CONCEPTUAL RECLAMATION AND CLOSURE PLAN

KUDZ ZE KAYAH PROJECT

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Prepared for:

BMC MINERALS (NO.1) LTD.

EXECUTIVE SUMMARY

BMC Minerals (No.1) Ltd. (BMC) proposes the development of the Kudz Ze Kayah (KZK) Project (the Project) in southeast Yukon and in the Kaska Nation (Kaska) Traditional Territory. The Project is a proposed open pit/underground copper, lead, and zinc mine located approximately 115 km southeast of Ross River, Yukon. This document presents the Conceptual Reclamation and Closure Plan (CRCP), which has been designed utilising a methodical approach in order to develop sound, appropriate, and responsible and achievable closure goals and objectives for the Project. The format of this CRCP is based on the Yukon Government's (YG) guidance document "Reclamation and Closure Planning for Quartz Mining Projects" (YG, 2013).

The CRCP is guided by the Project closure goal, which is grounded in responsible stewardship, consultation with stakeholders, and appropriate end land use considerations, including recognition of the Kaska Land Use Principles:

- *To return the mine site and affected areas to viable and, wherever practicable, self-sustaining ecosystems that are compatible with a healthy environment and with traditional land use activities.*

The CRCP illustrates the process by which closure measures (including design for closure work) have been designed to meet these objectives, and presents a framework for how attainment of the objectives will be evaluated through post-closure monitoring programs. The proposed closure measures, monitoring programs and investigative work described in this CRCP are conceptual. This level of detail is appropriate to ensure that closure measures:

- Support the Project's proposed closure goals and objectives;
- Are technically feasible and are practical to achieve
- Support the evaluation of potential environmental and socio-economic effects from the Project in the closure and post-closure phases; and
- Are defined adequately to support the conceptual cost estimate.

This CRCP presents the closure alternatives considered, as well as the conceptual progressive reclamation and reclamation research plans (some of which are currently underway) that will be undertaken leading up to and through mine construction and operations.

Three distinct closure phases, or 'periods' have been identified for the Project reclamation and closure at the end of the operational mining period (year 10): Active Closure Period (years 11 to 13), Transition Closure Period (years 14 to 26), and the Post-Closure Period (years 27 to 36). Conceptual closure measures are presented in more detail regarding decommissioning and reclamation work in the active closure period, and subsequent reclamation and water management measures specific to the transition closure and post-closure period. Monitoring and maintenance programs spanning all closure periods are also outlined.

During operations, mining will produce waste rock and tailings, which will be geochemically classified and stored accordingly in one of three storage facilities;

- The Class A Storage Facility is a co-disposal facility for waste rock and filtered reactive tailings that are strongly Potentially Acid Generating (PAG) and as such requires a land form and cover that reduces net percolation by 98%.

- The Class B Storage Facility is for weakly (PAG) waste rock and requires a landform and cover that reduces net percolation by 75%; and

- The Class C Storage Facility is for Non-PAG waste rock, which does not require a cover to reduce net percolation, but will be covered to re-establish vegetation.

All facilities will be progressively reclaimed during operations. During operations and the Active Closure Period collection ponds will store water from the Class A and B Storage Facilities that will be directed to a water treatment plant (WTP) or used as recharge water in the Process Plant. During the Transition Closure Period, the Constructed Wetland Treatment Systems (CWTS) will be constructed and commissioned which will treat (ensure?) any residual loading ensuring water quality objectives are met downstream. At this time the WTP will be decommissioned.

Reclamation and closure liability was estimated for the Project in the form of a high level estimate. The cost estimate assumes the use of third party contractors and equipment for implementation of major earthworks and terrestrial tasks. The Company intends to progressively rehabilitate the Project during its life however the total financial security, including contingency, has been estimated at CAD$ 90,500,000 assuming that there is limited progressive rehabilitation during the operation of the Project.

LIST OF ACRONYMS

AANDC	Aboriginal Affairs and Northern Development Canada
AEG	Alexco Environmental Group Inc.
AMP	Adaptive Management Plan
BCMOE	British Columbia Ministry of Environment
BMC	BMC Minerals (No.1) Ltd.
BSC	Biological Soil Crust
CCME	Canadian Council of Ministers of the Environment
Cominco	Cominco Ltd.
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CRCP	Conceptual Reclamation and Closure Plan
COPI	Constituents of Potential Interest
CWTS	Constructed Wetland Treatment Systems
DOC	Dissolved Organic Carbon
EMSRP	Environmental Monitoring, Surveillance, and Reporting Plan
EMR	Energy, Mines and Resources
FCH	Finlayson Caribou Herd
FMEA	Failure Modes and Effects Analysis
*H:*V	Horizontal Length to Vertical Length Ratio
HDPE	High Density Polyethylene
INAC	Indian and Northern Affairs Canada
ITRC	Interstate Technology Research Council
LFN	Liard First Nation
LSA	Local Study Area
LWMP	Lower Water Management Pond
Kaska	Kaska Nation
KP	Knight Piésold Ltd.
KZK	Kudz Ze Kayah
masl	Metres Above Sea Level
MEND	Mine Environmental Neutral Drainage
mg/L	Milligrams per Litre
MLU	Mining Land Use (Approval)
Mt	Million Tonnes
Mtpa	Million Tonnes per Annum
MVLWB	Mackenzie Valley Land and Water Board
pH($CaCl_2$)	Soil pH in $CaCl_2$
PFS	Pre-Feasibility Study
pWQO	Preliminary Water Quality Objective
QML	Quartz Mining License
ROM	Run-of-mine
RCP	Reclamation and Closure Plan
RRDC	Ross River Dena Council

RSA	Regional Study Area
SARA	Species at Risk Act
SER	Society for Ecological Restoration
SSWQO	Site Specific Water Quality Objective
TEM	Terrestrial Ecosystem Map
TSS	Total Suspended Solids
UWMP	Upper Water Management Pond
WRMP	Waste Rock Management Plan
WRSF	Waste Rock Storage Facility
WUL	Water Use Licence
YG	Yukon Government

GLOSSARY

Ablation: the removal of snow and ice by melting or evaporation.

Aquifer: a body of permeable rock that can contain or transmit groundwater.

Arrhenius Equation: an equation describing the mathematical relationship between temperature and the rate of a chemical reaction, expressed as $k = Ae^{-E/RT}$ where k is the rate of chemical reaction, A is a constant depending on the chemicals involved, E is the activation energy, R is the universal gas constant, and T is the temperature.

Bench-scale: testing of materials, methods, or chemical processes on a small scale, such as on a laboratory worktable.

Biological Soil Crust: early successional communities composed of bacteria, cyanobacteria, algae, mosses, liverworts, fungi and lichens.

Brunisol: a weakly developed mineral soil with a sufficiently developed B horizon that distinguishes it from a regosol.

Clean Rock: rock with geochemical characteristics that are benign-to-acid consuming, considered acceptable for general surface construction, such as roads, ditches, toe berms, and liner protectors.

Colluvium: material that accumulates at the foot of a steep slope.

Cryosol: permafrost soils.

Decommission: to take facilities out of service.

Decision Document: a written document issued by the Decision Body that accepts, varies, or rejects the recommendation made by the Yukon Environment and Socio-Economic Assessment Board following the completion of the assessment.

Ecoregion: ecoregions represent smaller areas of ecozones characterized by distinctive physiography and ecological responses to climate as expressed by the development of vegetation, soil, water, and fauna.

Ecosite: an area of vegetation association related to a combination of moisture and nutrient regimes specific to an ecoregion.

Ecozone: biogeographic realm is the broadest biogeographic division of the Earth's land surface, based on distributional patterns of terrestrial organisms.

Edatopic grid: a grid of moisture and nutrients used to define the variability of soil and vegetation types for a given region.

Effluent: liquid discharge.

Ethnography: the scientific description of the customs of individual peoples and cultures.

Fluvial: of or found in a river.

Fungi: a general term used to denote a group of eukaryotic protists, including mushrooms, yeasts, rusts, molds, smuts, etc., characterized by the absence of chlorophyll and by the presence of a rigid cell wall composed of chitin, mannans, and sometimes cellulose.

French Drain: a trench filled with gravel or rock or containing a perforated pipe that redirects surface water and groundwater away from or to an area.

Geochemical: the related chemical and geological properties of a substance.

Graminoid: herbaceous plants with a grass-like morphology, includes the families Poaceae (grasses), Cyperaceae (sedges), and Juncaceae (rushes). Graminoids are often dominant in open habitat comprising grasslands, marshes, and alpine meadows.

Heterogeneity: the uneven distribution of features and/or species in an area.

Hydraulic: denoting, relating to, or operated by a liquid moving in a confined space under pressure.

Hydrosoils: soils that are saturated with water for a long time.

Infiltration: the process by which water on the ground surface enters the soil.

Influent: water, wastewater, or other liquid flowing into a reservoir, basin or treatment plant.

Inoculation: the act of introducing microorganism or suspension of microorganisms (e.g., bacteria) into a culture medium.

Liability: the state of being responsible for something, especially by law.

Kame: a geomorphological feature, an irregularly shaped hill or mound composed of sand, gravel and till that accumulates in a depression on a retreating glacier, and is then deposited on the land surface with further melting of the glacier.

Kettle: a shallow, sediment-filled body of water formed by retreating glaciers or draining floodwaters.

Metal(loid): element whose properties are intermediate between metals and solid non-metals.

Mesic: an environment or habitat characterized by a moderate amount of moisture.

Microenvironment: the immediate small-scale environment of an organism or a part of an organism, especially as a distinct part of a larger environment.

Moraine: a mass of rocks and sediment carried down and deposited by a glacier, typically as ridges at its edges or extremity.

Overburden: rock or soil overlying bedrock or other underground feature.

Percent (%) Grade: vertical rise divided by the horizontal run multiplied by 100.

Permafrost: a thick subsurface layer of soil that remains frozen throughout the year, occurring chiefly in polar regions.

Pilot-scale: a small scale, preliminary study or test conducted to evaluate feasibility, time, cost, adverse events, and effect size in an attempt to predict results and improve upon the design prior to performance of a full-scale study or operation.

Project Area: refers to the general Project location and surrounding area.

Project Footprint: refers to the area within which the Project infrastructure will be located and is the area of direct disturbance from the Project activities.

Regosol: a very weakly developed mineral soil in unconsolidated materials often in mountainous regions.

Rhizomes: thick roots that the plants use to spread.
Solifluction: the gradual movement of wet soil or other material down a slope, especially where frozen subsoil acts as a barrier to the percolation of water.

Subaqueous: under water.

Sub-hydric: an environment or habitat characterized by a large amount of moisture.

Sub-xeric: an environment or habitat characterized by a small amount of moisture.

Tailings: fine ground rock left over from the mill and process plant after removing economic minerals.

Thermodynamic: the relations between heat and other forms of energy (such as mechanical, electrical, or chemical energy), and, by extension, of the relationships between all forms of energy.

Till: unsorted material deposited directly by glacial ice and showing no stratification.

Vegetation Association: group of plant species that occur together on a given area of land with a similar nutrient and moisture regime.

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1 INTRODUCTION

BMC Minerals (No.1) Ltd. (BMC) proposes the development of the Kudz Ze Kayah (KZK) Project (the Project) in southeast Yukon and in the Kaska Nation (Kaska) Traditional Territory. The proposed Project is an open pit/underground copper, lead and zinc mine located approximately 115 km southeast of Ross River, Yukon.

BMC purchased the Project from Teck Resources Ltd. (Teck) in January 2015. Since that time, BMC has actively engaged in a program of assessing historical work and conducting its own advanced exploration program, which has resulted in a revised resource estimate, a redesigned mine plan, baseline environmental studies, and First Nations and community engagement. This work has supported a mine development plan, a Project Description, and a Project Proposal to the Executive Committee of the Yukon Environmental and Socioeconomic Assessment Board. A key element of the mine planning and the Project Proposal is for the incorporation of progressive reclamation into daily mine operations, which will support the successful reclamation, decommissioning and closure of the Project. This document outlines the measures to be taken under the Conceptual Reclamation and Closure Plan (CRCP).

This CRCP presents a methodical approach designed to develop sound, appropriate and responsible closure goals and objectives for the Project. It will illustrate the process by which closure measures (including design for closure work) are designed to meet these objectives, and presents a framework for how attainment of the objectives will be evaluated through post-closure monitoring programs.

Closure planning is a continuum, and carries on up to (and beyond) the initiation of the active closure measures. The proposed closure measures for the Project outlined herein are at a conceptual level, and the level of detail of this plan will increase as closure planning advances.

1.1 SCOPE OF THE CONCEPTUAL RECLAMATION AND CLOSURE PLAN

This CRCP is based on Yukon Government's (YG) guidance document "Reclamation and Closure Planning for Quartz Mining Projects" (YG, 2013). This is a conceptual plan, at a level of detail appropriate to ensure that closure measures:

- Support the Project's proposed closure goals and objectives;
- Are technically feasible and practical to achieve;
- Support the evaluation of potential environmental and socio-economic effects from the Project in the closure and post-closure phases; and
- Are defined adequately to support the conceptual cost estimate.

This CRCP addresses the entire proposed mine development footprint including the Access Road, as far as the Robert Campbell Highway. It builds on closure planning work that was initiated with the planning by the previous site owner, Cominco Ltd. (Cominco), in the 1990's, which has been re-evaluated in both mine development planning (design for closure) and dedicated closure planning. This CRCP presents conceptual progressive reclamation and reclamation research plans (some of which are underway) that will be undertaken leading up to and through mine construction and operations. Conceptual closure measures are presented in more detail regarding decommissioning and reclamation work in the active closure period, and subsequent reclamation and water management measures specific to the transition closure and post-closure period (See Section 8 for Closure Schedule information). Monitoring and maintenance programs spanning all closure periods are also outlined in this document.

2 RECLAMATION AND CLOSURE PLANNING

The overall strategy for the CRCP is to provide a closure condition that requires minimal management and maintenance, with mine features decommissioned, landforms reclaimed, and monitoring conducted until mitigation measures have achieved the closure objectives. The focus of the CRCP is to guide the return of the site to appropriate and functional ecosystems, similar to pre-development conditions, while meeting agreed key end land use objectives.

This section outlines the framework adopted and utilized to establish a specific set of closure goals, objectives, criteria, and measures for the Project, and explains the distinctions and linkages between them.

2.1 CLOSURE OBJECTIVES, PRINCIPLES, AND REGULATORY GUIDANCE

The YG closure guidance document contains direction on the level of detail, information required and processes necessary for developing reclamation and closure plans (RCPs). More specifically, the guide has the following objectives:

- Describing the context for mine closure planning in the Yukon and the rationale for requirements to submit RCPs and liability estimates;
- Describe the principles, philosophy, and broad objectives for closure planning for Yukon mining projects;
- Describe the information expectations for RCPs and liability estimates;
- Provide draft text that will be included in the regulatory submission documents; and
- Identify key sources of additional guidance for preparing RCPs and liability estimates.

Principles and approaches presented by YG (2013) include fundamental reclamation and closure objectives, community and regulatory engagement, reclamation and closure principles, and principles for estimating liability. Specifically, the guidance document identifies the following global principles for reclamation and closure planning for mining projects in Yukon:

- Design for closure;
- Reducing impacted water;
- Source control;
- Progressive reclamation;
- Minimize long-term activities, plan for long-term monitoring and maintenance; and
- Adaptive management is not a reclamation plan.

Specific Project closure measures need to be demonstrably linked to sound goals and objectives for overall closure of the site. Principles and approaches for this reclamation planning at the Project begin with following the principles of the Kaska Dena Land Use Framework (Dena Kayeh Institute, 2010) and Government of Yukon guidance document Reclamation and Closure Planning for Quartz Mining Projects (YG, 2013).

Development on Kaska lands requires a commitment to restore impacted lands. Key principles of the Kaska Dena Land Management Framework that guide reclamation planning and activities include, but are not limited to, the following:

- Maintain ecological processes to sustain biological diversity;
- Respect fish and wildlife; and
- Compensate for and reclaim disturbed Kaska lands.

Importantly, the information available at the time of writing this plan suggests that the key traditional land use in the Project Area is hunting (Dialectic Research Services, 2016). Based on previous resource development in Kaska Traditional Territory, the Ethnographic Overview references sources that report an eastward 'shift' in Kaska land use (primarily hunting) away from the area where the Faro Mine was developed and operated from the 1960s to 1990s.

It is recognized that a complex set of personal, social, cultural, and environmental factors inform decision making of Kaska hunting locations; some of which are outside of the control of the proponent. Therefore, the guiding principle and aspiration of closure and reclamation of the Project is to retain or restore the habitat capacity of the Project Area to the degree possible while focusing on the areas that the proponent can control to support the potential for continued Kaska hunting activities in and around the Project Area and prevent another Kaska land use shift.

Section 2.3 outlines Kaska engagement work to date as it has related to reclamation and closure. Continuous dialogue and involvement of Kaska representatives from the Ross River Dena Council (RRDC) and Liard First Nation (LFN) is anticipated going forward as the closure goals and objectives (Section 3) and closure measures (Section 7) are refined through the continuum of closure planning.

The reclamation planning for the Project builds on these fundamental and generic objectives to establish specific closure goals, objectives, criteria, and associated monitoring programs details for the Project. These are defined by factors that include environmental conditions, site conditions, and community expectations. The Project reclamation planning also considers, for all stages of mine closure, the global principles presented above.

In BMC's approach, the closure goal guides the selection of clear, specific closure objectives for all Project components. For some closure objectives, a set of closure options that could achieve the objective is developed, and a selected closure activity (measure) selected from these options. For many objectives, the application of standard closure measures is then achieved without the need for evaluation from a set of options. Measurable closure criteria (design or performance) define success in achieving the specific closure objective, as determined through the associated design and monitoring initiatives.

Figure 2-1 below, adapted from Guidelines for the Closure and Reclamation of Advanced Mineral Exploration and Mine Sites in the Northwest Territories prepared by the Mackenzie Valley Land and Water Board (MVLWB) and Aboriginal Affairs and Northern Development Canada (AANDC) (MVLWB/AANDC, 2013) provides an overview of this approach to the development of a CRCP.

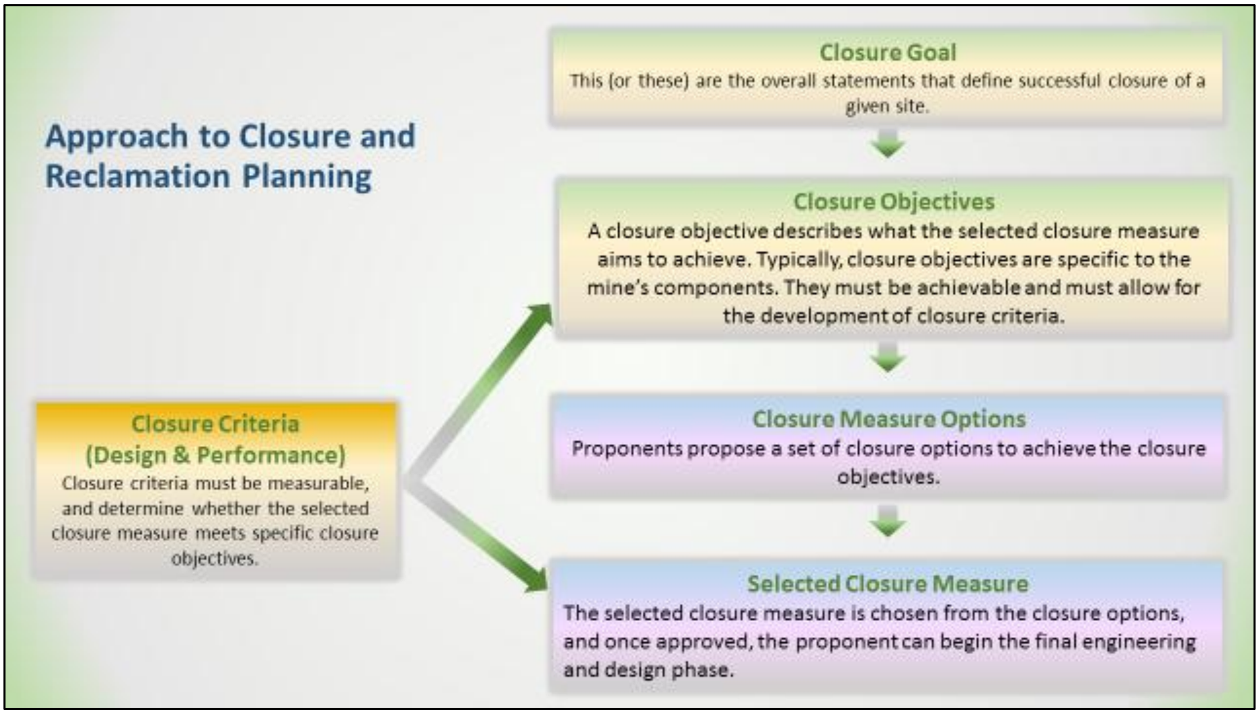


Figure 2-1: Approach to Closure and Reclamation Planning

(modified from MVLWB/AANDC, 2013)

Details defining this approach, adapted from the MVLWB/AANDC (2013), are presented below in Sections 2.2 and Section 3. Sources are cited where information was gathered from additional authors.

2.2 PROJECT CLOSURE GOALS

The closure goal is the guiding statement and starting point for closure and reclamation planning. The purpose of establishing goals is to ensure the long-term success of the program by developing a clear and executable plan. The closure goal is achieved once the proponent has satisfied all closure objectives.

The following proposed Project closure goal is grounded in responsible stewardship, consultation with stakeholders and appropriate end land use considerations, including recognition of the Kaska Land Use Principles (Section 2.1):

- *To return the mine site and affected areas to viable and, wherever practicable, self-sustaining ecosystems that are compatible with a healthy environment and with traditional land use activities.*

2.3 FIRST NATION AND STAKEHOLDER ENGAGEMENT

The discussion of closure concepts has been an integral component of consultation since Cominco originally permitted the Project in 1999. BMC has redesigned key elements of the Project that were originally designed and permitted by Cominco in 1999, (notably the replacement of in-valley slurried tailings facility with terrestrially deposited “dry” filtered tailings), and as such the closure concepts have changed since initial consultation.

Shortly after purchasing the Kudz Ze Kayah property in 2015, BMC developed a detailed Consultation and Engagement Plan (Access Consulting Group, 2015) to guide its engagement approach. BMC recognized four main groups with whom to consult:

- Residents of potentially affected communities (Faro, Watson Lake, Ross River, and Whitehorse);
- Kaska First Nations;
- Government regulatory agencies; and
- Other stakeholders and interest groups.

Throughout 2016, the Company held consultation events with these groups in Faro, Watson Lake, Ross River, and Whitehorse, which presented the mine design, operations, and closure planning information, to ensure their issues are considered.

The Kaska have a deep connection with the land; it is important to seek their input and to benefit from their Traditional Knowledge. As such, the Company held meetings with the Kaska political leadership (Chief and Council of Ross River Dena Council and Liard First Nation) to describe in general terms the mine plan including conceptual closure measures, and to listen to their concerns and answer their questions. The Company also held meetings with Kaska elders to explain the mine plan & related closure measures. A number of topics were raised during these meetings in relation to cultural, environmental and traditional use and a number of opinions were expressed regarding mine operation and general attitudes expected of a mining company. This input was carefully considered, and was beneficial to informing closure planning to highlight and address key Kaska concerns. In these meetings, it was also important to highlight the difference between historic regulatory requirements and industry practices and today’s more modern, responsible mining practices. The Company arranged a number of KZK site tours for all key regulatory agencies, specialist government departments, and First Nations, including elders and leadership.

