global circulation models to project future seasonal and annual climate variables by the Pacific Climate Impacts Consortium (PCIC). PRISM (Daly *et al.*, 2008) and ANUSPLIN (Hutchinson, 1991) monthly data (2.5 x 2.5 arcmin) is extracted and downscaled for specific locations based on a combination of latitude, longitude and elevation (optional). The programs also integrate historical (1901-2013) (Mitchell and Jones, 2005) climate data sets to output both directly calculated and derived climate variables. Methodologies used to calculate to generate 23 annual, 56 seasonal and 168 monthly climate variables are outlined in Wang *et al.* (2016). Reference evapotranspiration is based on the Hargreaves 1985 equation (Hargreaves *et al.*, 2003).

Annual precipitation and potential evapotranspiration for 1901-2019 were used as inputs to determine the evapotranspiration ratio as well as a simplified water balance of P-PET (precipitation – potential evapotranspiration). Annual values were used to situate the Tenas Project within an adaptation of the Holdridge *et al*. (1971) life zone classification, as presented in the Global Acid Rock Drainage (GARD) Guide (INAP 2012). The data suggests that the site is best suited towards either water covers or infiltration controlling (*i.e.*, barrier type) covers. Store-and-release and thermal covers on the other hand are not recommended for the site based on climatic conditions and long-term water balance considerations.



Source: www.gardguide.com/index.php?title =File:CoversandClimateTypes.jpg

Figure 3-1. Adaptation of Holdridge et al (1971) Life Zone Classification Presented in Global Acid Rock Drainage (GARD) Guide.

A longer-term water balance approach was also undertaken using ClimateWNA to determine how site-specific precipitation and reference potential evapotranspiration (PET) at the elevation of the cover area behaved over time. On an annual basis, only four (4) years from 1901 to 2019 had a deficit using the simplified water balance calculation of P-PET. For these 4 years, mean annual precipitation (MAP) spanned the 1:10 to 1:50 dry years as defined in the Hydrometeorological Baseline Report (Section 4.1.2., SRK 2021b) and PET was high due to high associated air temperature and solar radiation. Another eight years with similar MAP did not show a deficit. Average PET was 452 mm/year with a range from 371 mm/year to 542 mm/year.

Additionally, the PET estimates are unconstrained by soil parameters and moisture availability, which often limit actual evapotranspiration (AET). Thus, AET from studies in the Boreal region of Canada were assessed to determine the reasonability of the PET estimates, based on similar types of vegetation. The long-term actual evapotranspiration (AET) at established black spruce (1999-2017) and aspen (1996-2017) forests ranged from 252 mm/year to 446 mm/year. AET values from the spruce forest had a maximum of 350 mm/year while aspen forest AET reached a maximum of 450 mm/year (Stephens, 2020).

3.3.3 Other Considerations

Potential Cover Materials

Locally available, surficial soil samples have so far consisted of dominantly clay or clay-ey materials. These overburden soils were investigated as part of a characterization program intended to determine suitability for use as clay liners to ponds.

It is unknown if other candidate cover soil sources have been investigated. Based on the available data, cover material with less fines are desired to increased hydraulic conductivity and facilitate infiltration of meteoric waters will be required in certain areas. A saturated hydraulic conductivity (K_{sat}) exceeding $10E^{-5}$ m/s is desirable for the high infiltration zones, whereas the desired K_{sat} of cover zones with primarily vegetation support functions should be determined at a later time to satisfy specific agronomical requirements.

Seismicity

According to the 2015 National Building Code of Canada seismic hazard calculator, the corresponding peak ground acceleration (PGA) for the Tenas Project is 0.10 times the value of gravity for a 2% probability of exceeding in 50 years (1 in 2,475). This means that this site is not particularly seismically active (Pinto, 2000).

Overland Surface Runoff

It is important to remember that water introduced into the cover areas via runoff from direct precipitation will be encouraged to infiltrate to the deeper PAG and Non-PAG layers to retain saturated conditions, however, excess water from large storms must be managed to reduce the risk of excessive cover erosion. Therefore, the cover design must account for the volume, frequency and intensity of runoff that is anticipated and the seamless integrated designs of the cover and conveyance channel contact zones are integral to the overall success of the cover.

Less runoff implies that more water is available for infiltration. If a significant portion of the freshet season runoff infiltrates into the cover and PAG and Non-PAG materials, then the likelihood of reaching a workable ratio of infiltration versus potential evaporation increases, making this type of cover more viable.

Evapo-Concentration

Chemical constituents present in the mine waste pore water, specifically salts, can be transported up (“wicked”) towards the waste surface, and continue up through the cover soil due to capillarity associated with upward fluxes caused by evaporation and transpiration processes. This problem, also termed evapo-concentration, is common in net negative climates where the predominant flux is upward. If evapo-concentration occurs, it leads to contamination of surface water, which would constitute as non-compliance with the site closure objectives. During freshet, there would be a constant variability of the flux within the cover, but evapo-concentration is not likely to be a major concern. However, during prolonged dry periods, the predominant flux would be upwards, especially if the underlying waste has a high moisture content.