The Project closure objectives and goals of this CRCP are a direct consequence of the consultation with the Kaska First Nations and other stakeholders. Further consultation with these groups will span the life of the Project: before, during, and after mining operations, which will mean the closure plan will continue to evolve through the iterative assessment and licensing process with the benefit of continued consultation. As the Project progresses through permitting into operations, and finally execution of closure activities and post-closure monitoring the consultation on the closure plan will progress in the following manner:

Post YESAB, Pre-licensing:

- Meet with identified groups again after the Decision Document has been issued, to explain what, if any, changes were made to the CRCP; and
- As a component of the application for the Quartz Mining License (QML) and the Water Use Licence (WUL), a Reclamation and Closure Plan (RCP) is to be submitted for regulatory review, including a financial review to confirm cost estimates and therefore security requirements.

Post licencing, During Mining Operations:

- Monitoring and documentation of development activities, specifically with implications for closure requirements are submitted to Energy, Mines and Resources (EMR) in the annual QML Report, with a copy provided to the Kaska and local government bodies;
- Annual WUL Report's document progressive reclamation activities, which are publically available. This provides a portal for public review and monitoring of closure activities, and affords an opportunity to interact with the Water Board, or with BMC, if any concerns or questions arise from this review; and
- The RCP will be revised every two years as per EMR requirements, as such, closure plans and cost estimates will be reviewed in detail and amendments made as required by relevant government agencies and First Nations.

Post Mining Operations, During Active Closure Measures:

- Closure measures will be undertaken in accordance with RCP;
- Monitoring will be undertaken for 10 to 23 years, depending on the site component and site conditions, to confirm the expected performance of reclaimed components, which provides the opportunity to make any revisions that are deemed to be required;
- Regular update meetings will be held with Kaska and local communities; and
- As is done during operations, annual public reporting continues under both the QML and the WUL. This will provide the opportunity for governments including First Nations, stakeholders, and interested parties to be informed and to have input.

2.4 CLOSURE ALTERNATIVES

The mine development and closure planning teams have worked together to evaluate a range of closure options for the measures which are most consequential to the successful design and closure of the Project. Waste storage alternatives (Sections 2.4.1, 2.4.2, and 2.4.3) were evaluated by the mine planning team, with a particular focus on designing for closure. Waste cover alternatives (Section 2.4.4) were evaluated by both the mine and closure planning teams.

The nature of the timing of reclamation and decommissioning activities required for closure of the Project led the closure planning team to identify three distinct closure phases, or 'periods' for the Project:

1. Active Closure;
2. Transition Closure; and
3. Post-Closure.

Where applicable, the proposed closure objectives, criteria and measures reference these periods in the following sections. These periods and the closure execution strategy are outlined in more detail in Section 8.

2.4.1 Tailings Disposal Methods and Locations

The Project's previous owner Cominco conducted exploration, engineering design studies, baseline environmental studies and consultation activities in 1994 to1995 to support Project design. The Cominco mine plan included open pit mining for a nine-year mine life, storage of approximately 72 million tonnes of waste rock, with tailings deposited in a subaqueous valley-fill tailings facility, which included a permanent earthen tailings dam in Geona Creek.

BMC conducted exploration and as part of the redesign of the Project in 2015 and 2016, and retained Knight Piésold Ltd. (KP) of Vancouver to undertake a Tailings Management Alternatives Assessment to support mine design decisions during the completion of the Prefeasibility Design Report (KP, 2016a). BMC then expanded the alternatives assessment, in which considerations for closure featured prominently in the evaluation. The alternatives assessment is summarized below.

The KP study initially identified 13 potential tailings storage sites within approximately 10 km of the ABM Deposit. Two methods of tailings storage technology for each site were considered: slurry and filtered tailings. The tailings technology for each candidate was selected based on site specific constraints.

Pre-screening criteria were developed to evaluate and eliminate candidates with evident shortcomings (KP, 2016b). The four candidates remaining after the pre-screening were:

A. Slurry tailings facility located in Geona Creek;

B. Slurry tailings facility located in the East Hanging Valley;

C. Filtered tailings facility located near the current exploration camp, at the confluence of Geona and Finlayson Creeks; and

D. Filtered "dry stack" tailings facility located on the western hillside of Geona Creek.

For the purposes of this alternatives assessment, BMC then evaluated these four final candidate sites and types of deposition alternatives against the common performance criteria. A filtered tailings facility located on the western slope in the upper valley of Geona Creek ranks as the preferred alternative for this component. A summary of the assessment is presented in Table 2-1.

Table 2-1: Summary of Alternatives for Tailings Disposal Methods and Locations

Mine Component Alternatives	Performance Criteria				Overall rating against performance criteria
Tailings Disposal Methods and Locations	***Cost Effectiveness***	***Minimizes effects on the natural environment***	***Maximizes socio-economic benefits***	***Amenability to reclamation***	
A. Slurry tailings in Geona Creek	Preferred	Least preferred	Acceptable	Least preferred	
B. Slurry tailings in east hanging valley	Acceptable	Acceptable	Acceptable	Least preferred	
C. Filtered tailings at confluence of Geona and Finlayson Creeks	Acceptable	Acceptable	Acceptable	Acceptable	
D. Filtered tailings "dry stack', upper valley, Geona Creek	Acceptable	Preferred	Acceptable	Preferred	Preferred option

2.4.2 Waste Rock Storage Facility Locations Alternatives

Waste rock generated from mining the ABM open pit and the underground workings will be geochemically characterized into three distinct categories, based on their comparative potential to generate acid or produce a metals leachate. While the locations for the Class A and B Storage Facilities were selected according to their geochemistry-driven operations and closure requirements, the alternatives for location of the benign Class C Storage Facility were assessed as follows:

A. Southern Lakes Class C Waste Rock Storage Facility; and

B. Geona Creek Valley Class C Waste Rock Storage Facility.

Table 2-2: Summary of Alternatives for Waste Rock Storage Facility Locations

Mine Component Alternatives	Performance Criteria				Overall rating against performance criteria
Waste Rock Storage Facility Locations	***Cost Effectiveness***	***Minimizes effects on the natural environment***	***Maximizes socio-economic benefits***	***Amenability to reclamation***	
A. Southern Lakes Class C Waste Rock Storage Facility	Acceptable	Least preferred	Acceptable	Acceptable	
B. Geona Creek Valley Class C Waste Rock Storage Facility	Preferred	Preferred	Acceptable	Acceptable	Preferred option

In consideration of the above, permanent surface deposition of all Waste Rock Storage Facilities was ranked as the preferred alternative for this component. A summary of the assessment is presented in Table 2-2.

2.4.3 Waste Rock Management Alternatives

Waste rock storage facilities (WRSF), as described above, will be developed according to their comparative geochemical characteristics. There are essentially two management alternatives that could be employed for all three of the facilities;

- Construct and operate permanent facilities; or
- Deposit rock temporarily and rehandle back into the open pit at closure.

The two alternatives were assessed as follows:

A. Permanent Surface Deposition of all WRSF's; and

B. Temporary Surface Storage – Rehandling Waste Rock at Closure

Table 2-3: Summary of Alternatives for Waste Rock Management

Mine Component Alternatives	Performance Criteria				Overall rating against performance criteria
Waste Rock Management	***Cost Effectiveness***	***Minimizes effects on the natural environment***	***Maximizes socio-economic benefits***	***Amenability to reclamation***	
A. Permanent surface deposition of all Waste Rock Storage Facilities	Preferred	Preferred	Acceptable	Acceptable	Preferred option
B. Temporary surface storage – rehandling waste rock at closure	Least preferred	Acceptable	Acceptable	Preferred	

In consideration of the above, permanent surface deposition of all WRSF was ranked as the preferred alternative for this component. A summary of the assessment is presented in Table 2-3.

2.4.4 Waste Cover Alternatives

At closure, the overall objective for the waste rock and tailings facilities for the Project is to have safe and stable facilities that have limited environmental effects (particularly for water quality) and to respect traditional land use (see Section 7.4 for more information on closure objectives for these facilities). To achieve this, the Project planning team has undertaken an extensive geochemical characterization program that has informed the design and operational management plans for these storage facilities. The geochemical testing is discussed in detail in the Acid Rock Drainage and Metal Leaching Characteristics of Material Report (AEG, 2017e) and the operational design considerations are discussed in detail in the Prefeasibility Design Report (KP, 2016a), which is summarized herein. These designs, in turn, inform the measures that are required at closure to ensure environmental protection and appropriate end land use for the Project Area.

In base metals deposits, the key water quality risk to address is the generation of net acidity and the leaching of metals, under near neutral or acidic conditions. The preferred approach to controlling this risk is through source control; to prevent or minimize the generation of acid rock drainage and metal leaching (ARD/ML) potential at the source (i.e., in the waste rock or tailings). If it is not possible to prevent metal leaching, the second approach is to control the migration of "contaminated" drainage to the receiving environment. Even this may not always be possible to control completely, and a third level of control – collection and treatment of the drainage -may be required. The selection of the control measures for any project/facility considers both the risks and the benefits of each. This comprehensive trade-off analysis considers all of the specific Project objectives, as discussed in Sections 2.4.1 through 2.4.3 of this document.

Specific to meeting the closure objectives related to preventing/minimizing ARD/ML, the alternatives considered for waste rock and tailings management included:

- Source control by:

  - Deposition under water (rehandling waste rock into the pit or flooded tailings deposition); and
  - Maintaining net alkaline conditions (the ABA balance) by segregation, or blending, of waste rock or by co-disposal with the alkaline flotation tailings.
- Control of flushing, leaching and drainage of contaminated drainage by:
  - Diversion of upgradient "non-contact" water around disturbed areas and facilities to "keep clean water clean;"
  - Location of facilities away from natural water courses;
  - Liners for construction (and operations) and covers at closure; and
  - Filtered tailings "dry stack" approach.
- Collection and treatment:
  - Active water treatment; and
  - Semi-passive or in situ treatment.

The closure measures for the waste storage facilities were determined by the selected waste management options for operations, and are detailed in Section 7.4. In summary:

- Tailings are net acid generating and metal leaching. Tailings will be filtered and placed in a lined facility that will be progressively covered during the Project life and then completely covered at closure. This was evaluated as a more stable physical structure than a flooded tailings impoundment while still capable of maintaining geochemical stability.
- All waste rock will be placed in surface facilities and no material will be re-handled back into pit.
- Waste rock will be segregated to minimize the generation of "contaminated" drainage and therefore to minimize short-term and long-term water treatment requirements. There will be three waste rock storage areas. Specifically:
  - Waste rock with potential for acid generation and metal leaching will be co-disposed with the filtered tailings on a compacted till liner, progressively covered during the Project life and then finally covered at closure with a very low permeability cover. This will in turn be protected by approximately 3.0 m of "clean" waste rock as a frost protection layer. Growth media will then be placed to allow surface revegetation. This is referred to as the "Class A Storage Facility."
  - Waste rock with potential for metal leaching and minor or local net acid generation will be placed in the Class B Storage Facility. This facility will also be lined with approximately 1.0 m of compacted till to direct drainage into a collection system from which it will be pumped to the process plant for treatment, or use, during operations. Additionally, during operations, all runoff will be directed to this collection system. At closure, a low permeability cover will be placed over the waste rock to reduce infiltration and therefore reduce contaminated

drainage from the waste rock. This cover will also have a layer of rock for frost protection and growth media for surface revegetation. Clean runoff will be released to the environment.

- The waste rock that is not a significant source of metal leaching is referred to as Class C waste rock. This is stockpiled in a separate facility and will be a source of rock for construction during operations and for closure. This rock will be used, for example, for the frost protection layers on the Class A and Class B closure covers. The remaining rock in the Class C Storage Facility will receive a cover of growth media to promote revegetation. The uppermost portion of the Class C Facility is located in sub-alpine to alpine ecosystem, which requires a longer time period in which to support the limited alpine vegetation.

2.5 RECLAMATION RESEARCH

An important component of the reclamation planning process is ongoing reclamation research with the objective of developing the methods required to implement a successful reclamation program. Reclamation research will focus in certain areas related to the key and contingency closure methods proposed for the site, as well as the proposed adaptive management measures:

- Detailed engineering of the covers for the waste rock and tailings storage facilities;
- Revegetation and erosion control; and
- Semi-passive water treatment technologies.

The selection of these techniques for the Project considers industry experience, experience of BMC's management at other sites, and site-specific conditions. A conceptual reclamation research program has been designed to provide proof of concept, information for more detailed design, and/or to optimize reclamation techniques in the Project setting. The elements of this program are presented in this section. Some aspects of mine site reclamation such as recontouring and erosion stabilization techniques are well established and are less reliant upon site-specific research for success.

Information developed on site will be supplemented with information obtained from other mine reclamation programs in the Yukon and other jurisdictions. Considerable research has been carried out into the reclamation and revegetation of disturbed lands in the Yukon, including operating and abandoned mines, and mineral exploration sites. Much of this information is in the public domain and is well presented in the guidance documents: Mine Reclamation Guidelines in the Northwest Territories (INAC, 2007), and Yukon Revegetation Manual, Practical Approaches and Methods (Matheus and Omtzigt, 2013).

2.5.1 Waste Cover Systems

The conceptual cover designs presented herein are based on the required performance (reduction in infiltration and net percolation) to achieve the environmental water quality objectives. The next stage of design and reclamation research must address site specific and seasonal performance of these covers, following final design of the facilities. The conceptual cover design report provides further details and is included in Appendix A.

Multi-layer cover systems are intended for the Class A and Class B Storage Facilities to ensure the long-term chemical stability of the site. As discussed in more detail in Chapter 7 of this plan, the Class A Storage Facility will receive a three-layer cover comprising the following;

- Very low permeability layer to minimize the ingress of water to potentially acid generating and metal leaching rock;
- Layer with a minimum of 3.0 m of Class C "clean" rock for frost protection; and
- Final layer of approximately 0.30 m of growth media for revegetation.

The cover will be installed progressively in lifts.

The Class B Storage Facility will receive a 1.0 m compacted low permeable till layer covered by a minimum of 3.0 m of Class C "clean" rock for frost protection and approximately 0.30 m of growth media for revegetation. This cover will also be installed progressively in lifts.

As the Class C Storage Facility does not require control for long-term chemical stability this facility will be progressively reclaimed with 0.30 m of growth media for revegetation.

The following tasks are planned to finalize the cover designs and predict performance:

- Cover material characterization during the mine life including more detailed field confirmation of material quantities and properties to achieve the design cover performance of the compacted till layer. This program will be coordinated with the field work to confirm the design of the compacted till foundation layers for the Class A and Class B Storage Facilities;
- Hydraulic and geotechnical material characterization, including:
    - Particle size distribution curves and rock composition of Class C Materials; and
    - Borrow material hydraulic properties testing, such as Atterberg Limits, saturated hydraulic conductivities, and soil water characteristic curves (SWCC) for material to be used in cover systems;
- A program to determine frost penetration depth line at the waste storage facilities. This would include installing a temperature (thermistor) and moisture (conductivity) sensor(s) to create a profile in the top 6.0 m below ground surface to determine depth and seasonal freeze/thaw pattern. A sensor could be installed at the Class A facility meteorological station in the existing data logger if the ground conditions permit;
- Predictive modelling of cover performance during detailed design including site climate, storage facility slopes and aspect, and site specific borrow materials to determine realistic short term and long term performance of Class A and Class B Storage Facility covers;
- Evaluation of options for performance monitoring, such as equipment to measure water ingress through the cover material and the temperature profile of the frost protection cover during

progressive reclamation, to monitor and assess the covers during operations, closure, and post-closure; and

- All three facilities require a soil cover to provide appropriate substrate for revegetation and are designed to be covered with a minimum of 0.3 m of growth media based on typical rooting depths. During the mining phase, revegetation plot trials will be initiated and the rooting depth will be checked to determine if the prescribed 0.3 m can be reduced or needs to be augmented.

2.5.2 Revegetation

A key Kaska land management goal is to build capacity through Kaska participation in reclamation activities (Dena Kayeh Institute, 2010). To support this goal, BMC will collaborate with Kaska on the revegetation research and implementation program as much as possible. Tasks necessary for the revegetation program include:

- Optimize prescriptions of revegetation species mixes, integrating traditional knowledge for the area with Yukon revegetation guidance and commercially available naturalized species;
- Collect seeds and cuttings from site and carry out research to optimize species mixes, and germination and propagation techniques in a nursery, likely either in Ross River or at site;
- Prepare, seed, plant, fertilize, manage, and monitor research test plots on site; and
- Implement progressive reclamation during operations, closure, and post-closure.

Plants require, as a minimum, a medium that will allow roots to penetrate, that will retain adequate moisture and that contains suitable levels of nutrients for successful growth. The natural vegetation found on undisturbed sites around the mine generally provides information about the underlying soil properties, including texture, drainage, and pH, and the level of available nutrients that presently occur at the site. A soil sampling program was initially conducted in the Project Area in 2015 and 2016. The results of this program provide the basic information required for reclamation planning.

Reclamation research trial plots will be constructed during mine operations to collect site specific data to aid with the final reclamation treatments designed for the major storage facilities. Trial plots will be constructed after the first few years of operation, when there is sufficient material to evaluate the different storage facilities. The main disturbance areas of focus for the research trials will be the Class A, Class B, and Class C Storage Facilities as well as an area of unaffected surface disturbance to monitor as a control.

Probable initial trial sites include the first lifts on the Class A and B Storage Facilities, and the Class C water collection pond, which will have a similar aspect to the Class C Storage Facility. Trials will be constructed on flat and sloped surfaces for each disturbance area, as the ultimate closure objective will be to reclaim varying surface slopes. Each trial site will examine a combination of different revegetation treatments to help outline the most effective and efficient closure method for the areas requiring reclamation.

Treatment variables at sites will depend on the reclamation objectives for each reclamation unit, but could include:

- Plant species and seed ratios;

- Native seed and naturalized seed mix variations;
- Reseeding requirements;
- Willow staking (with careful consideration around constructed wetlands);
- Scrub birch seedling planting and protection requirements;
- Soil and fertilizer amendment types and application rates; and
- Surface treatment, and seeding and amendment application techniques.

Treatments at each trial will be randomly assigned and replicated in the trial to ensure data is accurately representing the treatment variation. Analysis of the effect of each variable will be used to inform the final reclamation prescriptions.

Plant species selection will be based on the Terrestrial Ecosystem Map (TEM) vegetation associations and the appropriate edatopic grid (based on soil moisture and nutrient regime). The goal of the site-specific revegetation will be to establish early successional species that will follow the successional trajectory aimed at ultimately reclaiming the site to the appropriate site edatopic grid unit given the expected moisture, nutrient, and aspect of post-mining landforms. More detail on the reclamation revegetation program at the site is presented in Section 7.1.2 General Reclamation Measures – Revegetation.

Trials will be monitored to compare relative percent cover, species composition, and height with respect to the seeding treatment and previous monitoring results. It is understood for the first two to three years, different species might be indistinguishable and therefore only percent cover and height will be recorded. Additionally, composite soil samples and tissue samples will be periodically collected from trial sites and examined for metal concentrations to monitor the relative amount of metal uptake occurring at each site compared to the control. Growth and succession will be recorded and reported annually and modifications made to the progressive revegetation program. Design of the research program will tie in with Yukon College research initiatives where there are related programs. One specific area of research Yukon College has undertaken relates to soil amendments and their potential to assist with germination, nitrogen-fixing and the development of biological soil crusts (BSCs) which improves seed germination and establishment of diverse vegetation communities. Research at the Project will include homogenizing native soil crusts (i.e., the lichens, bryophytes, and topsoil layer) at site and applying the mix to reclamation trial plots. Methods will be developed with the consideration of those determined to be successful in the Yukon College research by Stewart (2013), when reasonable and applicable.

2.5.3 Constructed Wetland Treatment Systems

The Project closure planning identified in Section 2.4 Closure Alternatives returned a recommendation to utilize constructed wetland treatment systems (CWTS) for final (secondary/tertiary) treatment of site seepage and runoff prior to discharge from the Project to the aquatic receiving environment. Passive treatment systems should be designed, piloted, optimized, implemented, and maintained in a site-specific manner to be successful. While no two systems are ever exactly the same, significant information may be gleaned from a diverse range of treatment systems, as scientific principles such as thermodynamic laws, Stoke's laws (settling), and concepts of coupled biogeochemical reactions are globally applicable. However, laboratory, pilot-scale (off site) and demonstration-scale (on site) experiments are recommended before full-scale implementation to ensure site-specific robustness and development of reaction rates associated with treatment which in turn allow for calculation and refinement of footprints needed.

A phased approach comprising up to five phases is often used for the design and implementation of CWTS. The objectives of each phase are outlined in Appendix B. Conceptual designs are for planning purposes and are ideally followed by bench- and pilot-scale testing and optimization to develop site-specific treatment rate coefficients and operational boundaries, and to determine maximum extent of removal. Accordingly, sizing estimates and performance expectancies would be refined as the planning for CWTS progressed through phased development.

Therefore, at a high level, the current and proposed future phases are:

- Phase 1a (complete, summary below): Information gathering and site assessment;
- Phase 1b (complete, Section 7.6.2.5): Conceptual design and sizing;
- Phase 2: Off site bench-scale testing and optimization;
- Phase 3: Off site pilot-scale testing and optimization;
- Phase 4: On site demonstration-scale implementation and monitoring; and
- Phase 5: Full-scale implementation.

2.5.3.1 Research Conducted to Date

To date, the closure planning team and the key consultant Contango Strategies Ltd. (CSL) have completed Phase 1a described above. After an initial information review, and to further evaluate the feasibility of utilizing CWTS as passive closure measures for the Project, CSL conducted a feasibility site assessment.

The CWTS feasibility site assessment was conducted on August 25 – 28th, 2015 (CSL, 2016b). The site assessment focussed on natural wetland and creek areas in the Project Area. Sampling locations were selected based on presence of potentially beneficial wetland plants, information from long-term monitoring, in situ measurements, and other visible features (that suggested the location might inform strategies for water quality improvement by CWTS). Eleven locations were sampled in situ, and included the collection of 10 water, 5 soil, 9 vegetation, and 15 microbiological samples for off site analytical testing. The native microbial communities were characterized to identify site treatment potential. Plant species collected included the emergent macrophyte *Carex aquatilis* (commonly known as aquatic sedge), and aquatic bryophytes (aquatic moss) from multiple locations at KZK for comparison purposes.

The CWTS feasibility site assessment report key findings are briefly summarized here:

- Passive and/or semi-passive water treatment is theoretically feasible at the KZK site;

- Wetland plant species *Carex aquatilis* (water sedge) and aquatic mosses are abundant at the KZK site, host natural beneficial microbes, and promote conditions conducive to water treatment;

- Wetland plant genus *Schoenoplectus* (bulrush) are abundant in the nearby geographic area as a secondary vegetation option;

- Natural beneficial microbes were found in abundance in wetlands, seeps, and creeks at the KZK site. These microbes are capable of water treatment processes such as reduction of nitrate, nitrite, selenium, and sulphate;

- Deterrence of local wildlife should be incorporated into the CWTS design given the evidence of both beaver and moose at existing wetland and creek areas in the Project vicinity; and

- Natural willows and alder growth may need to be considered in a long-term management plan as they alter wetland hydrology by promoting channeling of water and could also encourage beaver activity. Additionally, any revegetation work around wetlands should consider long term growth and its effect on the wetland.

The findings of the feasibility assessment have led to work in Phase 1b – Conceptual Design and Sizing, and the incorporation of CWTS into the set of closure measures proposed at the conceptual level for the Project. Details regarding the proposed conceptual design for the CWTS can be found in Section 7.6.2.5.

3 KUDZ ZE KAYAH PROJECT CLOSURE OBJECTIVES AND DESIGN CRITERIA

Section 2.1 identified the framework and process used to develop 'on the ground' closure measures that can be demonstrably linked back to the closure goals for the site. The broader closure goals are broken down into a number of objectives, the attainment of which through specific measures will indicate achievement of closure goals.

Closure objectives are statements that clearly describe what the selected closure measures aim to achieve. They must be achievable and must allow for the development of measurable closure criteria. Objectives are short-term, concrete, stepping stones toward achieving a goal and should be specific, appropriate and realistic. The purpose of implementing performance-based objectives is to encourage research and innovation resulting in cost-effective applications while ensuring public health and safety and environmental protection are met (YG, 2013).

3.1 RECLAMATION AND CLOSURE OBJECTIVES

The development of the reclamation and closure objectives for the Project start with the fundamental objectives established in the document Reclamation and Closure Planning for Quartz Mining Projects (YG, 2013) (Table 3-1).

Table 3-1: Fundamental Mine Reclamation and Closure Objectives (YG, 2013)

Value	Reclamation and Closure Objectives
Physical Stability	• All mine-related structures and facilities are physically stable and performing in accordance with designs. • All mine-related structures, facilities and processes can withstand severe climatic and seismic events.
Chemical Stability	• Release of contaminants from mine related waste materials occurs at rates that do not cause unacceptable exposure in the receiving environment.
Health and Safety	• Reclamation eliminates or minimizes existing hazards to the health and safety of the public, workers and area wildlife by achieving conditions similar to local area features. • Reclamation and closure implementation avoids or minimizes adverse health and safety effects on the public, workers and wildlife.
Ecological Conditions and Sustainability	• Reclamation and closure activities protect the aquatic, terrestrial and atmospheric environments from mine-related degradation and restore environments that have been degraded by mine-related activities. • The mine site supports a self-sustaining biological community that achieves land use objectives.
Land Use	• Lands affected by mine-related activities (e.g., building sites, chemical and fuel storage sites, roads, sediment ponds, tailings storage facilities, waste rock storage areas, underground workings, etc.) are restored to conditions that enable and optimize productive long-term use of land. Conditions are typical of surrounding areas or provide for other land uses that meet community expectations.
Aesthetics	• Restoration outcomes are visually acceptable.
Socio-economic Expectations	• Reclamation and closure implementation avoids or minimizes adverse socio-economic effects on local and Yukon communities, while maximizing socio-economic benefits. • Reclamation and closure activities achieve outcomes that meet community and regulatory expectations.
Long-term Certainty	• Minimize the need for long-term operations, maintenance and monitoring after reclamation activities are complete.
Financial Considerations	• Minimize outstanding liability and risks after reclamation activities are complete.

These fundamental objectives form the basis for the development of Project-specific and component/facility-specific objectives for the Project in post-closure. These are presented in Section 7.

3.2 DESIGN CRITERIA

A key principle in the reclamation and closure planning for the Project is design for closure. Success in applying this principle to the closure planning in turn supports other principles and fundamental closure objectives related to minimizing activities required at closure, and reducing associated closure risks and liabilities. Design criteria define the effectiveness of the design of the Project and Project elements, and in the context of reclamation and closure – the effectiveness of the design in meeting specific Project closure objectives.

Specific design criteria related to Project closure and mine components are presented in Section 7. These criteria have largely been developed by the Project engineering team, and presented in the KZK Project Prefeasibility Design Report (KP, 2016a).

4 ENVIRONMENTAL DESCRIPTION

4.1 REGIONAL SETTING

The Project is located in the Boreal Cordillera Ecozone, situated in a transitional climatic zone bordering on three different ecoregions: Yukon Plateau to the north, Liard Basin to the east, and Pelly Mountains ecoregion to the south (Smith et al., 2004). The Project Footprint is in the northern portion of the Pelly Mountains ecoregion (Figure 4-1). The major part of the Pelly River ecoregion is underlain by metamorphic rock; however, large bodies of volcanic and intrusive rocks and small bodies of sedimentary rocks occur throughout.

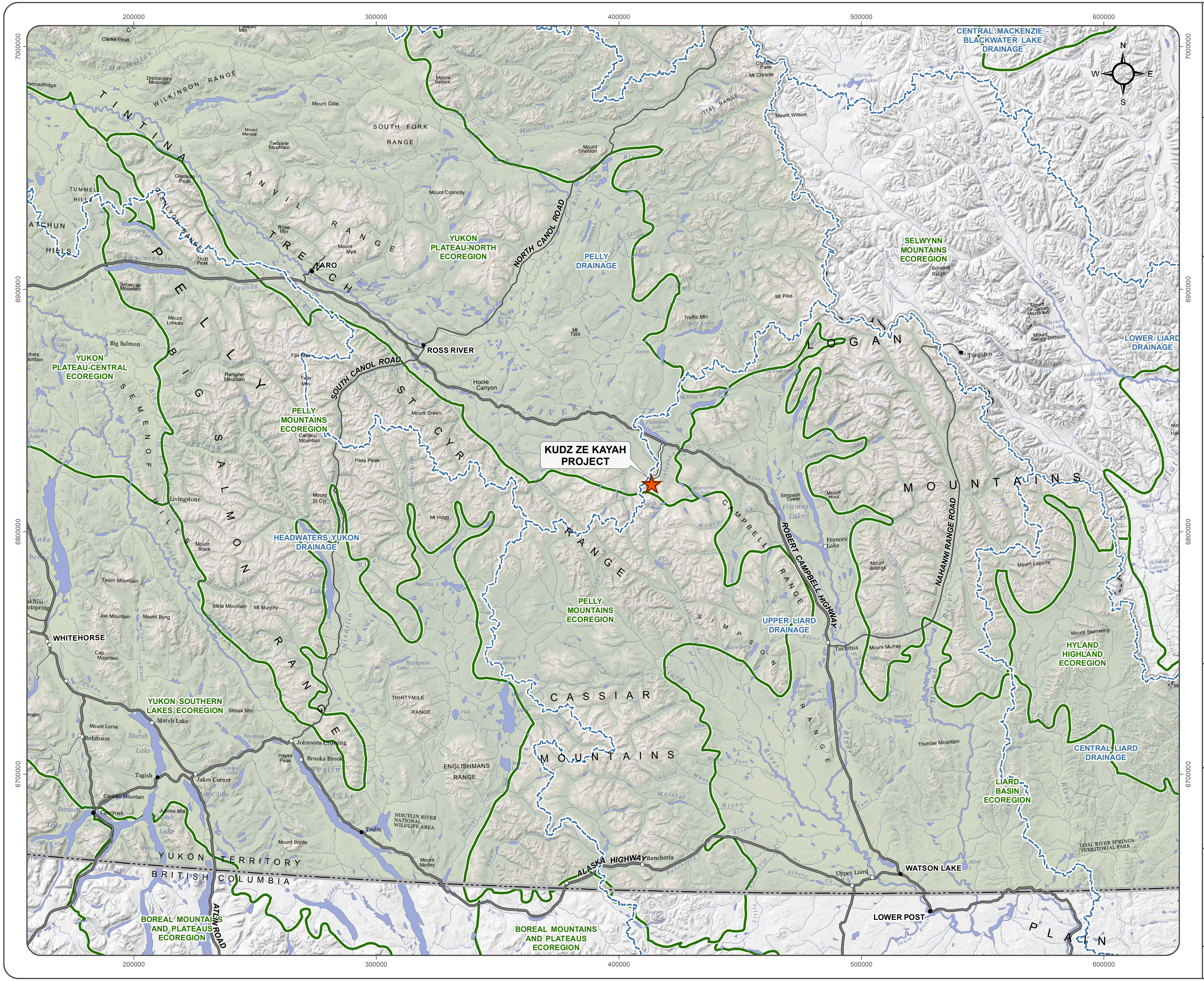
Elevation in the Project Area ranges from 1,000 metres above sea level (masl) at the beginning of the Tote Road (at the Robert Campbell Highway) to 2,000 masl at the southwestern extent of the Project Area, with the infrastructure located between 1,300 and 1,600 masl. (Figure 4-2). The Tote Road gradually climbs through a gently rolling plateau networked with small creeks and wetland complexes. East of the road is a large steep sided ravine in which Finlayson Creek lies. Once the road crosses the Finlayson Creek (17.5 km) it climbs into the Pelly Mountain Range foothills characterized by rounded glaciated mountains.

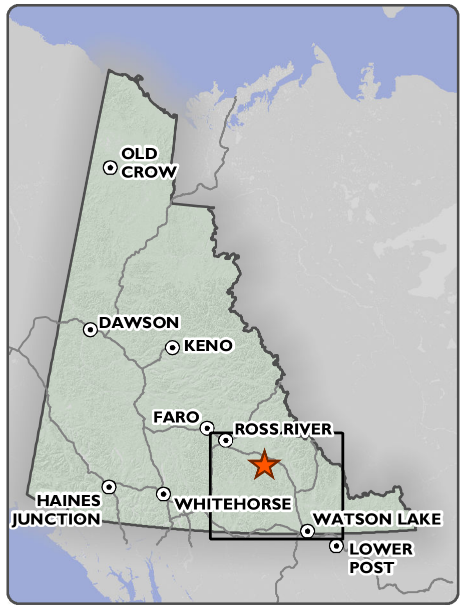
The Project is situated in the upper Geona Creek valley, which is surrounded by larger steeper sided mountain slopes. A series of shallow wetlands occur along Geona Creek due to historical beaver dams in the valley bottom. Side valleys east of the Geona Valley are relatively broad and 'U-shaped". Tributaries such as Fault Creek, are high velocity streams that have incised the mountain slopes before depositing sediment into Geona Creek.

The region has intermittent permafrost with moist depression areas containing peat plateaus, patterned fen and bog complexes. Scree covered slopes are most prominent in sedimentary rock. Deep colluvium occurs on steeper, mid to lower slopes. The Project Area is mostly a forest region, except for topographic peaks, which are in the tundra region. White spruce (*Picea glauca*) and black spruce (*Picea mariana)* are the most common tree types. Black spruce is usually dominant in wetter areas, while white spruce dominates in drier areas. Paper birch (*Betula papyrifera)*, trembling aspen (*Populus tremuloides*), balsam poplar (*Populus balsamifera*), and lodgepole pine (*Pinus contorta*) also occur; sub-alpine fir (*Abies lasiocarpa*) occurs at the treeline (1,350 masl to 1,500 masl). In dense coniferous stands, feathermoss dominates the understorey; however, in more open areas willow (*Salix* spp.) and heath-like shrubs become prevalent. Sedge or sphagnum tussocks are common in wetlands and under black spruce. Scrub birch (*Betula glandulosa*) and willow occur in the subalpine and extend well above the treeline.

The Project Area is in the Extensive Discontinuous Permafrost Zone. Permafrost has been encountered under the organic layers that cover the Geona and upper Finlayson valleys. Permafrost is typically located under poorly drained areas, cool aspects, and upper elevations. Permafrost related ground movement or solifluction is apparent on upper to middle elevation slopes.

Regionally significant wildlife resources occur in the Project Area. The area surrounding the Project forms part of the extensive regional habitat used by the Finlayson caribou heard from Spring to Fall, while the Pelly River lowlands are part of the area used by the herd in the winter. Caribou (*Rangifer tarandus*) provide a valuable food source for the Kaska and are also of economic significance to sport hunters and the guiding industry. Moose (*Alces alces*) are also a significant wildlife resource and are found in all habitats throughout the wildlife Local Study Area (LSA), except alpine. Furbearer populations are also prevalent throughout the wildlife LSA and are utilized by Kaska citizens. Waterfowl use the wetlands in the upper Geona Creek valley for nesting and foraging. Cliff-nesting raptors are actively nesting on rock outcrops within the wildlife LSA, and many species of songbirds utilize the various habitats throughout the wildlife LSA. Fish in the Liard River watershed include Arctic grayling (*Thymallus arcticus*), whitefish (*Coregonus clupeaformis*), lake trout (*Salvelinus namaycush*), and Dolly Varden (*Salvelinus malma*).





KUDZ ZE KAYAH PROJECT

BMC MINERALS

KUDZ ZE KAYAH PROJECT CONCEPTUAL RECLAMATION AND CLOSURE PLAN

FIGURE 4-1
KUDZ ZE KAYAH PROJECT LOCATION

FEBRUARY 2017

ALEXCO ENVIRONMENTAL GROUP

Digital elevation model created by the Yukon Department of the Environment interpolated from the digital 1:50,000 Canadian National Topographic Database (NTDB Edition 2) contour and watercourse layers. Obtained from Geomatics Yukon.

Canvec compiled by Natural Resources Canada at a scale of 1:10,000 - 1:50,000. Reproduced under license from Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources Canada. All rights reserved.
Drainage areas obtained from National Hydrology Network 2011

Datum: NAD 83; Projection UTM Zone 9N

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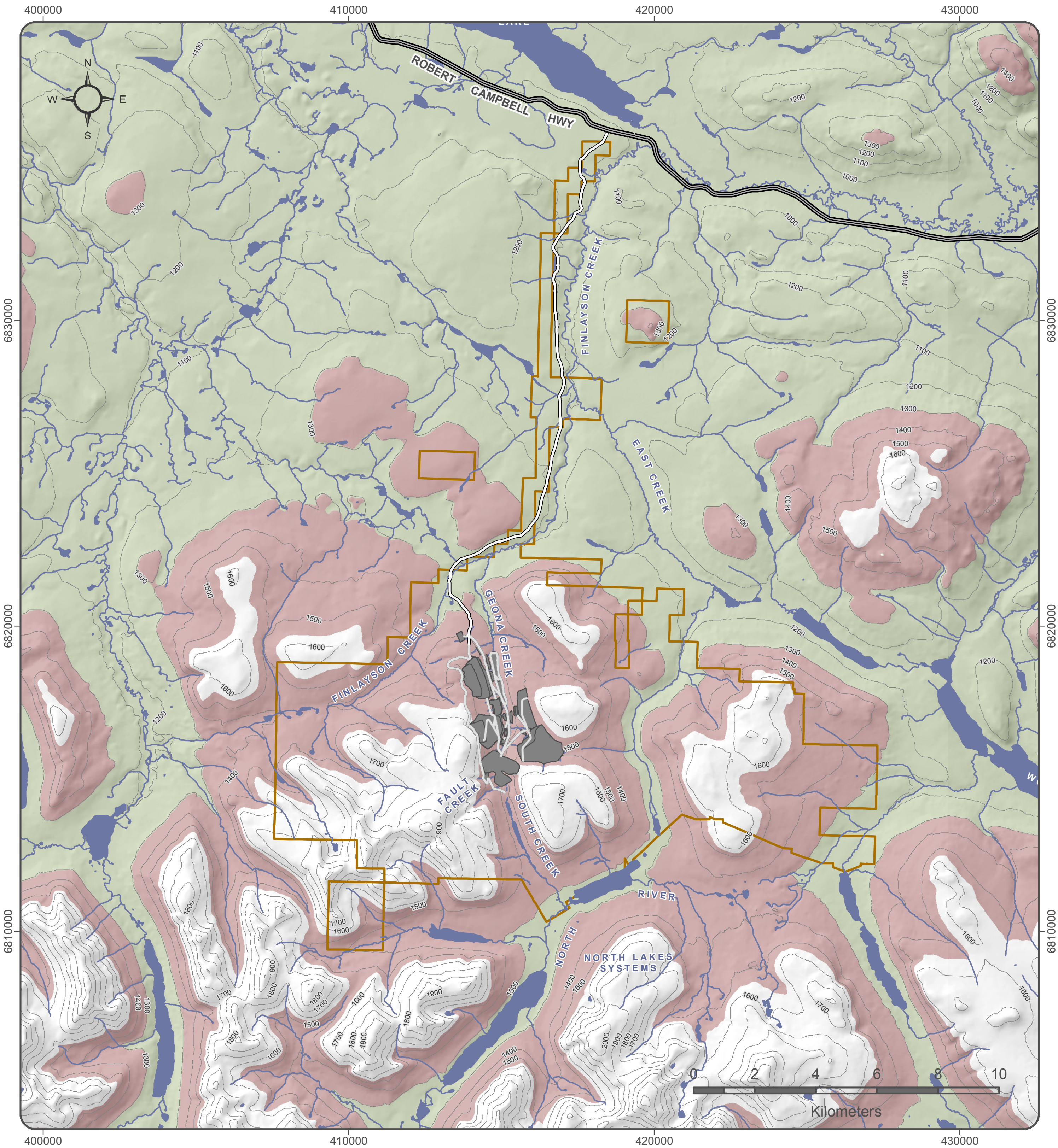

Bioclimate Zone

- Boreal High (850-1300m)
- Subalpine (1300-1550m)
- Alpine (>1550m)
- Location of Proposed Mine Infrastructure
- BMC Minerals (No. 1) Ltd. Mineral Claim Areas
- Contour (100m interval)
- Watercourse
- Waterbody

KUDZ ZE KAYAH PROJECT
CONCEPTUAL RECLAMATION AND CLOSURE PLAN

FIGURE 4-2 PROJECT AREA OVERVIEW

Datum: NAD 83; Projection: UTM Zone 9N

AEG

BMC MINERALS

FEBRUARY 2017

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4.2 CLIMATE

The Project Area has a typical northern interior climate, with cool and short summers and long and very cold winters. The mean annual temperature recorded at the Project meteorological stations from September 2015 to August 2016 was -0.47°C, with extremes ranging from -26°C to 20°C. When this available data was compared to both long-term regional averages and to regional data for the same period, the 2015-2016 record at the Project generally shows warmer winter temperatures (October to April), and cooler summer temperatures (May to September). The frost-free period is generally 40 to 60 days, although frost can occur in any month. Long-term temperature trends were analyzed at six regional stations. All stations displayed an increasing trend over the period of record for average minimum, average maximum, and mean monthly temperatures (AEG, 2016a).

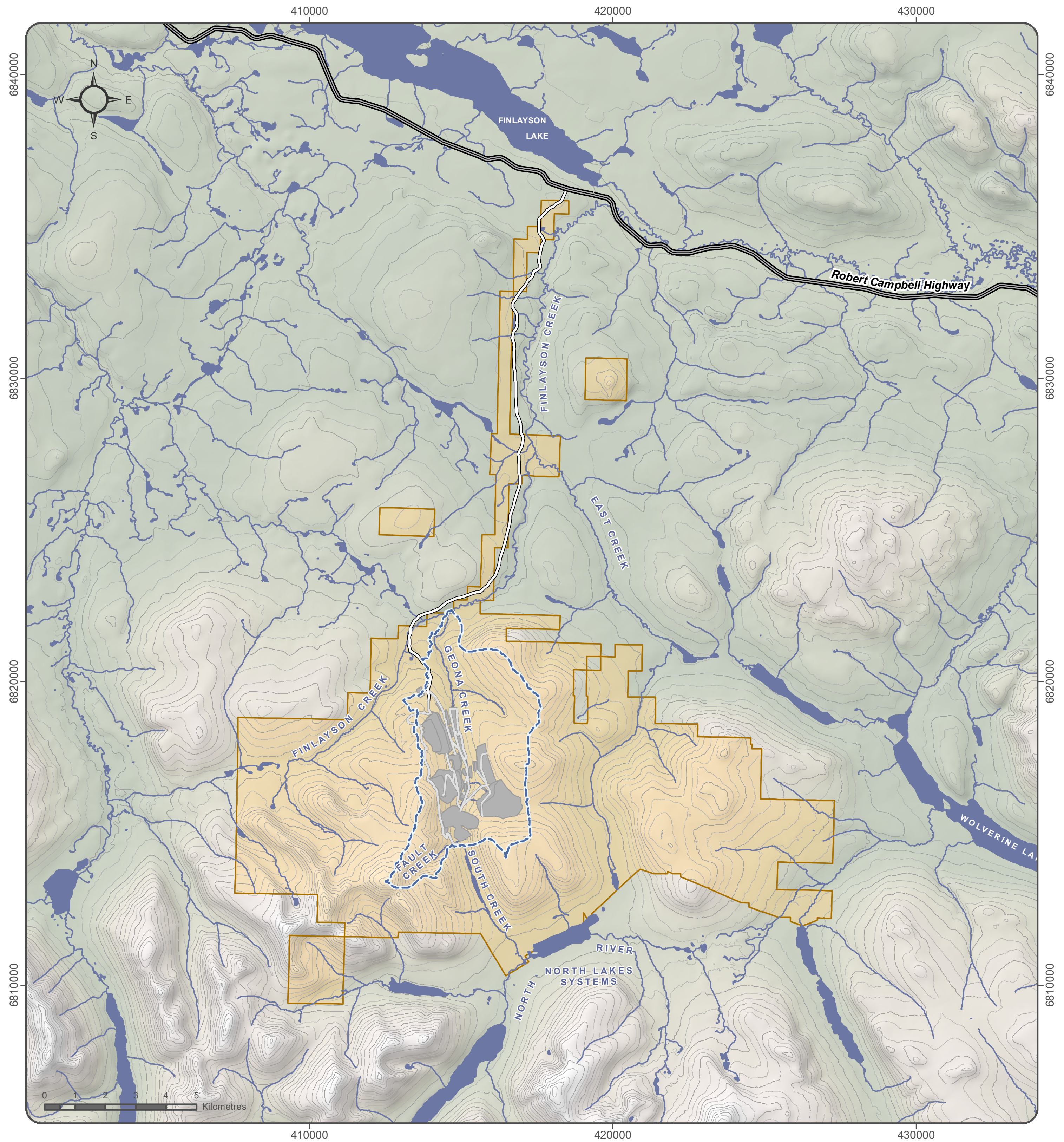
Total precipitation recorded on site from September 2015 to August 2016 was 343 mm, with July and August being the wettest months. Mean annual precipitation in the region ranges from 210.4 mm at Ross River to 709.8 mm at Ketza River Mine. The greatest amount of precipitation typically falls between June and September. The proportion of total annual precipitation falling as rain ranges from 39% at Ketza River Mine up to 70% at Ross River and Faro. No clear pattern emerges when looking at long-term total precipitation trends; however, the proportion of total precipitation falling as rain displays an increasing trend at all stations, consistent with the rising trends observed in air temperature (AEG, 2016a).

4.3 SURFACE WATER

4.3.1 Water Quantity

The Project lies in a small watershed called Geona Creek, which is a north flowing and north facing tributary to Finlayson Creek (Figure 4-3). Finlayson Creek meets the outflow of Finlayson Lake below the Robert Campbell Highway and flows east to eventually join the Frances River, and ultimately, the Mackenzie River. One of the highest elevation tributaries in Geona Creek is Fault Creek, which has a median elevation of 1,708 masl, and a catchment area of approximately 2 km^2. Fault Creek is characterized by steep slopes, and small trees and shrubs in the creek valley, but otherwise is an alpine environment. Geona Creek has a median elevation of 1,479 masl and spans from the alpine to sparsely forested areas at lower elevations. The Finlayson Creek catchment area is approximately 35 km^2 above the confluence with Geona Creek, and grows to 211 km^2 where it flows under the Robert Campbell Highway shortly before it joins the outflow of Finlayson Lake. The watershed divide of Geona Creek is characterized by several small ponds.

Peak flows typically occur in May in the smaller catchments, though they can occur in summer months in years when snow melt generated peak flows are less significant. Low flows occur late winter in March, April or even early May depending on the melt cycles and snowpack in any given year. None of the creeks were observed to freeze completely and some flow was observed in all months of the 2015-2016 monitoring program. Smaller catchments tend to peak earlier than large regional rivers. It was also observed that higher flows in September are likely driven by precipitation, which have a greater relative impact in small creeks than larger rivers as the large regional sites tend to dampen the effect of more localized rain events (AEG, 2016a).