This can however be mitigated by making the cover thick enough that all the meteoric action occurs within the cover with no contribution from the underlying Non-PAG and PAG layers. Another option would be including a physical barrier in the cover that prevents this pore water from migrating up through specific cover layers. The most common physical barrier is a capillary break. Since evapo-concentration is a potential issue at the Tenas Project, a capillary break should be considered during the detailed cover design.

Root Porewater Uptake

Allowing vegetation to establish on the final Tenas Project closure covers is probably the most sustainable long-term solution. A vegetative cover offers benefits such as erosional stability from wind and surface runoff by mitigating rainfall intensity via canopy interception and with roots providing soil retention. However, a vegetative cover can lead to creation of preferential flow paths through root penetration as well as potential contaminant uptake from the underlying waste by the plant root systems to the surficial plant biomass, which in turn could pose a terrestrial exposure risk.

Mitigation against root uptake could include limiting plant growth outright, or constructing a chemical or physical root barrier as part of the cover. Outright prevention of vegetation can only be done through active site management, since even if coarse rock is used as a cover, dust and seed will be transported to the cover over time through wind from neighbouring undisturbed land and, ultimately, some vegetation will establish. Since active site management is not acceptable and a vegetation cover is encouraged for the Tenas Project, a chemical or physical root barrier should be included as part of the cover to prevent root uptake of contaminants.

Chemical root barriers, although expensive, work well in cold climates and are likely to have a significant lifespan. A more common root barrier is a physical barrier, consisting of a layer of gravel and cobbles overtopped with fines such as the candidate cover soils. The overburden or cover soil layer thickness should exceed the potential root length and would need to be optimized based on the vegetation to be planted and expected wind-transported vegetation types. The layer of gravel and cobbles would act as a capillary break and decouple lower layers from the overburden or cover soil layer. In terms pf a physical root barrier, this layer should be at least 15-20 cm thick. The root barrier will serve a secondary purpose of acting as a bio-intrusion layer preventing burrowing animals from penetrating the underlying waste.

3.4 Specific Water Balance Considerations

3.4.1 NAG and PAG Material Compartment

Extensive calculations using the site-wide water and load balance model detailed in (SRK 2021a) have demonstrated that the Non-PAG and PAG material in the management ponds should remain saturated under a range of conditions, including both current hydrometeorology and forecasted climate change impacts.

3.4.2 Vegetation Cover Compartment

For the purposes of this assessment, the vegetation cover water budget is decoupled from the Non-PAG and PAG layers and is not expected to access water contained in the rock compartment below the active water surface. A simplified water balance of P-PET (precipitation – potential evapotranspiration) was used to determine if precipitation could support a vegetation cover without runoff contribution over a range of historical and current conditions (1901-2019). This calculation showed that 96% of years had precipitation contributions greater than the PET demand on an annual basis so it is expected vegetation can be supported given this result. Additional details on this approach are described in Section 3.3.2.

Results and Discussion

The availability of water for the vegetation cover seems sufficient according to a conservative water balance calculation for 100+ years encompassing MAP values of 1:10 to 1:50 dry and reference and reference crop PET. Long-term AET measurements from black spruce and aspen forests in the Boreal region of Canada were within the range of PET calculated for reference crops, which demonstrated the reasonability of the PET estimates. PET represents a maximum possible ET without consideration for moisture constraints. In combination with water balance considerations, the type of vegetation cover suitable for successful establishment within the topsoil cover of the Tenas Project area should be determined based on: (1) A PET module added to the site-wide water and load balance model for runs in stochastic mode that adequately explore initial conclusions and increase certainty surrounding vegetation type and related PET, (2) vegetation trials that will inform best practices in closure.

3.5 Conceptual Cover Design Description

3.5.1 Concepts for Construction

The PAG material will be disposed of in dedicated lined facilities, and a permanent water level will be maintained at the top elevation of the Non-PAG material cover to prevent (1) the oxidation of the underlying PAG material and (2) flushing of dissolved metals from the non-PAG materials. A schematic of this concept is shown in Figure 3-2.