Geona Creek Catchment

Location of Proposed Mine Infrastructure

BMC Minerals (No. 1) Ltd. Mineral Claim Areas

Robert Campbell Highway

Tote Road/Proposed Access Road

Proposed Mine Road

KUDZ ZE KAYAH PROJECT
CONCEPTUAL RECLAMATION AND CLOSURE PLAN

FIGURE 4-3
PROJECT AREA HYDROLOGY

FEBRUARY 2017

Datum: NAD 83; Projection: UTM Zone 9N

AEG

BMC MINERALS

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4.3.2 Water Quality

Creeks that drain the Project Area were circumneutral to alkaline (pH 6.8 – 8.7; median 7.8) and had hardness ranging from moderately hard (Fault Creek and South Creek) to hard (Geona Creek) in the upper watershed, and very hard in the lower watershed (Finlayson Creek and East Creek).

Dissolved organic carbon (DOC) ranged from <0.5 mg/L to 17.2 mg/L, with the highest concentrations measured in Geona Creek. The highest DOC concentrations were measured during freshet as snow melt rinsed surrounding organic soils and flushed organic carbon into the streams.

At all surface water stations, nitrogen species (nitrate, nitrite, cyanide, ammonia) were all typically below or marginally above the detection limit. Nitrate peaks coincided with freshet-period sampling; however, no concentrations exceeded the Canadian Council of Ministers of the Environment (CCME) threshold of 3 mg/L.

Fluoride commonly exceeded the CCME guidelines (0.12 mg/L) in East Creek with a median fluoride concentration of 0.17 mg/L, suggesting that East Creek drains an area of fluoride-bearing rocks. Only one fluoride exceedance was measured in Geona Creek (0.14 mg/L) and no exceedances occurred in South Creek.

Total phosphorus exceeded the CCME eutrophic guideline of 0.035 mg/L in at least one sample at many of the stations. These peaks typically occurred during freshet and were accompanied by high concentrations of total suspended solids (TSS) and total iron. Dissolved phosphorous was often below detection level.

Water quality guideline exceedances were observed sporadically for a number of constituents including total concentrations of aluminum, arsenic, cadmium, chromium, copper, iron, lead, mercury, selenium, and zinc. The majority of these exceedances coincided with freshet, when TSS concentrations were highest and metal(loid)s were largely transported as particulates.

A comparison of the 1994-1995 water quality dataset with the more recent baseline water quality monitoring dataset indicated that the majority of constituents shared a similar concentration span. This suggests there were no obvious differences between the two datasets. The exceptions were total selenium and total chromium (AEG, 2016b).

4.4 GROUNDWATER

4.4.1 Groundwater Quantity

The local hydrogeological system in the study area consists of two principal aquifers, a bedrock aquifer and an overburden aquifer. The overburden aquifer, overlain across valley floors, is over 10 m thick and is present in the sediments along the valley floor. Recharge to the overburden aquifer is through discharge from the underlying bedrock aquifer and infiltration of precipitation and snowmelt through surficial soils on valley flanks. Recharge to the bedrock aquifer occurs primarily through infiltration of precipitation and snow melt on valley flanks, where bedrock outcrops or overburden is thin. Discharge occurs to the overlying overburden along the valley floor, and eventually to Geona Creek and/or its tributaries. Groundwater velocities calculated for the overburden range from between 0.27 m/day and 17.4 m/day. Groundwater velocity in the bedrock aquifer ranges from 0.16 m/day to 0.70 m/day.

Groundwater elevations are variable across the study area with the water table at or very near surface across the valley floor, while beneath the mountains the water table may be greater than 200 m below surface. Based on the mountainous terrain that dominates the study area, groundwater flow is expected to be mainly controlled by the area's topographic features with flow from the topographically high mountain tops and slopes on either side of the valley toward discharge zones along the valley floors.

The Project is located in an area within the discontinuous permafrost zone. Previous studies conducted by Cominco (1996) noted that permafrost is present on north and west facing slopes along the Geona Creek valley, especially above 1,400 masl. Permafrost was found to be mostly absent on the western valley walls as well as in the area of the proposed open pit, except for some localized ice lenses. Where present, permafrost acts as a confining or semi-confining layer depending on the spatial extent and thickness, thereby limiting recharge to the aquifer in this area, which causes the groundwater table to be located at greater depth when compared to the east facing slopes where permafrost has been found to be mostly absent (AEG, 2017b).

4.4.2 Groundwater Quality

Groundwater quality varies across the study area, which is understandable due to the large spatial extent of the study area, the various groundwater flow systems and recharge sources, and the potential for differing chemistry in the vicinity of the ABM deposit (AEG, 2017b). Field pH values ranged from 5.68 to 8.50 units and averaged a slightly alkaline 7.38 in both overburden and bedrock aquifers across the whole study area. Dissolved hardness concentrations were variable across the site, ranging from 78.9 to 2,108 mg/L. Groundwater has an average total dissolved solids (TDS) concentration of 379 mg/L across the study area, with an average concentration of 406 mg/L in bedrock wells and 306 mg/L in overburden wells. Sulphate concentrations were typically more elevated in the pit area, with a maximum sulphate concentration of 280 mg/L and an average of 112 mg/L. The remainder of the Project Area had average sulphate concentrations of 61 mg/L (AEG, 2017b).

Higher concentrations of sulphate in the pit area are likely due to the oxidation of the sulphide minerals in the deposit. Natural zinc and lead concentrations were observed to be considerably higher in the vicinity of the ABM Deposit than across the rest of the study area. Dissolved arsenic, cadmium and iron are considered "key parameters" that have been detected at natural concentrations above guideline values in multiple wells across the site over the monitoring program. Natural dissolved arsenic and cadmium concentrations were generally more elevated in the proposed pit area, compared to the rest of the Project Area. Dissolved selenium concentrations were naturally elevated across the Project Area in numerous wells; however, concentrations in select wells were much higher in the areas surrounding the proposed Class A and Class B Storage Facilities (AEG, 2017b).

4.5 VEGETATION

A Terrestrial Ecosystem Map (TEM) in the vegetation baseline report (AEG, 2016c) was developed to define and quantify specific habitat types in the bioclimatic zones of the vegetation local study area. (Figure 4-4) Of the nine bioclimatic zones identified in the Yukon, three have been identified to exist in the study area. The three bioclimatic zones are Boreal High (40%), Boreal Subalpine (40%), and Alpine (20%) (Figure 4-2). A total of 27 vegetation communities have been defined based on 126 vegetation associations compiled from aerial photographs and data collection. The definitions of the bioclimatic zones are presented in Table 4-1 including the dominant vegetation communities in those zones.

Table 4-1: Bioclimate Zones and Definitions for the Project Area

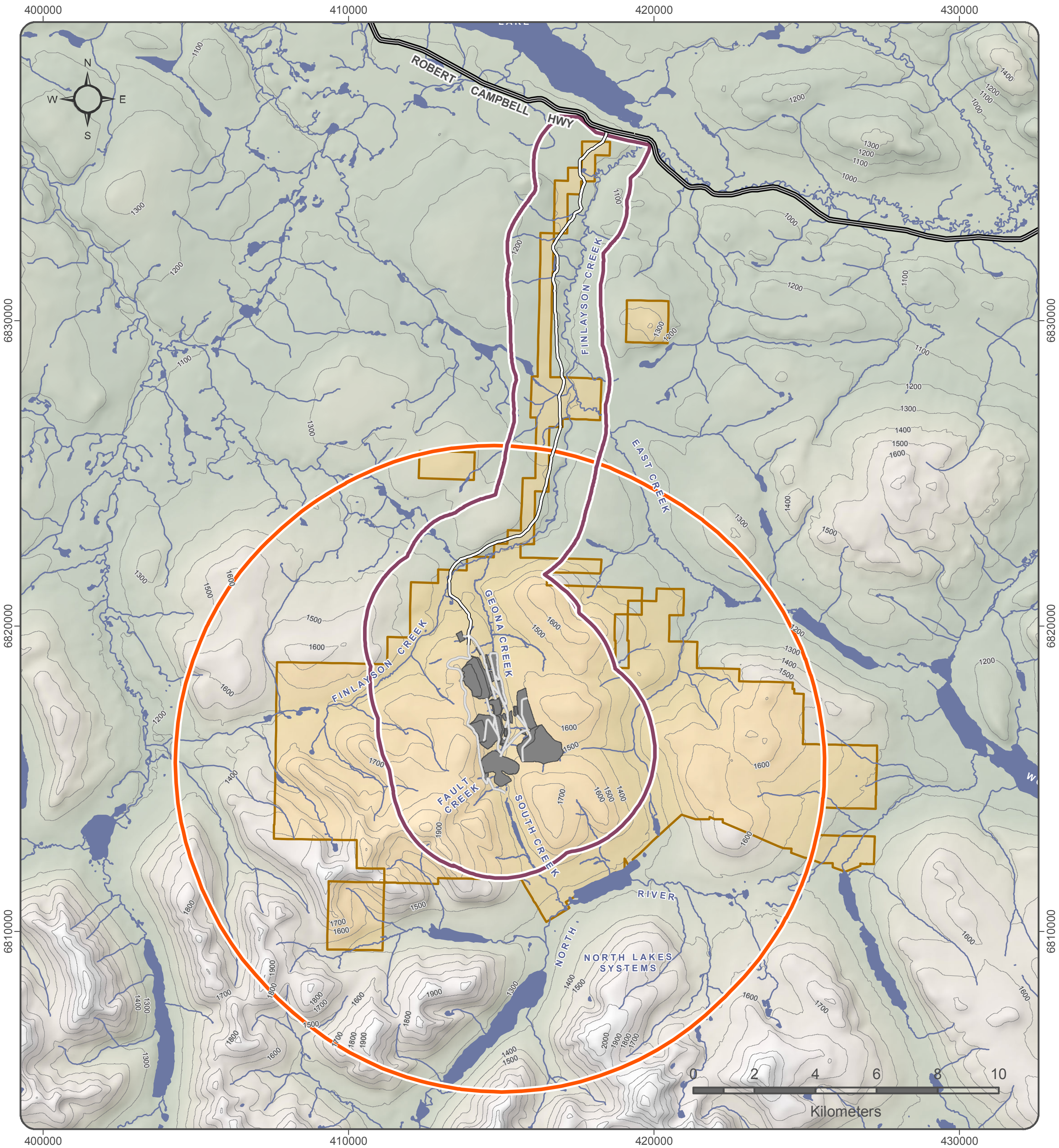
Bioclimatic Zone (elevation range)	Percentage of Total Area	Definition
Boreal High (850 – 1,300 masl)	49.7 km^2 40.0%	Boreal highland forested areas are a mix of subalpine fir with a lichen and moss understory on the majority of the slopes and subalpine fir-willow in drainage areas and upper elevation forests, with white spruce and subalpine fir. The canopy tends to be more open then Boreal Low with a moderate to well-developed shrub layer. Non-forested areas include: wetlands, riparian, avalanche tracks, exposed soil/rock and anthropogenic structures.
Boreal Subalpine (1,300 – 1,550 masl)	49.6 km^2 40.0%	Open to sparse forest canopy cover, main trees species are subalpine fir and white spruce which became less frequent at higher elevations. A well-developed shrub layer composed mainly of scrub birch, willow and *Vaccinium* ssp. replaced forest cover with only a few widely scattered subalpine fir. At the higher extent of this zone small woody shrubs, Dryas, mosses and lichen grew on exposed bedrock or talus piles.
Alpine (1,550+ masl)	25.0 km^2 20.0%	Alpine communities include dwarf ericaceous shrubs, scrub birch, willow, grass/sedges (*Gramineae*), forbs, lichen and often gravel, talus and bedrock at elevations above tree line.

The Tote Road between the Robert Campbell Highway and the Project is mostly located in the Boreal High bioclimatic zone. The primary tree species along the Tote Road are white spruce and black spruce. Understorey shrubs include Labrador tea (*Ledum groenlandicum*), scrub birch, and willows. Balsam poplar are found along creek sides and were seen regenerating along the road edges. Trembling aspen are uncommon, but were found along the Tote Road at the Finlayson Creek Bridge, on the steep south facing slopes. Small aspen stands were also present at lower elevations on well drained soils on moderate to steep south facing slopes. Aspen is a successional species occurring where there has been recent disturbance, such as spot fires or soil erosion. The boreal forest along the Tote Road is composed of mainly mature trees (greater than 100 years); some of the white spruce encountered are older (greater than 160 years) and are likely survivors of historic fires.

As the elevation increases, boreal forest ecosystems are gradually replaced by the subalpine plant communities. This is commonly a matrix of scrub birch and willows with an occasional stunted subalpine fir. Meadows also occur in the subalpine zone, populated by grasses, sedges, mosses, and a variety of forb species. On the top of mossy hummocks, the dwarf ericaceous shrubs still persist and Labrador tea exists. The lower and mid slopes of the subalpine valleys contain sparse subalpine fir and white spruce forests. The Project Footprint is primarily situated in the Boreal Subalpine bioclimatic zone

The Alpine bioclimatic zone is characterized by limited soil and harsh climatic conditions. Therefore, small, low-growing plants such as sedges, grasses, forbs, and dwarf shrubs persist at alpine elevations. Dwarf shrubs are an assemblage of ericaceous plants consisting of four-angled mountain heather (*Cassiope tetragona*), bog blueberry (*Vaccinium uliginosum*), lingonberry (*Vaccinium vitis-idaea),* crowberry (*Empetrum nigrum*), bearberry (*Arctostaphylos rubra*). Other low growing shrubs that were often observed at these high elevations included: mountain aven (*Dryas integrifolia*), willow species (*Salix arctica, reticulata, and polaris*), and diminutive scrub birch.

The riparian systems in the vegetation LSA are composed of two types: slow flowing creek/fen complexes with associated wetlands, or faster flowing creeks confined to deep valleys with definitive floodplains, such as Finlayson Creek. The riparian systems associated with slow flowing creeks contain organic substrates derived from sphagnum mosses and graminoids. Acid tolerant plants such as Labrador tea, bog blueberry, and cloudberry (*Rubus chamaemorus*) grow amongst the moss hummocks. The second type of riparian system has a rocky substrate; sediment is composed mostly of gravel, cobbles and boulders. The vegetation associated with this system is tall willows, balsam poplar, and white spruce on upper terraces.



Wildlife and Vegetation Local Study Area (LSA)

Grizzly Bear Regional Study Area (RSA)

Location of Proposed Mine Infrastructure

BMC Minerals (No. 1) Ltd. Mineral Claim Areas

Contour (100m interval)

Watercourse

Waterbody

KUDZ ZE KAYAH PROJECT
CONCEPTUAL RECLAMATION AND CLOSURE PLAN

FIGURE 4-4
LOCAL AND REGIONAL STUDY AREAS

FEBRUARY 2017

Datum: NAD 83; Projection: UTM Zone 9N

AEG

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4.6 WILDLIFE

The following sections summarize the wildlife baseline report for the Kudz Ze Kayah Project prepared by AEG (2016d).

4.6.1 Caribou

Among all wildlife species in the Project Area, the Finlayson caribou herd (FCH) has the most significant ecological, economic, and cultural importance in the region, to both the Kaska and resident or guided hunters. The herd is part of the Northern Mountain caribou population, assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as a species of special concern, and listed as such under the *Species at Risk Act* (SARA) in 2005.

The FCH uses the higher elevation areas around the Regional Study Area in spring, summer, and fall for calving and rutting, and the lowlands adjacent to the Pelly River for overwintering. The Project is located in key caribou rut habitat. Rut surveys performed in 2015 and 2016 observed a total of 712 and 660 caribou respectively, providing evidence that caribou are present near the Project Area during the rutting period. The habitat suitability map created for caribou identified 777 ha of moderately high and highly suitable rut habitat out of 357, 715 ha in the FCH range, and 118 ha of moderately high and highly suitable post-calving habitat out of 229,567 ha in the FCH range, that will be directly affected by the proposed mine infrastructure Footprint.

4.6.2 Moose

Moose in the area are similarly a significant wildlife resource to First Nation, resident, and guided hunters alike. Moose are widely distributed in the Project Area, and prefer shrub-dominated ecosystems near forest cover such as treeline edges, riparian or wetland complexes, and regenerating burn areas. Two different surveys were conducted to assess moose distribution patterns and abundance in the Project Area. A total of 31 moose and 152 moose were observed during the 2015 and 2016 late-winter surveys, respectively. Moose were primarily observed using flat or gently sloping terrain close to streams with plenty of shrub understory. In addition, moose were mainly found at higher elevations, and more bull moose were observed above treeline than cows. Furthermore, it was observed that moose make use of the Tote Road and drill access roads for efficient movement through the Project Area. Results of the 2015 post-rut aerial survey found a total of 114 moose. They were mainly utilizing the upland portion in the east, south and west of the Project Area. The habitat suitability map created for moose identified 936 ha of moderately high and highly suitable post-rut habitat, and 837 ha of moderately high and highly suitable late-winter habitat, that will be directly affected by the proposed mine infrastructure Footprint.

4.6.3 Grizzly Bears

Grizzly bears (*Ursus arctos*) are the top predator at the Project Area and have been observed on a couple dozen occasions. They have large home ranges, preferring open valleys and subalpine regions, and may occur in all habitat types as they move through their range. Grizzlies are known to occupy the subalpine valleys and alpine plateaus of the wildlife LSA and Grizzly Bear RSA (Figure 4-4) where they feed on vegetation, berries, small mammals, and ungulates. Accurate densities of grizzly bear near the Project Area are unknown; however, their density is expected to be higher than 10 to 16 bears per 1,000 km^2, which are the estimated densities in the Southern Lakes region of Yukon (Larsen et al., 1989, Desrochers et al., 2002; Environment Yukon, 2005). Grizzly bears were confirmed denning in the Grizzly Bear RSA through the observation of two active dens. One den was discovered in May 2015, located above treeline approximately 4.5 km southwest of the Project Footprint. A second den was observed in 2016, approximately 4 km west from the proposed Project Footprint.

4.6.4 Wolves

Wolves (*Canis lupus*) are another important species at the Regional Study Area that play a vital role in the predator-prey relationship with moose and caribou. This relationship has resulted in wolf populations near the Project Area to be the subject of government studies in the 1980s. A wolf control program was undertaken by YG from 1983 to 1989 to monitor the effect of a reduced wolf population on the population of the FCH. The wolf population was reduced in the area by 85% (Cominco, 1996). As a result of the wolf control program, the FCH population increased. However, after the cessation of control measures, the wolf population rebounded, and the FCH population decreased to near pre-control levels (Cominco, 1996). Many wolves and wolf tracks were observed throughout the wildlife LSA in 2015 and 2016. Observations were mostly made along the Tote Road and along the Geona Creek valley.

4.6.5 Furbearers

Other furbearer species, such as wolverine (*Gulo gulo*), red fox (*Vulpes vulpes*), and lynx (*Lynx canadensis*) are present in the wildlife LSA, though little is known about their abundance or distribution in the region. Incidental observations of these species were recorded during the 2015 and 2016 seasons. In addition, collared pika (*Ochotona collaris*) and hoary marmot (*Marmota caligata*) were observed on mountains to the south and west of the proposed Project Footprint in the wildlife LSA. Pika were observed at high elevation sites that exhibited large, talus rock with crevices below, that may provide cover. It is probable that collared pika and hoary marmot are present throughout the wildlife LSA at all high elevation sites with suitable habitat. Confirmed bat vocalizations were also recorded in the wildlife LSA. The bat recordings came from wetlands in boreal forest habitat along the Tote Road. It is probable that the recordings came from the little brown bat (*Myotis lucifugus*) as this is the only species of bat whose range overlaps the Project Area.

4.6.6 Birds

A total of 42 bird species were observed during surveys conducted in 2015, and 61 species were observed in 2016 in the LSA. Among these species, five are reported as at risk by COSEWIC. Olive-sided flycatcher (*Contopus cooperi)*, bank swallow (*Riparia riparia)*, and barn swallow (*Hirundo rustica)* are considered threatened, while red-necked phalarope (*Phalaropus lobatus)*, and rusty blackbird (*Euphagus carolinus)* are considered special concern. The most frequently observed species were white-crowned sparrow (*Zonotrichia leucophrys*), American tree sparrow (*Spizella arborea*) and Wilson's warbler (*Cardellina pusilla*). A total of five habitat types were surveyed including riparian, wetland, alpine, mixed subalpine, and boreal forest. An active golden eagle (*Aquila chrysaetos)* nest, located in the proposed Project Footprint, was used in 2015 and 2016. Other raptor species observed in the Project Area include bald eagle (*Haliaeetus leucocephalus*), northern harrier (*Circus cyaneus*), and gyrfalcon (*Falco rusticolus*). Ptarmigan (*Lagopus* sp.) were frequently observed in the high elevation habitat around the Project Area.

A total of 20 species of waterfowl and other aquatic birds were observed during the 2015 and 2016 surveys in the LSA. This included seven duck, seven shorebird, three gull, one loon, one swan, and one goose species. Predominant waterfowl using the wetlands in the wildlife LSA and reference wetlands were scaup (*Aythya* spp.) and goldeneye (*Bucephala* spp.). Other waterfowl include green-winged teal (*Anas crecca*), northern pintail (*Anas acuta*), mallard (*Anas platyrhynchos*), bufflehead (*Bucephala albeola*), and red-breasted merganser (*Mergus serrator*). Waterfowl nesting on the wetlands in the wildlife LSA include mallard, green-winged teal, and northern pintail. No waterfowl or shorebird species of conservation concern were reported nesting at any of the wetlands in the wildlife LSA or reference wetlands.

4.7 SOIL AND GEOLOGY

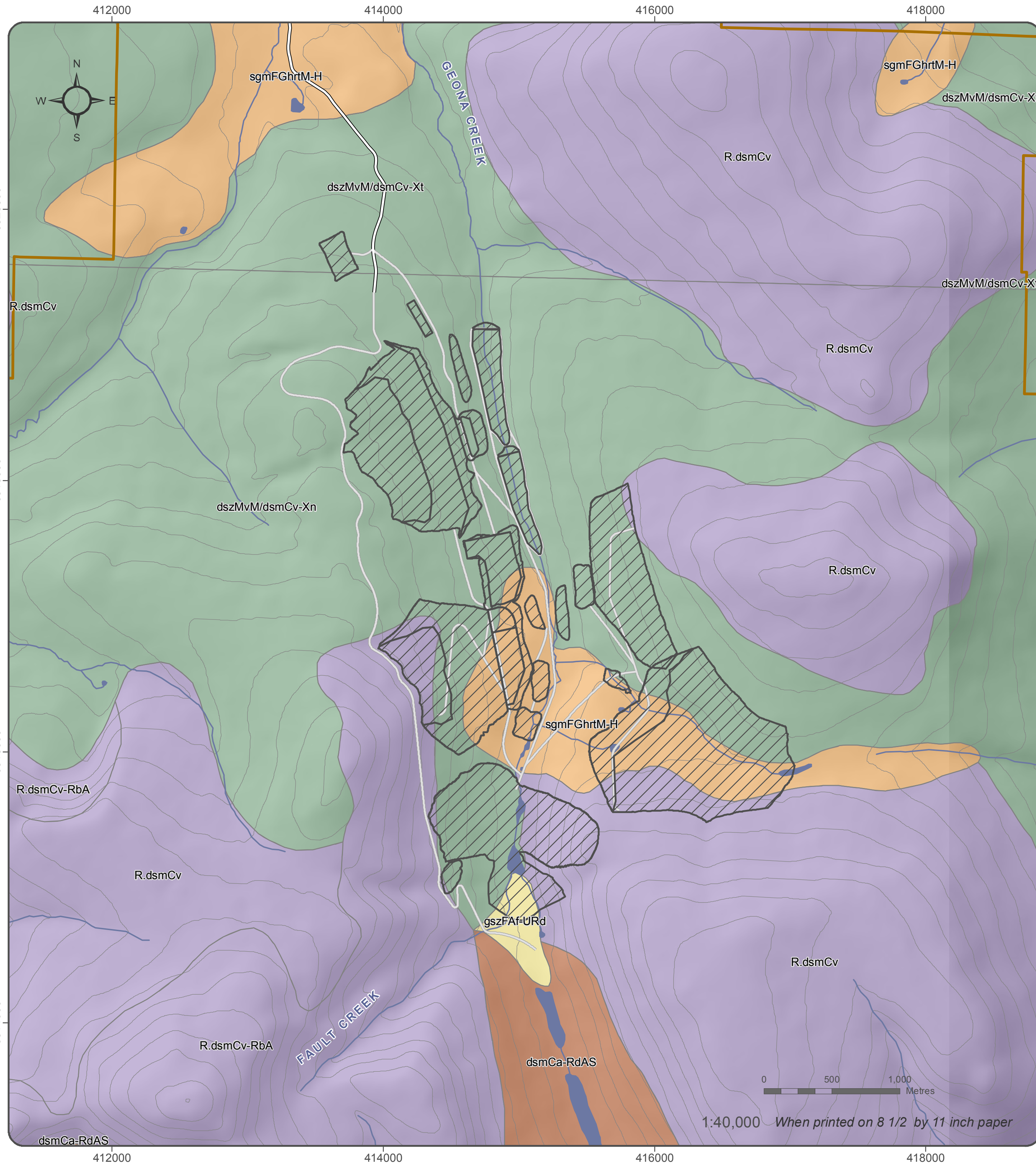
4.7.1 Soils and Surficial Geology

Glacial, periglacial (ice related), and fluvial processes are the main processes which have been involved in the creation of landforms and are the origin of surficial deposits in the Project Area (Cominco, 1996). This was confirmed by work conducted by Knights Piésold in 2015 and 2016 (2016c). The main surficial deposits in the area are as follows:

- Alluvial deposits – geologically recent and result from water processes reworking the sediments deposited during the last ice age;
- Glaciofluvial deposits – the result of water processes from the melting of glaciers and ice sheets. The valley bottoms are infilled generally with sand and gravel deposits from alluvial and glaciofluvial processes to depths of up to 20 m. There are some glaciofluvial deposits on the west side of Geona Creek near the confluence with Finlayson Creek where a deposit in excess of 40 m thick is present;
- Glacial till deposits – the result of the direct glacial action. These silty sand and gravel deposits overlie much of the area, ranging in thickness from less than 1 m to up to 10 m. The thickness of these deposits generally decreases with increasing elevation;
- Colluvium deposits – the result of frost loosening of bedrock which is then transported by debris and avalanche flows to the base of steep slopes. In the Project Area colluvium is generally found above about 1,500 masl; and
- Organic material – generally less than 0.5 m thick overlies colluvium and glacial till deposits.

Surficial geology in the Project Area, based on information from the Yukon Geological Survey, is presented in Figure 4-5). In general, the soils in the Project Area are acidic sandy loams, and are low in macronutrients. Organics occur on gentle slopes and valley bottoms in association with fens and bogs found along drainages.

The most common Soil Order (soil classification based on dominant physical, chemical, or biological properties) encountered during the ecosystem survey were Cryosols. Cryosols are soils that overlay shallow permafrost (less than 2 m below the surface) especially on the north aspects in Spruce/Feathermoss forests and in the valley bottoms where thick organic layers insulate mineral soils from solar radiation. The other orders of mineral soils encountered with in the study area were Dystric Brunisols (displaying some horizontal development) found on south facing mountain slopes and old alluvial plains. Regosols are young soils with a poorly developed B horizon. Regosols are mainly located in the alpine, where soils evolve slowly or in floodplain corridors where there is repeated disturbance by high water events.



Colluvium
Fluvial
Glaciofluvial
Morainal
Bedrock
Location of Proposed Mine Infrastructure
BMC Minerals (No. 1) Ltd. Mineral Claim Areas
Tote Road/Proposed Access Road
Proposed Mine Road
Contour (40m interval)

KUDZ ZE KAYAH PROJECT CONCEPTUAL RECLAMATION AND CLOSURE PLAN

FIGURE 4-5

SURFICIAL GEOLOGY PROJECT AREA

FEBRUARY 2017

Datum: NAD 83; Projection: UTM Zone 9N

AEG

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4.7.2 Permafrost

Permafrost is discontinuously present on north and west facing slopes, especially above 1,400 masl elevation, although permafrost has been observed as low as 1,250 masl. Permafrost related ground movement or solifluction can be found on some slopes steeper than about 4H:1V (Cominco, 1996).

The 1995/1996 Cominco field program found 35 test pits that encountered permafrost; a further 40 test pits observed ice lenses and ice segregation, which is interpreted as an active layer rather than permafrost. Permafrost was not identified in any of the nine thermistors installed in 2016; however, frozen soil and ice were encountered in samples at approximately 1.5 m and 5.0 m from a drill hole in the Class C Storage Facility footprint.

Site investigations, comprising test pitting and boreholes, were carried out at the site in 1995 and 1996. Additional site investigations, including test pitting, boreholes and installation of thermistors was carried out by BMC in 2015 and 2016 (KP, 2016c). Additionally, a monitoring well installed in the Class A Storage Facility area was discovered to be frozen in the bedrock at approximately 6 m below ground surface (KP, 2016c).

4.7.3 Bedrock Geology

The Project is located in the Finlayson Lake District, a crescent-shaped area approximately 300 km long and 50 km wide that extends from Ross River in the north to Watson Lake in the south. The Finlayson Lake District comprises Devonian to Lower Carboniferous (Mississippian) volcanic, intrusive, and sedimentary rocks separated from the Proterozoic and Paleozoic strata of the ancient North American continental margin to the southwest by the Tintina Fault. The combined Yukon-Tanana and Slide Mountain terranes are separated from the ancient continental strata to the northeast by the Inconnu Thrust (Mortensen & Jilson, 1985; Plint & Gordon, 1996; Tempelman-Kluit, 1979).

The Project Area is underlain by rocks of Devonian-Mississippian age with the Big Campbell thrust sheet that host the ABM Deposit (Figure 4-6). In the Finlayson Lake District, the Jules Creek Fault separates the Yukon-Tanana Terrane from the Slide Mountain Terrane. The Yukon-Tanana Terrane of the Finlayson Lake District is contiguous with the main part of the Yukon-Tanana Terrane, which underlies most of west central Yukon, after restoration of approximately 425 km of Late Cretaceous right-lateral, strike-slip movement along the Tintina Fault (e.g., Mortensen, 1992; Peter et al., 2007).

The Yukon–Tanana terrane in the vicinity of the Finlayson Lake belt is composed of foliated and lineated greenschist to lower amphibolite-grade metasedimentary, metavolcanic and metaplutonic rocks. The Yukon–Tanana terrane was imbricated by Permian thrust faulting into the Cleaver Lake, Money, and Big Campbell thrust sheets. The KZK Property is located within the Big Campbell thrust sheet, which is the structurally deepest of the Yukon–Tanana terrane. The Grass Lake and Wolverine middle Palaeozoic unconformity-bound groups are exposed in the Big Campbell thrust.

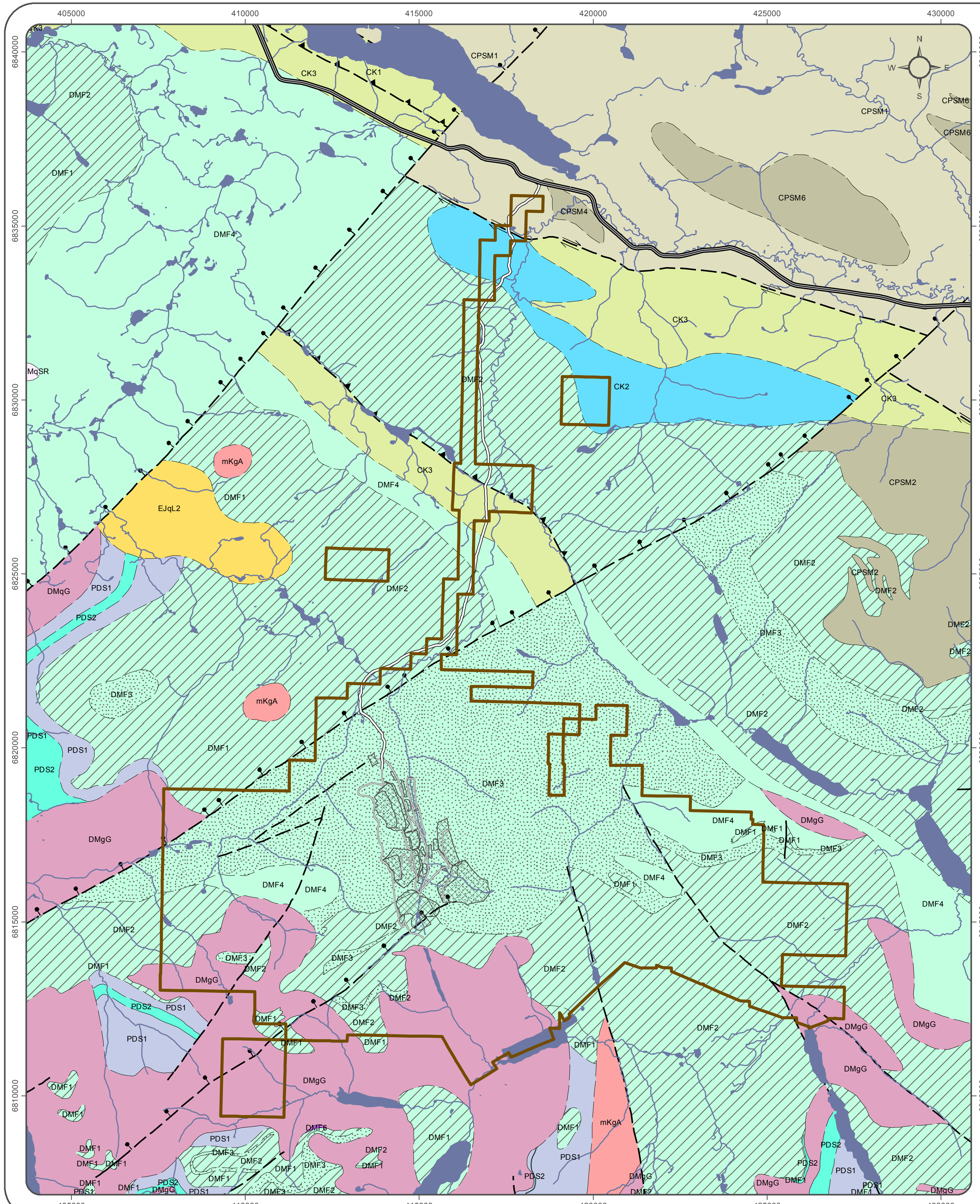
On the KZK Property, the Grass Lake Group is divided into three main stratigraphy components:

- The Kudz Ze Kayah Formation felsic volcanic package hosting all significant VMS mineralization on the Property;

- The overlying "Upper Sedimentary and Mafic Volcanic Sequence" metasedimentary package (or "Wind Lake Formation"); and
- The underlying "Lower Sedimentary Sequence" metasedimentary package.

The KZK Formation is a thick felsic, epiclastic and intrusive/flow (dome) complex with minor mafic sills and flows and rare interbedded sediments. Sediments consist of tuffaceous and carbonaceous mudstone, wacke and orthoquartzite.

The Upper Sedimentary and Mafic Volcanic Sequence base is approximately 200 m above the ABM deposit. It is composed of variably carbonaceous and calcareous mudstone with minor quartzite, siltstone and limestone, intercalated with mafic volcanic and minor felsic volcanic units. It is finer grained than the Lower Sedimentary Sequence formation.



FAULTS

- normal, approximate
- strike slip, dextral, approximate
- thrust, approximate
- unknown, approximate
- unknown, inferred

CONTACTS

- intrusive, approximate
- intrusive, defined
- stratigraphic, approximate
- stratigraphic, defined

BEDROCK GEOLOGY

MID-CRETACEOUS

- mKgA: ANVIL:

EARLY JURASSIC

- EJqL2: LONG LAKE SUITE: massive to weakly foliated, fine to coarse grained biotite, biotite-muscovite and biotite-hornblende quartz monzonite to granite, including abundant pegmatite and aplite phases; commonly K-feldspar megacrystic (Long Lake Suite)

LATE DEVONIAN TO MISSISSIPPIAN

- MqSR: Simpson Range - granite, granodiorite
- DMqG: GRASS LAKES; granite
- DMgG: Grass Lakes

DEVONIAN, MISSISSIPPIAN AND OLDER

- DMF6: FINLAYSON: serpentinite, metagabbro
- DMF4: FINLAYSON: light green, fine-grained siliciclastic and metavolcaniclastic rocks; quartzite, psammitic schist
- DMF3: FINLAYSON: carbonacoues phyllite, quartzite; chert
- DMF2: FINLAYSON: felsic volcanic rocks
- DMF1: FINLAYSON: mafic volcanic rocks

LATE PROTEROZOIC AND PALEOZOIC

- PDS2: Snowcap marble
- PDS1: Snowcap clastic

CARBONIFEROUS

- CK1: KLINKIT: medium to dark green to purple-grey, locally amygdaloidal or vesicular intermediate to mafic volcanic flows, flow breccias, volcanic fragmentals and tuffs; blocks of calc-silicate common in the breccias and fragmentals
- CK2: KLINKIT: carbonate
- CK3: KLINKIT: clastic rocks

CARBONIFEROUS TO PERMIAN

- CPSM6: SLIDE MOUNTAIN: felsic volcanics
- CPSM4: SLIDE MOUNTAIN: ultramafic
- CPSM2: SLIDE MOUNTAIN: basalt (Campbell Range)
- CPSM1: SLIDE MOUNTAIN: chert, argillite (Fortin Creek)

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KUDZ ZE KAYAH PROJECT

FIGURE 4-6

PROJECT BEDROCK GEOLOGY

FEBRUARY 2017

- Robert Campbell Highway
- Tote Road/Proposed Access Road
- Proposed Mine Road
- Location of Proposed Mine Infrastructure
- BMC Minerals (No. 1) Ltd. Mineral Claim Areas
- Waterbody
- Watercourse

ALEXCO ENVIRONMENTAL GROUP

Digital elevation model created by the Yukon Department of the Environment interpolated from the digital 1:50,000 Canadian National Topographic Database (NTDB Edition 2) contour and watercourse layers. Obtained from Geomatics Yukon.

Datum: NAD 83; Projection UTM Zone 9N

1:130,000 when printed on 11 x 17 inch paper

0 1 2 3 4 5

Kilometres

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4.8 SEISMICITY

The Project is located in the Yukon-Tanana Terrane in southeastern Yukon Territory. The Yukon-Tanana Terrane is located on either side of the Tintina Fault, located approximately 30 km to the west of the Project Area. The Tintina fault is a dextral strike slip fault that trends to the northwest and extends from BC to Alaska. The Tintina Fault separates the stable North American continent from accreted terranes to the west. The Tintina Fault is not considered to be active by the Geological Survey of Canada (Cominco, 1996).

The 1996 Cominco KZK report states that the Project Area is in an area of low seismic activity (Cominco, 1996), which is verified by a study Earthquakes and seismic hazard in the Yukon –Beaufort-Mackenzie (Hyndman et al., 2005) and a preliminary desktop study by KP (2016a). As the 2,475 year return period quake is the only one with potential to affect the Project, it is the only event that is considered in this assessment.

4.9 AQUATIC RESOURCES

Aquatic resources baseline information is summarized from AEG (2016e) and includes information pertaining to fish and fish habitat, stream sediments, benthic invertebrates, periphyton and chlorophyll *a*.

Historical and recent fisheries surveys have indicated the presence of Arctic grayling in the upper reaches of Geona Creek, as well as throughout the regional drainages (South Creek, North River, Finlayson Creek, East Creek). Other species identified in the area include burbot and slimy sculpin.

The uppermost reach of Geona Creek provides marginal habitat that supports fish that are potentially part of an aboriginal fishery further downstream in Finlayson Creek. In accordance with Section 35 of the Fisheries Act, BMC has prepared a Fisheries Offsetting Plan to support the request for a Fisheries Act Authorization.

Stream sediments were collected in 1994 and 1995 by Cominco as part of the baseline environmental studies (Cominco, 1996). In addition, Environment Canada collected sediment samples in 1995. After regulatory approvals 1999 (Water Use Licence QZ97-026), stream sediments have been conducted in Geona Creek, East Creek, Finlayson Creek and North River every two years since 2002 to meet the requirements of the WUL. Analyses of metal concentrations in sediment have shown concentrations of the select metals do not show substantial variability over time at most of the sites. The highest concentrations of several of the selected metals occurred in the sediments at KZ-7, Geona Creek near the ore body. Cadmium and zinc concentrations have increased over the past decade at KZ-7, although there has been no disturbance at this site. It is interpreted to most likely be that as the stream channel changes over time, more mineralized zones are being eroded and moving sediment loads into these areas. Arsenic concentrations are considerably higher at East Creek, KZ-21 (Laberge Environmental and Can-Nic-A-Nick Environmental, 2015). The dominant sediment size at each site was more or less consistent over time.

Benthic invertebrate community composition results (diversity and dominant taxa) indicate that the populations in the study area are stable over time. Mean metal concentrations in collected benthos samples fall well below the mean concentrations in the Yukon database (AEG, 2016e) indicating that metals in the aquatic system are not transferring through the trophic levels relative to the similar Yukon habitat.

Periphyton samples were collected from Finlayson Creek, Geona Creek, East Creek and Fault Creek in September 2015. Results showed that abundance and density were the highest in Geona Creek (KZ-9) and the lowest in Fault Creek (KZ-2). These results are generally consistent with benthic invertebrate results. Diversity was highest in East Creek (KZ-21) and lowest in Fault Creek (KZ-2). The dominant phylum observed at all sites was *Bacillariophyta*, with other phyla generally representing less than 1% of the total number of algae.

Determining chlorophyll *a* concentrations provides a measure of algae biomass and thus, the primary productivity of a given location. Sunlight, water temperature and nutrients are factors influencing chlorophyll *a* concentrations. Chlorophyll *a* samples were collected on Finlayson Creek, Geona Creek, East Creek and Fault Creek in September 2015. Results showed that chlorophyll *a* concentrations in the Project Area were generally low, which is an indication of low productivity systems. The highest concentration was observed at the mouth of Geona Creek (KZ-17) and the lowest in Finlayson Creek just above the confluence with Geona Creek (KZ-16). Canopy coverage, and therefore sunlight penetration, may explain in part the differences observed among the sites.

4.10 HERITAGE RESOURCES

Five sites containing heritage resources have been identified and recorded across the Project Footprint. These consist of three high elevation wood fragments and two prehistoric archaeological sites. Two of the wood fragments appeared to have been modified and/or carried into areas planned for ground disturbance and were submitted to Yukon Heritage Resources Unit for care and curation. The third wood item with the wire attached, appears to be a modern snare pole in an area not planned for ground disturbance, and was left in place.

In 2016, additional investigations were conducted across the Project Footprints but no additional sites or resources were identified. Furthermore, no additional site specific heritage resources were identified in the Project Footprint through the 2016 Traditional Knowledge overview for the Project. However, many traditional land uses were described which reflect past Kaska use which would leave physical remains of heritage resources in the Project Area (ECOFOR, 2016). It is also important to note that the entire KZK Project Footprint was the subject of a Traditional Knowledge study by the Ross River Dena Council (RRDC) TK Team in 1995, commissioned by Cominco prior to their final mine design. BMC's revised Project design occupies essentially that same Project Footprint and is therefore considered appropriately pre-assessed for heritage resources. Nevertheless, BMC has agreed with RRDC that a second TK study will be undertaken for the Project and an initial ground truthing exercise was carried out by RRDC elders in 2016.

5 PROJECT DESCRIPTION

The Project is located on the northern flank of the Pelly Mountain Range, 260 km northwest of Watson Lake and 115 km southeast of Ross River, Yukon (Figure 4-1). The Project Area lies approximately 24 km south of Finlayson Lake and 25 km west of the Wolverine Mine, in the upper portion of the Geona Creek valley, at approximate Universal Transverse Mercator (UTM) coordinates of 415,000 mE, 6,815,500 mN, Zone 9 NAD 83. The Project Area is a located at approximately 1,400 masl elevation in a broad, gently sloping valley.

The Project is in the Traditional Territory of the Kaska.

5.1 MINE FEATURES, FACILITIES, AND EQUIPMENT

BMC is proposing mining, construction and mineral processing activities for the ABM Deposit, of which there are two zones; the ABM Zone and the Krakatoa Zone. The ABM Deposit is a polymetallic volcanogenic massive sulphide deposit containing economic concentrations of copper, lead, zinc, gold and silver. Mining is planned to be conducted utilizing both open pit and underground mining methods, with ore processed into separate copper, lead and zinc concentrates via sequential flotation through a processing plant that will nominally treat 2.0 million tonnes per annum (Mtpa).

Tailings will be deposited in a purpose built dry stack tailings storage facility on the western slope of the Geona Creek valley, or alternatively stored as cemented paste backfill in the mined out underground workings. Waste rock will be classified according to acid generating and metal leaching potential and stored in purpose built waste storage facilities. Strongly acid generating material will be co-disposed with the tailings while other waste rock material will be placed in the surface storage facilities noted above.

5.1.1 Mine Waste Rock

Waste rock material from the ABM Open Pit and underground workings is classified into three categories, based on the ARD/ML test results:

- Class A material: strongly potentially acid generating (SPAG) – approximately 11.6 Mt rock and 15.1 Mt tailings;
- Class B material: weakly potentially acid generating (WPAG) – approximately 48 Mt; and
- Class C material: potentially non-acid generating – approximately 64 Mt.

The Class A Storage Facility will be used to manage filtered flotation tailings and Class A rock. The waste rock will be co-disposed with the filtered tailings solids. The Class A Storage Facility is located north of the Process Plant Facility on the western hillside of the Geona Creek valley. The volume of Class A rock is approximately 8 Mm^3, and the tailing volume is approximately 7 Mm^3 for a total of 15 Mm^3.

A Class B Storage Facility will be used to manage Class B material. The Class B Storage Facility is located on the western hillside of Geona Creek adjacent to the ABM open pit. The total volume of Class B material is approximately 24 Mm^3, assuming a bulk density of 2.0 t/m^3.

A Class C Storage Facility will be used to manage Class C material. The Class C Storage Facility is located in a hanging valley on the east side of Geona Creek. The total volume of Class C material is approximately 32 Mm^3, assuming a bulk density of 2.0 t/m^3.

Other materials that will be managed include overburden and topsoil. The Overburden Stockpile is a temporary structure and will be used to manage the overburden material removed from the ABM open pit area. The total tonnage of overburden material from the Open Pit area is 16.1 Mt, and using a dry bulk density of 1.8 t/m^3, the facility is sized for a storage volume of 9 Mm^3. Topsoil stockpiles will be located at various location on the site.

5.1.2 Infrastructure

Minor infrastructure that supports the main mining activities on site are summarized below in Table 5-1.