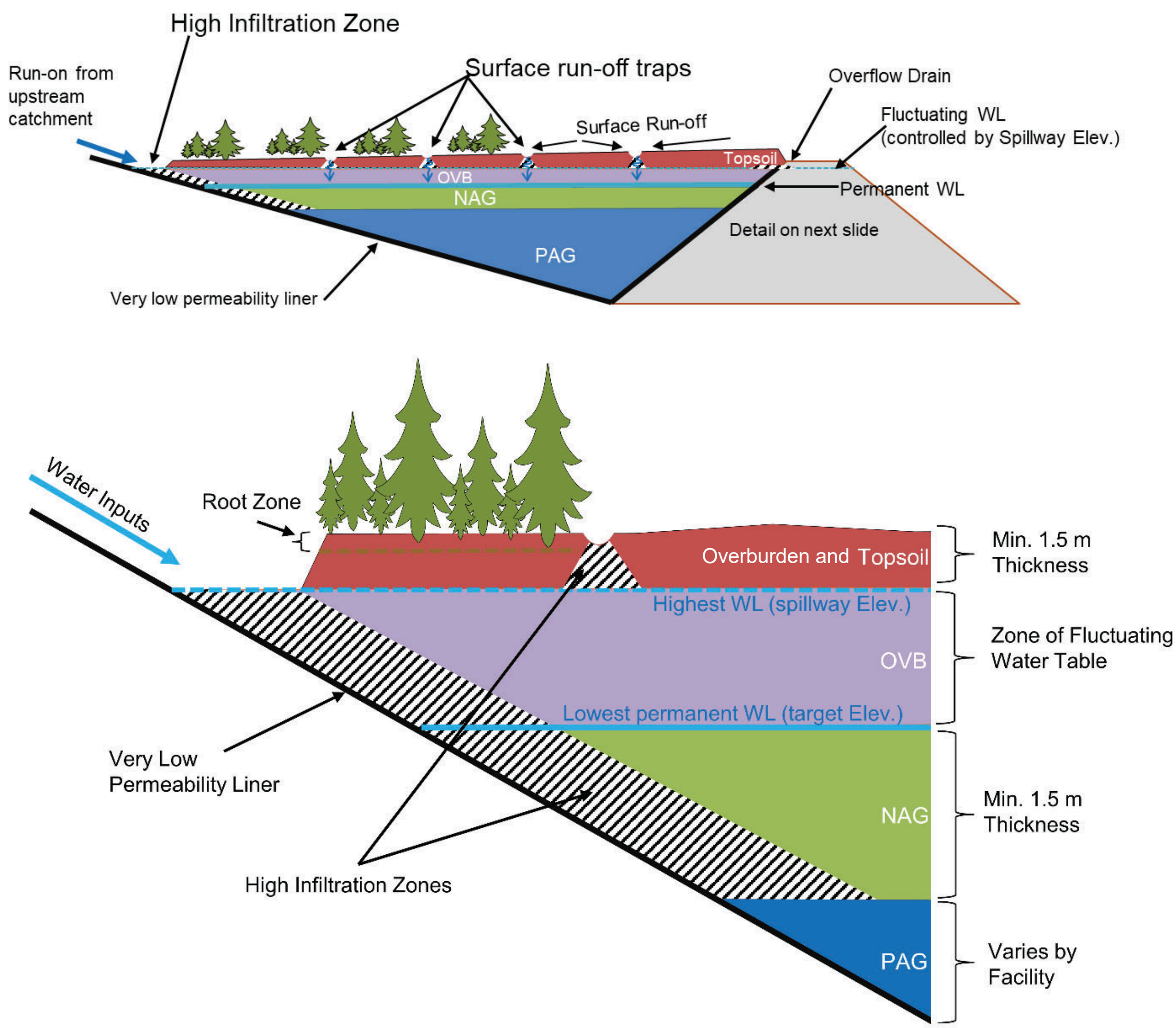


Figure 3-2: PAG and NAG Management Ponds Concept Schematic

Sources: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\1300_CoverDesign\Telkwa_Cover&WB_ConceptSketch_rev01_IM.pptx

Notes: Very low permeability liner constructed of sand/bentonite mixture

A variably saturated overburden cover will be constructed on top of the non-PAG material, and the water level will be allowed to change within this layer but never to drop below the bottom of it, *i.e.*, into the non-PAG material layer. This will ensure that a reserve is built up at times when the climatic water balance is positive. During subsequent dry periods, this accumulated reserve will compensate for seepage losses.

A vegetation support cover will be constructed atop the overburden layer using locally harvested and stockpiled topsoil. This layer must be thick enough so that the surface flux balance (runoff, infiltration, evapotranspiration, storage) will have negligible influence on the underlying variably saturated overburden layer. Most importantly, upward flux from the overburden layer must be eliminated, as much as possible. Conceptually, this represents a decoupling of the water balance within the vegetative cover and the water balance of the underlying layers. If deemed necessary, a layer of coarser material could be placed between the overburden and topsoil layer to act as a capillary break to ensure decoupling of the topsoil layer (supporting vegetation) from lower layers.

High Infiltration Zones

Captured free water will be directed into the Management Ponds through a system of high infiltration zones, an example of which is shown in Figure 3-3.