Table 5-1: Support Infrastructure Summary

Infrastructure Item	Description
Paste Fill Plant	Provide paste backfill using cement and tailings to the underground mine.
Warehouse and Administration Complex	Contains various areas to support mine operations; assay lab, first aid room, maintenance area, cold storage area, mine dry, warehouse, administration area, board room, and office space.
Fuel Storage and Distribution	LNG for power generation will be stored in two 132,000 litre Type C vacuum insulated tanks. Diesel for power generation will be stored in a facility with a capacity of 700,000 litres. Diesel for mining operations will be stored in a separate bulk fuel storage facility located adjacent to the truck shop. It will include four 100,000 litre tanks. Diesel will also be used for heating of air entering the underground mine during the winter months. Diesel for this purpose will be stored in a 5,000 litre tank, located adjacent to the underground mine portals. A 30,000 litre gasoline tank will be maintained on site for ancillary gasoline use. A small supply (nominally 5,000 litre) of aviation fuel will be maintained on site for exploration activities requiring helicopter support.
Fire Protection	Fire water distribution system will be installed around the processing plant site and camp area with wall hydrants at strategic locations.
Sewage Collection and Treatment	Sewage will be collected from the accommodation complex and the Process Plant/office. Treatment will occur at a Sewage Treatment Plant. The treated water will then be diverted to septic field. Bio-sludge from the treatment plant buried on site at an approved location.
Accommodation facilities	Modular accommodation facilities; Kitchen and mess facilities; Administration office; Recreation facilities; Laundry facilities; Lockers and storage facilities.
Power Plant	Bio-fuel power plant will supply power for the site. It will be located adjacent to the processing plant facilities. The power plant will consist of six 4.2 megawatt (MW) continuous rated generators in an N+2 configuration.
Roads	The Tote Road is approximately 24 km in length and extends from the Robert Campbell Highway, south to the ABM deposit.
Finlayson Lake Airstrip	Located at km 246 on the Robert Campbell Highway and is approximately 12 km from the Project Tote Road entrance. This Finlayson Lake airstrip is currently the primary air access to and from the Project.

5.2 MINING OPERATIONS

The mine is planned to operate for a minimum of 10 years, producing an average 185,000 tonnes (t) zinc, 60,000 t copper, and 35,000 t lead concentrates annually. Concentrate will be transported to the port of Stewart in British Columbia for sale to export markets in North America, Europe and Asia.

5.2.1 ABM Open Pit

The majority of the ABM Zone will be mined by open pit mining methods. A single open pit will be mined that covers the will access the ABM and Krakatoa Zones. The mining of the ABM Zone will be staged into three separate phases to manage overall waste stripping requirements and the Krakatoa Zone mined in a single phase. All open pit mining is planned to be completed by a mining contractor over a period of approximately 10.5 years, including a 17-month preproduction period to provide construction materials and build ore stockpiles to maintain continuity of supply of ore to the processing plant. A brief summary of design specifications for the two open pits is provided in Table 5-2.

Table 5-2: ABM Open Pit Design Specifications

Descriptor	Open Pit Specifications & Dimensions	
	ABM Zone	Krakatoa Zone
Max. Vertical Extent (masl)	1573	1460
Min. vertical Extent (masl)	1220	1265
Max. N-S Extents (m)	700	450
Max. E-W Extents (m)	1250	546
Bench Face Angle (deg.)	70 (65 for North Highwall)	46-70
Catch Bench Width (m)	8 (10 for North-East Cutwall)	8.5
Vertical Bench (m)	20 (10 for East Endwall)	20
Interramp Angle (deg.)	41-52.5	36-52
Bench Height (m)	10	5 Ore/10 Waste
Haul Road Width (m)	22	22
Waste Volume (Mm^3)	52.3	
Ore Volume (Mm^3)	3.7	
Total Volume (Mm^3)	56.0	

All material is expected to require drilling and blasting except for the overburden, which is unconsolidated material and can be excavated with conventional heavy equipment. Primary loading of ore and waste will be by excavators in backhoe configuration and two different sized excavators will be required, due to the difference in densities between ore and waste, and to allow greater selectivity for mining of ore. In addition to the primary loading excavators, a large front end loader (100 tonne class) will also be available for support activities such as pit floor cleanup and to cover truck loading requirements when excavators are undergoing maintenance. There are four primary destinations for hauling material from the pit:

- The run-of-mine (ROM) pad (for ore);

- Class A Storage Facility;
- Class B Storage Facility; and
- Class C Storage Facility.

The waste storage facilities are described above in Section 5.1.1.

5.2.2 Underground Mine

Underground mining has only been considered for the lower portion of the Krakatoa Zone of the Deposit, due to the majority of the ABM Zone being mined by open pit methods.

The primary mining method planned for the underground mine is overhand cut and fill, which will be used for mining of the Main Lens of the Krakatoa Zone (Entech Mining Ltd, 2016). Long hole stoping with fill will be used for mining smaller lenses in the hanging wall and foot wall of the Main Lens. All underground stope voids will be filled with paste backfill.

The underground mine development is planned to commence at the end of Year 2 when the ABM Zone Stage One open pit has progressed down to the 1,340 masl bench. The underground schedule will finish just prior to completion of open pit mining at the end of Year 9.

Access to the underground mine will be via a single ramp collared at the 1,340 masl from in the Stage One ABM zone open pit. Access to the underground portal location will become available in the second half of Year Two of open pit production. Trucks will haul ore and waste out of the mine and dump adjacent to the portal, where the open pit load and haul fleet will subsequently transfer the material to ROM pad or waste storage facilities as appropriate.

A second ramp is proposed for ventilation and will act as a second means of egress; in the event the main ramp was to be become compromised.

5.2.3 Ore Processing

The KZK process plant and associated service facilities will process ROM ore at a nominal rate of 2.0 Mtpa, to produce separate copper, lead and zinc concentrates and tailings. The process will consist of crushing and grinding of the ore, separate sequential pre-float, rougher and cleaner flotation of copper, lead and zinc and regrind of copper, lead and zinc rougher concentrates. Concentrates will be thickened, filtered and stockpiled on site prior to being loaded onto trucks for transport to third party smelters. The flotation tailings will be dewatered by thickening and filtration before the tailings are transported either for disposal at the Class A Storage Facility or combined with cement to produce underground paste backfill.

5.3 WATER MANAGEMENT

5.3.1 Construction

5.3.1.1 Dewatering

Overburden dewatering in the open pit area will occur during the pre-production period to facilitate mining activity in the pit. The first step in dewatering the open pit area will be to divert Fault Creek from its present channel, which flows into uppermost Geona Creek, into the South Creek drainage. The overburden dewatering design incorporates a series of trenches and sumps, which will be used to collect water for pumping to the Pit Rim Pond for sediment settlement. Water is expected to meet discharge criteria and will then be pumped downstream to Geona Creek for discharge to the environment.

Water management in the open pit operation will be managed by a combination of surface interception, dewatering wells and in-pit sumps and localised drains. Once the overburden has been effectively drained, these trenches will be mined out by the open pit development, with any recharge of the overburden flowing into the mined open pit excavation.

In parallel with the overburden dewatering trenches a minimum of three dewatering wells will be constructed to maintain water levels in the three local major fault structures in the open pit below the operating pit floor.

Horizontal drains will be utilised in the open pit, where required, to drain localised water that could affect open pit wall stability, while temporary in-pit sumps will be maintained to ensure that dry conditions are available for the operating pit floor. Water from in the ABM open pit will be collected in these sumps and pumped to the Pit Rim Pond for settling of sediments and subsequent reuse, treatment or discharge as may be appropriate.

5.3.1.2 Diversions, Runoff and Erosion Control

Fault Creek will be temporarily diverted during operations to restrict flow into the Project Area and will be re-established along its original alignment at closure. Fault Creek will be diverted south towards the North Lakes, interrupting flow towards the Open Pit area during operations. The water balance has assumed the diversions have a nominal 50% efficiency rating other than the Fault Creek diversion, which has an assumed nominal 100% efficiency rating. More Project description information is provided in Chapter 4 of the YESAB Project Proposal submission and in the Water Balance Report by KP (2016d).

Erosion management and sediment control at the project will be a process of establishing diversion and collection ditches to manage surface water runoff, constructing sediment control ponds, stabilizing disturbed land surfaces to minimize erosion, establishing temporary vegetative cover, and re-establishing vegetation that is similar in structure to natural vegetation where final slopes are created.

5.3.2 Operations

The aim of the water management plan is to utilize water in the Project Area to the maximum practicable extent. The water management plan involves collecting and managing site runoff from disturbed areas and maximizing the recycle of process water. Surplus water will be stored on site in the Upper and Lower Water Management Ponds and used for the milling process. All water in contact with the mine facilities, including the Class A, Class B, the Open Pit, and the Process Plant Site and other infrastructure will be collected, treated if required, and conveyed to the Upper and Lower Water Management Ponds and eventually discharged to Geona Creek and Finlayson Creek. The contact water from the Class C Storage Facility and Overburden Stockpile will be collected, settled and tested before being conveyed to the northeast diversion where it will be discharged to Geona Creek.

5.3.2.1 Open Pit Water Management

Water management in the open pit operation will be managed by a combination of surface interception, dewatering wells and inpit sumps and localized drains. As described in 5.3.1.1, once the overburden has been effectively drained, these trenches will be mined out by the open pit development, with any recharge of the overburden flowing into the mined open pit excavation.

In parallel with the overburden dewatering trenches, a minimum of three dewatering wells will be constructed to lower water levels in the three major water-bearing fault structures to below the operating pit floor level.

Horizontal drains will be utilized in the open pit where required to drain localized water that could affect open pit wall stability, while temporary inpit sumps will be maintained to ensure that dry conditions are available at the operating pit floor. Water from in the pit will be collected in these sumps and pumped to the Pit Rim Pond for settling of sediments and subsequent reuse, treatment or discharge as may be appropriate.

5.3.2.2 Underground Water Management

As in the strategy for pit dewatering, the dewatering strategy for the underground workings involves the collection of seepage water augmented by horizontal drains, as needed to reduce bedrock saturation near the excavation faces in the event of elevated flow rates or structural instability. Drainage from the walls and horizontal drains will be conducted to a series of sumps to be located at appropriate locations in the workings. Collected water will be pumped from the sump to the surface Pit Rim Pond where it can be routed for subsequent reuse, treatment or discharge as may be appropriate.

5.3.3 Water Treatment Plant

A water treatment plant designed to treat the particular COPI characteristics of the discharge water will be constructed at the processing facility to treat contact water from the collection ponds of the Class A and B Storage Facilities, and the runoff from the process plant area collected in the perimeter sumps. The plant will have additional capacity to treat water pumped from the pit rim pond as required. The water treatment plant will be designed to treat up to a nominal volume of 2,035,000 m^3 per year. The treatment will consist of pH adjustment, clarification, and any other processes that may be required to bring the water to a suitable standard for discharge to the environment. The treated effluent will either be discharged to the Lower Water Management Pond or used in the processing circuit.

5.3.4 Water Storage and Distribution

The process water will be originally supplied from wells and from open pit dewatering, as start-up water for the process. This water will then be recirculated through the process, requiring minimal ongoing raw water make-up to supplement the process during normal operation. Due to the positive water balance, any water reclaimed from site precipitation run-off will be treated, if required, and eventually discharged to the environment. Process water will be stored in a lined pond adjacent to the Process Plant.

Potable water at the camp will be sourced from the existing exploration camp supply well. Potable water will be distributed to the campsite via gravity pressure pipe. Water storage at the camp will be held in an insulated bolted steel gravity reservoir located approximately 50 m in elevation higher than the camp.

The potable water system at the plant site will be a separate system delivering water to the mine dry, change houses, washrooms, administration offices and other areas in the plant site as required. Process Plant raw make-up water will be drawn from wells and pumped into an (approximately) 800 m^3 storage tank located adjacent to the Process Plant.

6 TEMPORARY CLOSURE

Temporary closure in a mine site context is defined as a closure of a site that exceeds six months and is not expected to last longer than five years, and can include both planned and unplanned closure (Yukon Energy, Mines and Resources, 2006). This condition assumes that the owner is still in active control of this site (i.e., not abandonment). This section presents how BMC will manage the Project in the event of a temporary closure.

The approach to temporary closure is based on maintaining the site in a state of physical and chemical stability, while also ensuring the site is secure, safe, and in compliance with all regulatory requirements and authorization obligations. While ensuring these conditions, the Project and infrastructure will be maintained in such a manner so as to facilitate the resumption of mining operations in a timely manner.

To accomplish these temporary closure objectives, the site will be prepared as described in Section 6.1. The subsequent specific measures employed to meet the temporary closure objectives are outlined in Sections 6.2, 6.3, 6.3, 6.4 and 6.5. Monitoring and maintenance programs for a temporary closure are presented in Section 6.6.

Socio-economic implications of potential temporary closure are described in Chapter 17.4 (Accidents and Malfunctions) of the Project Description (AEG, 2017a).

The Project Operational Plans will form the basis of the site management program during a temporary closure, and these are discussed further in the following sections.

6.1 TEMPORARY CLOSURE PREPARATIONS

If a temporary closure condition is triggered through the definition stated in the Project Quartz Mining License, it is expected that a notice will be provided to the appropriate authorities stating:

- The nature and reason for the temporary closure;
- The anticipated duration of the temporary closure; and
- Actions planned to maintain compliance with Project permits and plan approvals.

The focus of the activities to prepare the site for temporary closure will be on securing the site in a manner which will allow for continued maintenance of site access, security, water conveyance infrastructure, and any facilities which will be required for adhering to applicable licences, permits, and regulations.

To prepare the site for temporary closure, assets not required during the temporary closure period will be secured and major contractors will most likely be demobilized depending upon the temporary closure timeline expected. Steps will be taken to reduce environmental liability; hazardous materials that will not be required during temporary closure will be removed from site. Any portions of the camp and process facilities which will not be in use during temporary closure will be considered for decommissioning to a practical extent, without undermining the ability of the Project to be successfully and efficiently returned to operations upon the resumption of mining operations.

A full-time staff will ensure a consistent site presence during temporary closure, and the camp will be prepared for a reduced staff. The staffing numbers on site at a given time are likely to range from four to ten people depending on the circumstances of the temporary closure. Environmental personnel will complete all of the environmental monitoring and inspection requirements. Appropriate trades personnel will conduct routine maintenance activities and water treatment plant operators will be employed as required to achieve water management and effluent discharge objectives.

Mining facilities will be de-energized, winterized, and secured to allow access only to authorized personnel. Any components of the processing facilities which are either not required to be in use during the temporary closure or which are not likely to suffer negative maintenance outcomes, will be drained, cleaned, and secured. The explosives facilities will be secured to ensure access is limited to authorized personnel only. More detail is provided in the following sections.

6.2 SITE SECURITY AND SAFETY

Site security will be maintained in a manner comparable to the operational period with access to the site controlled either by maintaining a consistent presence in the gatehouse or permanent gate closure. Personnel accessing the site will be required to be on an approved site manifest. This will ensure that management has an awareness of specific personnel accessing the Project. All visitors will be required to check in with the camp administrator upon arrival.

All operational safety protocols, plans, and site orientation measures will be held in place and strictly enforced during temporary closure. This includes all aspects of the Health, Safety and Emergency Response Plan, Traffic Management Plan, Environmental Policy and the BMC Occupational Health and Safety Policy.

6.3 MINING OPERATIONS AND MINE WASTE FACILITIES

After open pit mining operations have ceased, the open pit ramp will be protected against casual and/or unauthorised entry and signage warning of potential hazards will be posted (if not already in place) and otherwise maintained. Access may still be required for water management and/or other monitoring activities depending on when the closure is in relation to the remaining mining schedule

Underground mining portals, if developed at time of temporary closure, will be similarly protected and will have signage posted if not already in place warning of hazards. Access may still be required for water management activities, including maintenance of dewatering equipment depending upon when the closure is in relation to the remaining mining schedule.

The face of the Class A Waste Storage Facility will undergo progressive reclamation during operations, which will help to minimize the area of exposed tailings and waste rock if a temporary closure is initiated. There are three main potential risks under conditions of temporary closure:

- Surface desiccation and wind erosion (dusting);
- Oxidation of the exposed tailings and waste rock resulting in oxidation; and
- Metal leaching particularly as the surface dries.

The most appropriate practice for minimizing the potential risks is to place a temporary 'isolation' cover on any exposed tailings surface. This will consist of a 0.25 to 0.50 m overburden cover that is compacted enough to be trafficable by equipment.

The waste and overburden facilities are designed to be physically stable upon construction, and substantial regrading should not be required during closure (temporary or otherwise). Monitoring activities will continue per the operational schedule at all mine waste facilities (Section 7.11)

Management of explosives products on site will depend on the expected period of temporary closure. At a minimum, secure storage on site will be ensured, however bulk explosives may be removed from site for an extended temporary closure duration. The explosives provider would be consulted to determine the most appropriate approach after taking the closure period into account.

6.4 EQUIPMENT AND PROCESSING FACILITIES

The storage, removal or otherwise of any equipment, machinery or consumables on site during a period of temporary closure is totally dependent on the expected nature, period and extent of the expected closure and will be judged on a case by case basis. As a general rule of thumb, any equipment remaining on site that is not required for temporary closure activities or for any other projected activities will be secured on site. Consumables will be stored and secured on lined areas, inside shops, or underground.

Prior to commencement of temporary closure, the crushed ore stockpile and bulk solid reagents (lime and cement) stock levels will be run down if possible. Depending on the expected period of temporary closure, cement stocks may need to be removed from site to prevent the risk of cement hardening in the cement silo. Lime will still be required for water treatment activities.

Slurries will be drained from all process equipment and tanks which will then be flushed with water. Residual reagent solutions remaining in mixing and storage tanks will also be drained and flushed with water. Reagents in stock will initially be secured in the reagent storage area, with removal from site considered for an extended temporary closure period. Grinding media in the semi-autogenous grind (SAG) mill, ball mill and stirred regrind mills will be removed and stored for reuse when operations recommence.

The water treatment plant and associated infrastructure will remain operational for ongoing water treatment requirements as discussed in Section 5.3. Lime will continue to be used on site for water treatment, however at lower quantities than when the processing plant is operational. A temporary pipeline and storage dam will be constructed within the processing plant footprint to store the water treatment plant underflow.

A care and maintenance crew will be responsible for maintaining the shutdown plant and equipment, including periodically bumping all electrical motors to maintain bearing condition and ensuring essential services, such as the fire water pumps and the potable water treatment plant, are on standby and can be run if required.

Any hazardous materials remaining on site during temporary closure will be stored in secured areas or buildings as appropriate and as authorized. Reagents required for water treatment will be stored in a location to facilitate their use during temporary closure for active water treatment but in a secured manner, limiting access to authorized personnel only. Waste Management Areas (i.e., landfill, Land Treatment Facility) will be managed per approved management plans and YG permit conditions.

Fuel storage will be utilized in a reduced manner during temporary closure and will be secured and maintained by maintenance staff.

The ROM pad and LGO stockpiles will be left in place with any stockpiles at the time of initiating temporary closure. They will be inspected periodically with other site facilities for physical integrity, and signs of erosion. All runoff from the stockpiles will continue to be collected and treated as during operation.

6.5 WATER MANAGEMENT

During temporary closure, the strategy from the Operational Water Management Plan will be maintained. This will see existing diversions, seepage collection systems, water storage structures, and treatment systems maintained and utilized/operated as proposed for the operational period. The water management strategy includes the following key principles:

- Water collected in seepage collection ponds, as well as water collected from dewatering activities will continue to be treated as per the operational water management plan such that it is acceptable for discharge in compliance with all applicable regulations, licences, and permits;

- Non-contact water will continue to be diverted around the site in existing diversion channels/ditches. These channels and ditches will be maintained through temporary closure to ensure that non-mining impacted water is being appropriately diverted; and

- The ABM Open Pit and Underground will continue to be de-watered during a temporary closure on an as required basis

However, if the underground workings are developed to the point of needing substantial dewatering, the dewatering activities will continue during temporary closure and the ABM open pit allowed to flood. The dewatering will be discontinued as deemed necessary by the company if the temporary closure is protracted. As the portal is in the ABM open pit confines, any discharge from the portal would be managed with the ABM open pit water.

6.6 MONITORING AND MAINTENANCE

During temporary closure, the site will be monitored in compliance with the approved Environmental Monitoring, Surveillance, and Reporting Plan (EMSRP). An updated EMSRP with a reduced monitoring frequency may be developed and submitted for approval if a temporary closure period is expected to be protracted.

Monitoring (and inspection) activities will include, but are not limited to:

- Environmental protection monitoring and reporting as per the approved EMSRP;

- Physical stability inspections per the approved EMSRP, looking for signs of instability and problematic erosion/sedimentation;

- Inspections of the water conveyance systems to ensure the facilities function as designed;

- Inspections of equipment, buildings, and processing facilities to ensure the they remain in good repair; and

- Follow-up investigation by the appropriate personnel as warranted based on reports of changes to the physical status of any part of the site.

Facilities and equipment required during temporary closure will be maintained on a preventative maintenance program similar to that used during operations. Maintenance activities are likely to include, but not be limited to:

- Maintaining the physical stability and functionality of diversion channels;

- Maintenance of water conveyance equipment and systems;

- Maintenance of the access road and site/haul roads including surface drainage, ditches, culverts, and road grading as required;

- Maintaining progressively reclaimed and temporary cover areas of mine waste facilities to prevent/minimize erosion and sedimentation;

- Maintenance of seepage collection and sediment control ponds;

- Preventative maintenance of equipment;

- Maintenance of solid waste facilities (landfills) and special waste/land treatment facilities;

- Maintenance and securing of fuel storage areas; and

- Maintenance and operation of the water treatment plant.

7 FINAL RECLAMATION AND CLOSURE MEASURES

This section outlines the conceptual reclamation and closure plan for the Project. This level of detail is appropriate to ensure that closure measures:

- Support identified closure goals and objectives;
- Are technically feasible;
- Support the evaluation of potential environmental and socio-economic effects from the Project in the closure and post-closure phases; and
- Are sufficient to support a conceptual cost estimate.

The following sections will present specific closure objectives and corresponding closure criteria and closure measures for both broadly applied (general reclamation) measures, and specific Project components (e.g., ABM open pit, Class A Storage Facility).

7.1 GENERAL RECLAMATION MEASURES

Reclamation of the Project will rely on a combination of standard, commonly applied reclamation strategies as well as some Project- and component-specific measures to meet reclamation and closure objectives. Section 3.1 outlined the fundamental reclamation and closure objectives (YG, 2013) that Yukon Government's Mine Closure Policy dictate must be achieved through closure and reclamation measures. The general or broadly applied measures proposed to meet these fundamental objectives are summarized and described in this section. Sections 7.2 through 7.9 present more component specific objectives, design and performance criteria and closure and reclamation measures.