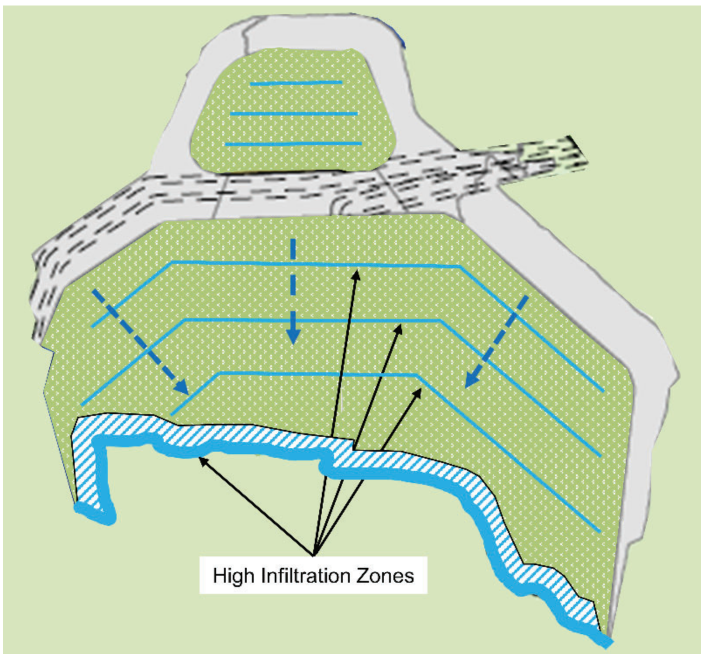


Figure 3-3: Concept Schematic in Plan View of High Infiltration Zones Along Periphery of and Within Management Ponds

Runoff will be directed to the high infiltration zones located at the periphery of the Management Ponds. The infiltration zones would extend in depth through the topsoil and overburden into the non-PAG material to ensure water is transmitted as efficiently as possible into the non-PAG and PAG layers. High infiltration zones will consist of high permeability granular materials, predominantly sandy soils with a minimum saturated hydraulic conductivity of $10E^{-5}$ m/s. Granular material may be wrapped in a geotextile to limit water losses into the topsoil layer and promote vertical drainage to the NAG material. The depiction and shape of the high infiltration zones in Figure 3-3 is purely conceptual and can be changed to suit future, more refined designs. In this manner some of the water is allowed to infiltrate while the excess, such as during high flow events, can be passed quickly to mitigate possible cover erosion and instability concerns.

The surface run-off channels would be constructed as “leaky ditches” with the base of the channel formed using soils with suitably high K_{sat} values.

Vegetation Support Cover

Based on the conceptual water balance of a vegetation cover, with consideration of local and regional climate and typical endemic vegetation, natural precipitation will provide sufficient water to vegetation without a runoff contribution from surrounding catchments.

Capillarity of the topsoil should be low enough that upward migration of water from the underlying variably saturated overburden layer is insignificant. Ideally the hydraulic properties of the topsoil and overburden are different enough such that a moderate capillary break effect is created. As a contingency, a relatively thin layer (0.15 m) of coarser granular material could be constructed between the two layers to purposefully introduce the capillary break.

Testing of physical and hydraulic properties of the candidate topsoil materials will have to be completed to confirm that sufficient storage is available so that no severe water shortage will occur leading to poor vegetation success, and to avoid vegetation sending roots deep into the cover to extract water from the variably saturated overburden layer.

Variably Saturated Overburden Layer

As shown in Figure 3-2 the overburden layer sits between the mine material stored in the management ponds and the vegetation support cover. The function of this layer is to act as storage and prevent the water level dropping below the bottom of this layer and into the NAG material.

This layer would be variably saturated in the sense that water will rise to the top of this layer during periods of high precipitation and the water level could gradually decrease during periods of dry weather. The top level would be controlled by the spillway elevation.

4 Conclusions and Recommendations

The hydrologic and climatic regime at the Tenas Project site appears suitable to maintain saturated conditions within the Non-PAG and PAG layers (SRK 2021a). A cover design system comprised of a Non-PAG/PAG compartment that should remain perennially saturated with an overlying overburden material and topsoil cover with high infiltration zones is recommended. A capillary break should also be considered during the detailed cover design, in the form of gravel and cobbles, which will also impede root uptake of contaminants. Additional optimizations of overburden or cover soil layer thickness may be required based on root length of selected vegetation (spruce and pine forest) for the final covered surface.

The available overburden and topsoil material at the Tenas Project are not suitable for construction of these high infiltration zones. This means that other source materials should be located. A vegetation cover should be established in the topsoil over top of the overburden layer. Multiple approaches were used to determine that the water balance under current and future conditions can support an isolated vegetation cover independent of runoff contribution.

This report, "Tenas Project – Scoping Level Cover Assessment for Closure Covers" was prepared by

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All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

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