Table 7-1: General Reclamation and Closure Objectives and Measures for Project Final Closure

Value	Reclamation and Closure Objectives	Measures
Physical Stability	• All mine-related structures and facilities are physically stable and performing in accordance with designs • All mine-related structures, facilities and processes can withstand severe climatic and seismic events	• The objectives are all achieved through design that considers the long term performance of the facility – facilities are constructed on stable foundations, with appropriate factors of safety, the Class A and B Storage Facilities, as well as the UWMP and the LWMP are built to convey and withstand 1:200-year precipitation event flows
Chemical Stability	• Release of contaminants from mine related waste materials occurs at rates that do not cause unacceptable exposure in the receiving environment	• Mine waste facilities, where required, are lined and covered with low permeability materials to minimize contact with oxygen and water to minimize contaminated runoff/seepage and windblown tailings mobilization • ABM Lake water will be treated with lime and carbon sources as required as it fills to reduce aqueous contaminant concentrations prior to release • Active water treatment infrastructure and capacity will be retained on site until passive water treatment systems are achieving performance objectives • Progressive reclamation and revegetation strategies will limit the potential for waste and waste cover erosion and sediment mobilization
Health and Safety	• Reclamation eliminates or minimizes existing hazards to the health and safety of the public, workers and area wildlife by achieving conditions similar to local area features • Reclamation and closure implementation avoids or minimizes adverse health and safety effects on the public, workers and wildlife	• All worker health and safety systems, protocols and preventative measures employed during the operational period will persist during the active closure period • Infrastructure and facilities deemed by the company to be surplus to requirements will be decommissioned and removed from the Project Footprint • The ABM open pit will be signed and barricaded (ramp access) and bunded (pit rim) to minimize the potential for deliberate or inadvertent access by humans or wildlife
Ecological Conditions and Sustainability	• Reclamation and closure activities protect the aquatic, terrestrial and atmospheric environments from mine-related degradation and restore environments that have been degraded by mine-related activities • The mine site supports a self-sustaining biological community that achieves land use objectives	• Revegetation strategies are informed by a comprehensive terrestrial ecosystem mapping inventory of pre-existing conditions. Revegetation prescriptions for disturbed areas will balance the objectives of restoring like ecosystems with erosion stabilization and stability monitoring objectives • Seepage and runoff from closed site facilities will receive passive treatment in constructed wetlands prior to release from the Project Area • No remaining water management ponds will have exposed liners that could entrap wildlife
Land Use	• Lands affected by mine-related activities (e.g., building sites, chemical and fuel storage sites, roads, sediment ponds, tailings storage facilities, waste rock storage areas, etc.) are restored to conditions that enable and optimize productive long-term use of land by wildlife and traditional use by Kaska members (focussed primarily on hunting) • Conditions are typical of surrounding areas or provide for other land uses that meet community needs, interests, and expectations through discussions and involvement from Kaska representatives from RRDC and LFN	• Wildlife use has been well documented, and Kaska traditional use is understood at a general level. Habitat and land capability requirements of species that are key to the primary Kaska land use of hunting – caribou and moose – are the basis of the development of revegetation prescriptions for all restoration activities
Aesthetics	• Restoration outcomes are visually acceptable	• Waste storage facilities have been designed with low angle slopes and features that mimic the surrounding topography • No constructed facilities will be higher than surrounding features (i.e., not visible from afar) • Revegetation strategies will employ native species and will be informed by vegetation communities on similar slopes, aspects and elevations in the surrounding area
Socio-economic Expectations	• Reclamation and closure implementation avoids or minimizes adverse socio-economic effects on local and Yukon communities, while maximizing socio-economic benefits • Reclamation and closure activities achieve outcomes that meet community and regulatory expectations	• The Project and the closure measures are designed to minimize long term maintenance and management requirements (e.g., filtered tailings, passive water treatment, lined/covered waste facilities, no classified dams remaining) • There is a Socio Economic Participation Agreement in place with Kaska, and this agreement contains a framework for contract preference, which will persist and apply in closure/post-closure
Long-term Certainty	• Minimize the need for long-term operations, maintenance and monitoring after reclamation activities are complete	• The Project and the closure measures are designed to minimize long term maintenance and management requirements (e.g., dry-stacked tailings, passive water treatment, lined/covered waste facilities, no classified dams remaining)
Financial Considerations	• Minimize outstanding liability and risks after reclamation activities are complete	• Facilities designed for closure; alternatives assessment considered closure conditions for waste placement to minimize environmental liability and therefore costs to conduct reclamation and closure activities • Risk assessment will be completed prior to RCP finalization to further identify potential failure modes and effects, and to refine closure measures to reduce risk and costs at closure and in post-closure condition

Details regarding some of these closure and reclamation measures are presented in the following sections.

7.1.1 Re-grading and Re-sloping

As most Project facilities are designed for closure (i.e., forms and slopes are appropriate to meet closure objectives), there are limited requirements for substantial earthworks to re-slope facilities for long-term physical stability or prior to the placement of cover systems. Much of the reclamation will be undertaken in a progressive fashion during operations, and will use standard earthworks methods with appropriate machinery (e.g., dozers and graders).

7.1.2 Revegetation

Revegetation is a key component of mine reclamation (SER, 2002), and is a critical measure employed to meet a variety of mine closure objectives, including erosion control and restoration of land use and habitat capability. Reclamation of wildlife habitat is an implied commitment required by developers on Kaska lands (Dena Kayeh Institute, 2010). Land use for traditional hunting, trapping, and gathering lost during mine operations will also be restored through revegetation and reclaiming wildlife habitat.

The revegetation plan is based on information from the baseline terrestrial ecosystem mapping (TEM) for the Project Area (AEG, 2016c). The TEM shows what groups of plant species (vegetation associations) grow on different types of soils in the Project Area. The types of soils are categorized into ecosites which are defined by the nutrient and moisture regimes at various elevations, aspects, and slope gradients. Figure 7-1 shows a portion of the TEM for the Project Footprint where baseline conditions exhibit a variety of vegetation associations, dominated mostly by scrub birch (dark yellow) and willow (red) with some subalpine fir (purple), white spruce (green), and grasslands (yellow).

The second component of the reclamation and revegetation measures consider the changes to the topography and landforms that will occur from mine development. The results were used to determine what revegetation can be done during operations and what can be done after closure on the post-mining landforms. Post-mining landforms are generally composed of sterile, coarse overburden, waste rock, and fines. These materials have varying degrees of acid generating and metal leaching potential. In the case of the Project, the Class A and Class B Storage Facilities are designed to encapsulate reactive or potentially reactive material using unreactive, sterile mine rock and overburden cover systems as described in Section 7.4.

Post-mining landforms were characterized to determine their likely resulting ecosite based on expected moisture regime, which was in turn based on the likely type of material, aspect, and slope. All materials were assumed to be nutrient poor in the post-mining landform based on experience at other metal mines in BC and Yukon (Polster, 2015). When soil is stripped during construction and stockpiled for use in reclamation the soil loses its structure, nutrients, and microbial communities, seeds in the soil lose their viability, and anaerobic conditions form that degrade the soil further (Strohmayer, 1999). Ideally, storage of soil in low berms, less than 1 m deep, re-vegetating stockpiles, and staging progressive reclamation to minimize soil storage times help retain soil nutrients and biota and improve revegetation success (Strohmayer, 1999). However, stockpile depth needs to be balanced with minimizing the footprint of disturbance. Opportunities to reuse soil quickly are limited given the development schedule for the mine; however, continuous progressive reclamation techniques are expected to at least partially offset the potential deconditioning of stripped soils, as the entire areas are not stripped prior to mine operations. Paquin and Brinker (2011) found retaining large woody debris in stripped soils helped retain nutrients and promote revegetation; this technique is also recommended for overburden stockpiling at the Project.

Long-term vegetation associations were estimated based on the predicted ecosites on the post-mining landforms. Short-term revegetation goals were also targeted, incorporating known revegetation seed mixes and recommendations in the Yukon Revegetation Manual (Matheus and Omtzigt, 2013). Once pioneer species of vegetation develop through seeding and planting, surrounding plants will take over through succession with the expectation that the more diverse, long-term vegetation associations will develop (Polster, 2013). Table 7-2 summarizes the expected ecosite on each component of the post-mining landforms, the target species for seeding and planting in the short-term, the long-term target vegetation associations expected to develop through natural succession, and the primary wildlife species expected to use the resulting habitats.

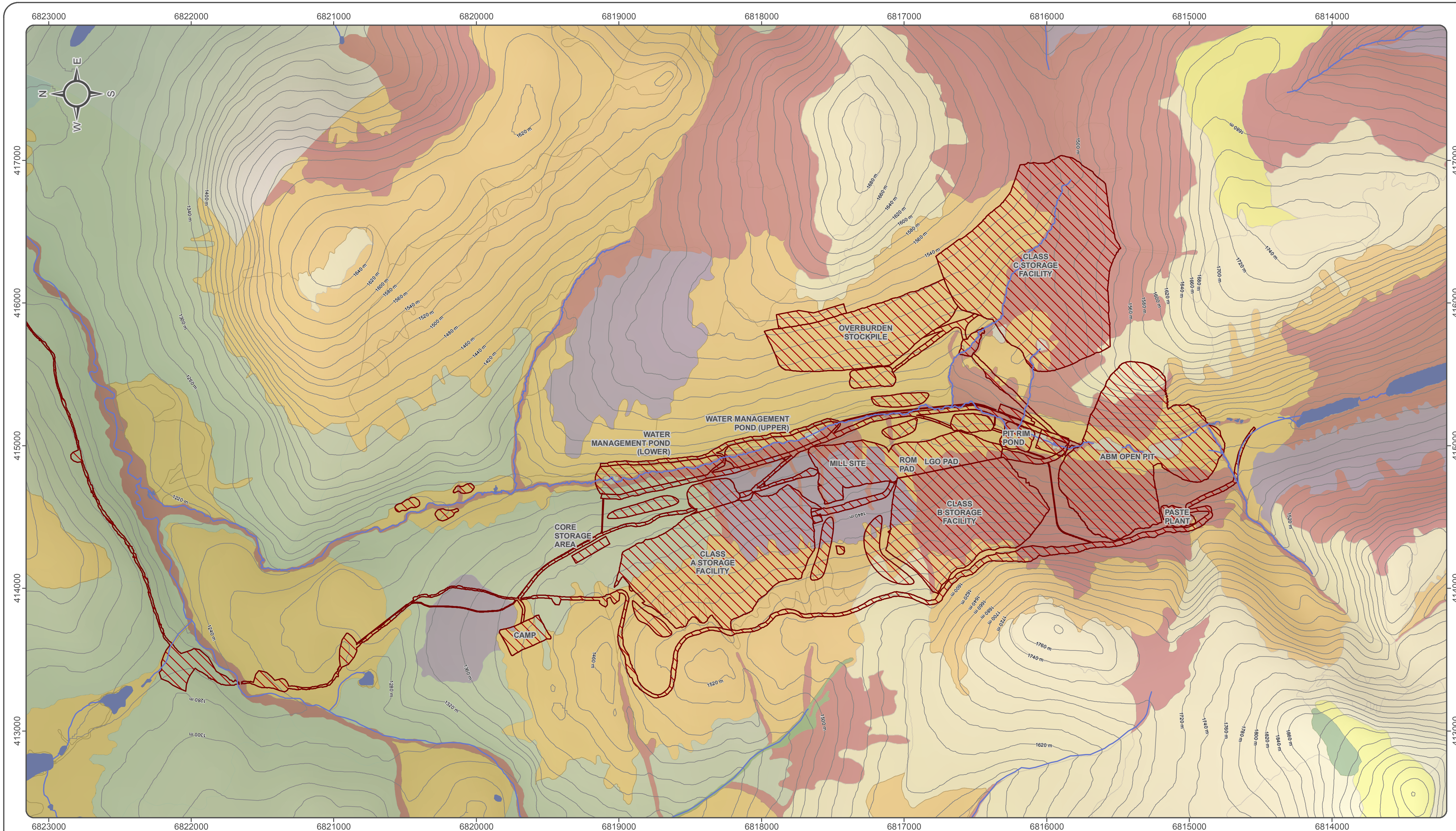
Figure 7-2 shows the vegetation associations expected on the post-mining landforms. The main objective of the revegetation program is to develop self-sustaining vegetation on all facilities except the ABM open pit. In the short-term, revegetation on slopes of the Class A and Class B Storage Facilities will focus only on graminoids that will allow for geotechnical monitoring of the physical stability of the facilities. The physical and chemical stability of these facilities is a priority of the reclamation program.

Long-term vegetation associations are expected to be dominated by scrub birch on facilities on the slopes surrounding Geona Creek due to the expected low moisture and nutrients (Figure 7-2). Permafrost is expected to redevelop on the post-mining landforms, especially north aspect slopes, which will influence the resulting revegetation. Revegetation is proposed to also include planting scrub birch, blueberry, and low bush cranberry seedlings on flatter, moister slopes to restore habitat for some of the larger focal wildlife species. Berry bushes are a target species to help create suitable habitat for grizzly bear and are also traditionally important plants for Kaska (Wein and Freeman, 1995). A revegetation target of grasses and low shrubs on upper portions of facilities is expected to restore suitable caribou habitat. It is expected that subalpine fir will recolonize the edges of facilities over time, in particular on the Class C Storage Facility where north aspect slopes will retain more moisture. Wetlands and riparian vegetation will develop along Geona Creek where there is more moisture. Willow staking will be employed to help restore riparian vegetation and suitable habitat for moose as well as wetland habitat for many other wildlife species. Overall, it is expected that furbearers, small mammals, and game birds will also use the restored grass and shrublands.

Revegetation is challenging on northern mine sites (Adams and Lamoureux, 2005). Revegetation has been found to be most successful on flatter slopes with native species and natural recolonization (EBA, 2011). Re-establishing the bacteria and fungi in the soils has also been found to be a limiting factor to revegetation on sterile soils (Bowker, 2007). Research has shown that amending the overburden with native bacteria, fungi, and bryophytes helps re-establish the biological soil crust which improves the success of seed germination (Bowker, 2007; Stewart, 2013); therefore, research with soil amendments is proposed for reclamation to develop a biological soil crust and promote succession.

Maintaining biological diversity is a key management strategy by Kaska land stewards (Dena Kayeh Institute, 2010). More diverse vegetation and wildlife communities can be created by increasing heterogeneity of landforms to create a variety of microenvironments (Polster, 2013). This will be achieved by contouring slopes loosely and less uniformly which reduces wind and water erosion and allows for better retention of moisture and accumulation of fines (Polster, 2013). Non-uniform seeding and planting can also help develop habitat diversity. The proposed seed mixes for the revegetation program are discussed below.

moisture and accumulation of fines (Polster, 2013). Non-uniform seeding and planting can also help develop habitat diversity. The proposed seed mixes for the revegetation program are discussed below.



ECOSYSTEMS BY LEADING SPECIES

- Carex species
- Dwarf shrubs
- Scrub Birch
- Subalpine Fir
- Graminoids
- Black Spruce
- White Spruce
- Willow species
- Mine Development Footprint
- Watercourse
- Waterbody

Datum: NAD 83; Map Projection: UTM Zone 9N

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AEG

BMC MINERALS

KUDZ ZE KAYAH PROJECT
CONCEPTUAL RECLAMATION AND CLOSURE PLAN

FIGURE 7-1
EXISTING ECOSYSTEMS AND PROJECT FOOTPRINT

JANUARY 2017

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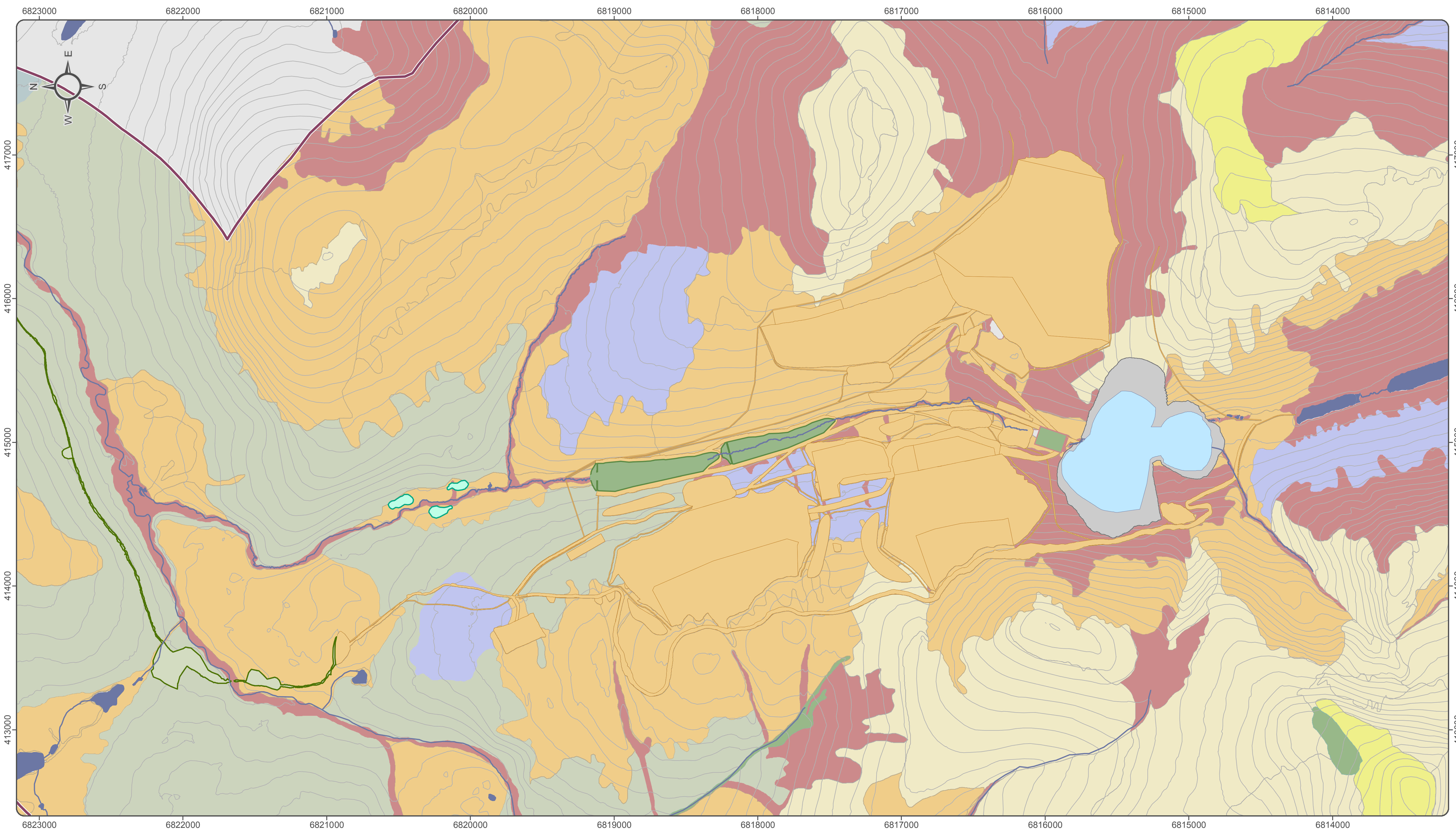
Table 7-2: Post-Mining Land Use - Revegetation Objective and Potential Wildlife Use by Facility

Facility	Facility Sub-Area	Area (ha)	Target Ecosite # / Nutrient-Moisture Regime	Short-term Target Revegetation Treatment and Rationale	Long-term Target Post-Mine Vegetation Association	Estimated Post-Mine Habitat Suitability
Class A Storage Facility						
	Top	32.9	Subalpine 23/ Poor-Mesic	Grasses and forbs. Seed with commercial and locally collected native seed mix, fertilize. Plant scrub birch seedlings. Research planting with native *Vaccinium spp.* (blueberry and lowbush cranberry) if final overburden pH, nutrients, and soil moisture are favorable to restore grizzly habitat.	Scrub birch, willow, and crowberry.	Caribou rut, moose post-rut, grizzly bear, wolf, small mammals, and upland game birds.
	Slopes	53.9	Subalpine 11/ Poor-Subxeric	Low growing species to allow for monitoring physical and chemical stability of facility. Grasses and forbs. Seed with commercial and locally collected native seed mix, fertilize. Research with inoculation to restore lichens and mosses in biological soil crusts.	Scrub birch, and lichen.	Moose post-rut, and wolf.
Class B Storage Facility						
	Top	16.0	Subalpine 23/ Poor-Mesic	Grasses and forbs. Seed with commercial and locally collected native seed mix, fertilize. Plant scrub birch seedlings. Research planting with native *Vaccinium spp.* (blueberry and lowbush cranberry) if final overburden pH, nutrients, and soil moisture are favorable to restore grizzly habitat.	Scrub birch, willow, crowberry.	Caribou rut, moose post-rut, grizzly bear, wolf, small mammals, and upland game birds.
	Slopes	50.7	Subalpine 11/ Poor-Subxeric	Low growing species to allow for monitoring physical and chemical stability of facility. Grasses and forbs. Seed with commercial and locally collected native seed mix, fertilize. Research with inoculation to restore lichens and mosses in biological soil crusts.	Scrub birch, and lichen.	Moose post-rut, and wolf.
Class C Storage Facility						
	Top	65.3	Subalpine 23/ Poor-Mesic (70%)	Grasses and forbs. Seed with commercial and locally collected native seed mix, fertilize. Plant scrub birch seedlings.	Scrub birch, willow, and crowberry.	Caribou rut, moose post-rut, wolf, ptarmigan, voles, and mice.
		28.0	Subalpine 31/ Poor-Subhygric (30%)		Fir-scrub birch, feathermoss, and lichen.	
	Slopes	32.3	Subalpine 22/ Poor-Submesic	Grasses and forbs. Seed with commercial and locally collected native seed mix, fertilize. Research with inoculation to restore lichens and mosses in biological soil crusts.	Scrub birch, feathermoss, and lichen.	Caribou rut, moose post-rut, and wolf.

Facility	Facility Sub-Area	Area (ha)	Target Ecosite # / Nutrient-Moisture Regime	Short-term Target Revegetation Treatment and Rationale	Long-term Target Post-Mine Vegetation Association	Estimated Post-Mine Habitat Suitability
Overburden Stockpile						
	Slope	46.1	Subalpine 23/ Poor-Mesic	Grasses and forbs. Seed with commercial and locally collected native seed mix, fertilize. Plant scrub birch seedlings.	Scrub birch, willow, and crowberry.	Moose post-rut, and wolf.
ABM Open Pit						
		83.1	Flooding	No revegetation.	ABM Lake.	Waterfowl.
Water Management Ponds						
	Constructed Wetland	1.6	Subalpine 42/ Poor-Hygric	Engineered design and species selection based on water treatment requirements. Full design will be completed during operations.	Carex spp.	Waterfowl, passerines, moose, grizzly bear, and small mammals.
	Water management ponds	6.5	Subalpine 42/ Poor-Hygric (30%)	Locally-collected willow staking.	Willow, horsetail, forbs, and grass.	Waterfowl, passerines, moose, grizzly bear, and small mammals.
		15.2	Subalpine 35/ Rich-Subhygric (70%)	Supplement organics.		
	Seepage collection ponds	18.7	Subalpine 23/ Poor-Mesic	Grasses and forbs. Seed with commercial and locally collected native seed mix, and fertilize.	Scrub birch, willow, and crowberry.	Moose, small mammals, and passerines.
Process Plant and Ancillary Facilities						
	Process Plant and ore pads	35.9	Subalpine 23/ Poor-Mesic	Scarify. Grasses and forbs. Seed with commercial and locally collected native seed mix, and fertilize.	Scrub birch, willow, and crowberry.	Moose, small mammals, and passerines.
	Other disturbed areas	39.5	Subalpine 01/ Medium-Mesic	Contour and scarify where needed. Grasses and forbs. Seed with commercial and locally collected native seed mix, and fertilize.	Subalpine fir, scrub birch, willow, feathermoss.	Moose, small mammals, and passerines.
Access Road Right of Way						
	Access road and site roads	121.7	Boreal and Subalpine 01/ Medium-Mesic	Scarify. Grasses and forbs. Seed with commercial and locally collected native seed mix, and fertilize.	White spruce, willow, forbs, and feathermoss in Boreal High.	Caribou, moose, small mammals (including bats), and passerines.
					Scrub birch, willow, feathermoss in Subalpine.	



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ECOSYSTEMS BY LEADING SPECIES

- Carex species
- Dwarf shrubs
- Scrub Birch
- Subalpine Fir
- Graminoids
- Black Spruce
- White Spruce
- Willow species
- Bare Rock
- Local Study Area
- ABM Lake @ 1380 masl
- Fish Habitat Compensation Pond
- Watercourse
- Waterbody

BMC MINERALS

KUDZ ZE KAYAH PROJECT
CONCEPTUAL RECLAMATION AND CLOSURE PLAN

FIGURE 7-2

EXISTING AND PREDICTED ECOSYSTEMS BY LEADING SPECIES

JANUARY 2017

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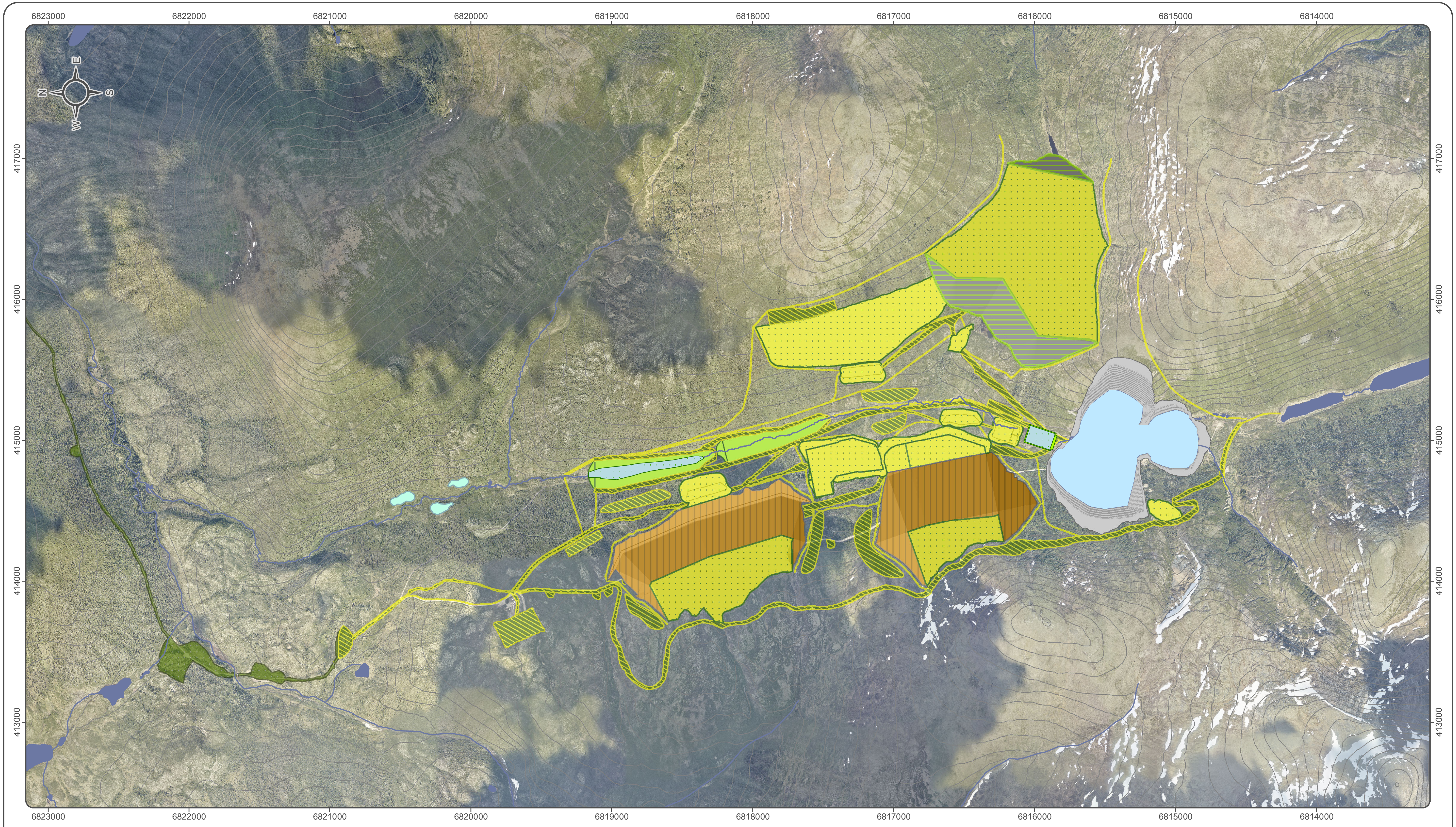

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PREDICTED POST-MINING ECOSYSTEM VEGETATION ASSOCIATIONS
(only dominat vegatation shown)

- Fir-Scrub birch-Willow-Feathermoss
- White Spruce Willow-forbs-Feathermoss
- Scrub Birch-lichen
- Scrub birch-Feathermoss-Lichen
- Scrub birch-Willow-crowberry
- Willow-Horsetail-Forbs-Grass
- Bare Rock
- ABM Lake @ 1380 masl
- Constructed Wetland
- South Constructed Wetland, Footprint
- Fish Habitat Compensation Pond
- Waterbody

BMC MINERALS

KUDZ ZE KAYAH PROJECT
CONCEPTUAL RECLAMATION AND CLOSURE PLAN

FIGURE 7-3

PREDICTED POST-MINING ECOSYSTEMS ON BACKGROUND IMAGERY

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7.1.2.1 Species Selection

The currently used seed mix for exploration revegetation includes the following:

- 37% slender wheatgrass;
- 25% rough fescue;
- 25% Rocky Mountain fescue; and
- 13% tufted hairgrass.

BMC plans to add locally-collected seeds into its reclamation program. Seed germination is usually low in colder subalpine areas and locally-collected seed germination has been found to be more successful. A combination of naturalized, commercial native seed mixed with locally-collected seeds is therefore proposed for the mine reclamation program. Commercially available native species should be trialed on sites based on facility-specific soil pH and nutrient content of the final overburden. The pH of soils at site are generally acidic (average pH($CaCl_2$) of 5.10, standard deviation 0.71 (AEG, 2016c)).

The Yukon Revegetation Manual (Matheus and Omtzigt, 2013) recommends Rocky Mountain fescue and violet wheatgrass for alkaline soils; glaucous bluegrass for a broad range of pH; and, ticklegrass, tufted hairgrass, alpine bluegrass, and spike trisetum for acidic soils. Species that are recorded at site and recommended by Matheus and Omtzigt (2013) include alpine sweetgrass, mountain timothy, alpine sagewort, arctic lupine, and mountain avens.

Progressive revegetation on the main facilities (Class A, B, and C Storage Facilities) is proposed to start with combined commercially available and locally-collected native seed mixes.

Table 7-3 summarizes the proposed seed mixes for these facilities. The tops of these facilities are expected to be acidic, moister than the slopes, and nutrient poor; therefore, the seed mix should start with glaucous bluegrass, ticklegrass, tufted hairgrass, alpine bluegrass, alpine sweetgrass, and arctic lupine. The slopes of these facilities are expected to be acidic, well drained, and nutrient poor; therefore, the seed mix is likely to start with glaucous bluegrass, alpine bluegrass, mountain timothy, and alpine sagewort. For revegetation success, Matheus and Omtzigt (2013) recommend seeding on subalpine sites should not exceed 1,500 seeds/m^2 and fertilizer should not exceed 50 kg/ha of nitrogen.

Table 7-3: Proposed Initial Species for Revegetation

Facility Areas		Commercial Native Species (seeds)	Locally-Collected Native Species (seeds)	Locally-Collected Native Species (staking or seedlings)
Class A, B and C Storage Facilities Tops		glaucous bluegrass, ticklegrass, tufted hairgrass, alpine bluegrass	alpine sweetgrass, mountain timothy, and arctic lupine	Scrub birch seedlings (near edges of facility) *Vaccinium* spp seedlings
Class A, B and C Storage Facilities Slopes and Overburden Stockpile		slender wheatgrass, glaucous bluegrass, alpine bluegrass	northern rough fescue, wheatgrass, alpine sagewort	
Water Management Ponds		tufted hairgrass, fowl bluegrass, American sloughgrass	northern rough fescue, arctic lupine	Willow staking (felt leaf willow, *Salix alaxensis* preferred; plus, plane-leafed willow, *S. planifolia,* and small tree willow, *S. arbusuloides)*
Process Plant Site and Ancillary Facilities		slender wheatgrass, rough fescue, Rocky Mountain fescue, tufted hairgrass	northern rough fescue, wheatgrass, arctic lupine	
Access Road		slender wheatgrass, rough fescue, Rocky Mountain fescue, tufted hairgrass	Wheatgrass, sagewort, wormwood, arctic lupine	

The revegetation treatments proposed in the overall revegetation program will be tested and optimized through the onsite research program during progressive reclamation, discussed further in Section 2.5.2. Mosses and lichens comprise a large proportion of groundcover in the Project footprint (Figure 7-1; AEG, 2016c) and research is proposed to restore this groundcover as presented in Table 7-2. Reclamation research has been conducted by Yukon College and its partners on ways to rebuild this biological soil crust, a layer of soil that contains necessary mosses, fungus, lichen, algae, and bacteria necessary for successional restoration of low organic overburden such as found at mine sites (Stewart, 2013). Additional research has been done with biochar to restore soil nutrients. Project revegetation strategies and treatments will also consider ongoing research on other projects that will work to restore the native moss and lichen groundcover at site.

7.2 ABM OPEN PIT

The majority of the ABM Deposit will be mined by open pit mining methods. A single pit will be mined, with mining of the ABM Zone staged into three separate phases to manage overall waste stripping requirements. All open pit mining is planned to be completed by a mining contractor over a period of approximately 10.5 years, including a 17-month preproduction period to provide construction materials and build ore stockpiles to maintain continuity of ore to the processing plant.

Section 2.1 outlines the planning approach to the development of project closure objectives, and Sections 3.1 and 7.1 present fundamental Project closure objectives and general closure measures to meet those objectives. Table 7-4 presents refined closure objectives specific to the ABM open pit closure, grouped by value categories (e.g., physical stability and safety, environment and land use). This table also summarizes relevant design criteria and closure measures that have been developed to achieve the objectives, and performance criteria which will be used to define achievement of the objectives in post-closure monitoring.

Details regarding the closure measures for the ABM open pit are provided in Section 7.2.1.

Table 7-4 ABM Open Pit Closure Summary

Value	Specific Closure Objective	Closure Performance Criteria	Closure Design Criteria/Closure Measures
Physical Stability and Safety	• Minimize potential for pit wall collapse	• No major pit wall failures which compromise engineered outflow or pit crest stability	• Overburden designed with 25° slope angle in the valley floor, 30° slope angle on western and eastern valley walls • Pit slope inter ramp angles designed between 36° and 52° based on geotechnical considerations
	• Provide safe egress from the pit (if someone or something falls into it)	• No casualties as a result of not being able to egress pit	• Egress location maintained at pit ramp/spillway.
	• Prevent inadvertent access to the pit (falling in over the edge)	• No casualties as a result of falling into pit	• Limit access to pit crest and provide measures to alert people of hazard • Setback from the crest, 2.0 m high safety bunds around high wall
Environment and Land Use	• Minimize contaminant loading from the pit in the closure period	• ABM Lake water quality is in predicted range of contaminant concentrations	• Batch treatment of ABM Lake (add lime, and organics, with initial filling of pit if required) to address flushing of secondary mineralization and related metal concentrations
	• No active water treatment required to maintain chemical stability or environmental compliance	• No active water treatment in post closure	• In situ pit water treatment and contingency passive treatment constructed wetlands in Geona Creek
	• Limit impact on wildlife, in particular waterfowl	• No wildlife mortalities due to exposure/use of ABM Lake	• In situ pit water treatment • Wildlife barrier around ABM Lake walls
Long Term Risk	• Minimize outstanding liability and risks in post closure, and minimize the need for long-term operations, maintenance and monitoring in post closure	• Monitoring surveillance and adaptive management programs are executed as planned without increasing maintenance demands	• Removal of Fault Creek diversion removes long term maintenance requirement • Engineered outlet to control outflow from ABM Lake • Safety bund around high wall

7.2.1 Closure Measures

The ABM open pit and surrounding areas will undergo reclamation to the extent of ensuring that the pit walls are stable and pose no danger to the general public or local wildlife. Rock safety bunds will be created around high wall edges to prevent inadvertent access by people or wildlife. The open pit will be allowed to flood as dewatering will cease, and equipment will be removed. Fault Creek will be redirected to the ABM open pit. This will provide a long-term control on oxidation and metal leaching from the majority of the pit walls.

The accumulation of secondary minerals during weathering of the exposed pit walls and pit floor may result in the presence of elevated trace element concentrations in pit water during its flooding. Water quality data collected from the pit during its initial filling will be used to determine if lime addition is necessary to control pH. However, acidic conditions are not anticipated due to the limited presence of acid generating pit wall lithologies and the alkalinity provided by water sourced from Fault Creek and from groundwater. If some limited lime addition is required, lime will be added to the pit lake to raise the pH to circumneutral levels (target 8.0), which will also facilitate metals precipitation in the pit. Lime handling and slaking systems (if required) will be performed using equipment associated with the water treatment plant. The slurried lime will be trucked to the pit and pumped into the flow of Fault Creek as it enters the open pit to achieve adequate mixing of the lime into the pit water.

Water quality modelling suggests that the ABM Lake that forms will contain elevated constituents of potential interest (COPI) concentrations which may impact the quality of the Geona Creek and Finlayson Creek receiving environment when the lake starts to overspill downstream. Given the expected circumneutral pH of the ABM Lake water, there is not expected to be sufficient dissolved iron in the lake to enhance metals removal during lime amendment by co-precipitation with iron oxyhydroxide phases. Furthermore, COPI such as nitrite, selenium, and uranium may not be significantly sequestered following lime amendment, even if a source of ferric iron is also supplied to the lake. Therefore, an alternative in situ treatment of the ABM Lake will be initiated in the final few years of the lake formation to help address elevated COPI levels.

Soluble organic carbon (e.g., alcohol and molasses) will be distributed throughout the ABM Lake, either via direct addition to the discharging Fault Creek water or via piping or water cannons, to stimulate the development of reducing conditions. This treatment approach has been successfully implemented at numerous pit lakes in the USA to treat the COPIs present in ABM Lake, including nitrate, nitrite, selenium and uranium treatment in the Sweetwater pit, Wyoming (Harrington, 2002) and nitrate, nitrite, cadmium, copper, and zinc treatment in the Anchor Hill pit, South Dakota (Harrington et al., 2004). Organic carbon will be injected into the ABM Lake to stimulate native microorganisms to form reducing conditions in the water column. Enough organic carbon will be added to consume dissolved oxygen, nitrate and nitrite, and cause the partial conversion of some dissolved sulphate to sulphide. Under such reducing conditions, elements such as selenium and uranium are largely transformed to less soluble forms (e.g., elemental selenium and uraninite phases). Chalcophile elements such as cadmium, zinc, copper, antimony, and lead will precipitate as poorly soluble sulphide minerals. The insoluble phases formed will settle to the lake bottom for long term storage. Reactive iron sulphide minerals will also form during treatment, which will help scavenge some COPIs via co-precipitation and also act as a sacrificial anode to maintain the reduced COPIs in their stable precipitated forms in the lake sediment.

Addition of the soluble organic carbon will occur a few years prior to any discharge from the ABM Lake. Treatment will be initiated in late summer at a time when microbial respiration rates are highest. As reducing conditions develop over the subsequent months, the formation of an ice layer over the lake will help limit the ingress of oxygen and prolong the period of time that the lake will remain reducing, thus maximizing COPI removal.

Water quality monitoring of the ABM Lake will be used to evaluate the lake chemistry and ensure that the concentrations of constituents which are expected to respond to in situ treatment (e.g., nitrite, zinc, cadmium, copper, nickel, lead, antimony, selenium, and uranium) are minimized. This will include the collection of samples at strategic depths in the water column to evaluate the development of any stratification, since the presence of an anoxic hypolimnion (lower layer of water in a stratified lake) at depth will further assist the preservation of the reduced COPIs in their stable precipitated forms.

An engineered spillway will be constructed to control outflow from the ABM Lake. The constructed wetland treatment systems in Geona Creek downstream of the pit will provide both a contingency treatment for those constituents that may not be efficiently ameliorated by in situ treatment (e.g., arsenic, nickel, uranium) and a secondary polishing step for other COPI (e.g., zinc, lead, cadmium, selenium, and copper).

7.3 UNDERGROUND MINE WORKINGS

Section 2.1 outlines the planning approach to the development of Project closure objectives, and Sections 3.1 and 7.1 present fundamental Project closure objectives and general closure measures to meet those objectives. Table 7-5 presents refined closure objectives specific to the underground mine workings, grouped by value categories (e.g., physical stability and safety, environment and land use). This table also summarizes relevant design criteria and closure measures that have been developed to achieve the objectives, and performance criteria which will be used to define achievement of the objectives in post-closure monitoring.

Table 7-5: Underground Mine Workings Closure Summary (Active Closure and Transition Periods only)

Value	Specific Closure Objective	Closure Performance Criteria	Closure Design Criteria/Closure Measures
Physical Stability and Safety	• Reclamation of mine openings and closure implementation avoids or minimizes adverse health and safety effects on the public, workers and wildlife	• No injuries or casualties as a result of interaction with closed mine workings	• All underground working accesses are in the ABM open pit boundaries • Portal entrances will be backfilled to prevent access while the workings are flooded • Portals and workings will be flooded and under the final ABM Lake elevation in Post-Closure period
Environment and Land Use	• No active water treatment required to maintain chemical stability or environmental compliance	• Seepage from underground workings to ABM Lake do not contribute to requirements for active water treatment in Post-Closure period	• Any seepage from underground workings will be captured and treated in the ABM Lake, or the load will be treated in secondary wetland treatment with ABM Lake water that spills
Long Term Risk	• Minimize the need for long-term operations, maintenance and monitoring after reclamation activities are complete	• No long term maintenance required for underground workings or openings	• Portals sealed with waste rock to prevent access during active closure/transition period

7.3.1 Closure Measures

During the active closure period, or even prior to the completion of active surface mining, underground mining equipment and infrastructure will be removed, including de-watering equipment. The portal entrances will be closed and secured to prevent access to the portals and underground workings as they slowly flood during the active and transition closure periods.

7.4 STORAGE FACILITIES FOR WASTE ROCK AND TAILINGS

7.4.1 Ground Conditions

The physical stability of the Storage Facilities for both operation and closure are evaluated and described in the engineering design reports, Kudz Ze Kayah Pre-Feasibility Study – Class A Storage Facility Assessment (KP, 2017a) and Kudz Ze Kayah Pre-Feasibility Study – Design of Class B and Class Storage Facilities and Overburden Stockpile (KP, 2017b).

7.4.2 Class A Storage Facility

The alternatives assessment undertaken to review, evaluate, and select a preferred waste rock and tailings management strategy (Section 2.4) determined that a filtered tailings/waste rock facility located on the hillside to the west of Geona Creek in the Project Area was the preferred candidate. This Class A Storage Facility is designed to contain both filtered tailings and Class A waste rock (strongly potentially acid generating). Commingling of filtered tailings with the waste rock will increase the stability of the Class A Storage Facility compared to tailings deposition in isolation. The rock and tailings will be mixed together prior to placement as much as is feasible with the intent of minimizing voids where acid generation can occur. Furthermore, the higher neutralization potential of the tailings relative to the strongly potentially acid generating Class A waste rock will serve to buffer acid generation over the short term.

The Class A Storage Facility is on the western Geona Creek valley slope, with the majority of the Storage Facility slope facing northeast. The facility will have an overall grade of 4H:1V with a crest elevation at 1,495 masl. The key Class A Storage Facility specifications are provided in Table 7-6. The cover will be installed progressively during operations once the appropriate volume of waste has been stored in the facility as per the mine plan. Details on the revegetation plan for this facility are presented in Section 7.1.

Table 7-6: Class A Storage Facility Physical Specifications

Parameter	Class A Storage Facility
Elevation	1,400 masl to 1,495 masl
Aspect	Northeast
Final Surface Area (m^2)	741,860
Overall Slope	4H:1V
Bench Height	n/a
Storage Capacity	15 Mm^3
Estimated Waste Volume	15 Mm^3

The final configuration and construction details of the facility are discussed in Section 5.1.1.

Section 2.1 outlines the planning approach to the development of Project closure objectives, and Sections 3.1 and 7.1 present the Project closure objectives and closure measures to meet those objectives. Table 7-7 presents refined closure objectives specific to the Class A Storage Facility, grouped by value categories (e.g., physical stability and safety, environment and land use). This table also summarizes relevant design criteria and closure measures that have been developed to achieve the objectives, and performance criteria which will be used to define achievement of the objectives in post-closure monitoring.

Table 7-7: Class A Storage Facility Closure Summary

Values	Specific Closure Objective	Closure Performance Criteria	Closure Design Criteria/Closure Measures
Physical Stability and Safety	• Ensure long-term physical stability to minimize erosion, subsidence and slope failure	• No signs of gully erosion or slope creep • Geotechnical monitoring program does not return unacceptable levels of slope movement	• Facility constructed at maximum 4H:1V overall slope • Buttress constructed at maximum 3H:1V overall slope • Three-layer cover: Very low permeability layer with a minimum of 3.0 m Class C material and 0.3 m growth media • Buttress constructed at toe of facility with Class C material • Progressive reclamation will limit waste surface area exposed to erosional forces, and will establish erosion control (revegetation) on reclaimed surfaces • Revegetation prescription and methods consider ecosystem unit and cover material properties to minimize erosion/slope failure potential
	• Able to withstand severe climatic and seismic events	• No failure of facility due to severe climatic or seismic event	• Facility located on stable foundation – stripped to bedrock and till foundation • Minimum Factor of Safety (FOS): Static 1.5, seismic <1; current design FOS are Static:1.55, Seismic: 1.01 (KP, 2017a) • Buttress constructed at toe of facility with Class C material • Engineered low permeability cover system and revegetation
Environment and Land Use	• Seepage volumes from the facility are minimized	• Cover system performance of 98% reduction in infiltration. • Seepage quantity will be at or below predicted volumes (approximately 2,404 m^3/year)	• Encapsulation of materials provided by low permeability till foundation and very low permeability cover system • Progressive reclamation minimizes infiltration • Cover system performance of 98% reduction in infiltration
	• Ensure long-term chemical stability such that runoff and seepage quality is acceptable, without long-term reliance on active water treatment	• Seepage quality will be at or below predicted contaminant concentrations	• Encapsulation of materials provided by low permeability till foundation and a very low permeability cover system • Active water treatment systems maintained until performance objectives achieved • Passive treatment systems to yield water quality acceptable for discharge in long term

	• Restored capability for use by wildlife and traditional aboriginal use, and conditions are typical of surrounding area	• The following ecosystem attribute variables are similar to control sites:
		  • Diversity – Richness and abundance of different functional groups
		  • Vegetation structure – cover and biomass
		  • Ecological processes – nutrient availability and seedling density
		• Monitoring transects indicate signs of use by wildlife (e.g., sightings, browse, scat, burrows, trails) similar to control sites
			• Facility design maintains natural slopes, aspect and elevations, similar to surrounding area
			• Revegetation planned and executed in consideration of pre-existing vegetation communities and final facility features (elevation, slope, aspect) to maximize revegetation success and use by wildlife

Long Term Risk	• Minimize outstanding liability and risks in post closure, and minimize the need for long-term operations, maintenance and monitoring in post closure	• Monitoring surveillance and adaptive management programs are executed as planned without increasing maintenance demands	• Facility constructed at maximum 4H:1V overall slope • Buttress constructed at maximum 3H:1V overall slope • Engineered cover with a minimum 3.0 m Class C material and 0.3 m growth media • Facility is designed for closure, minimal re-grading required at closure. • Progressive reclamation minimizes reclamation work required at end of operations • Design/location on stable foundation minimizes long term risk associated with subsidence

7.4.2.1 Closure Measures

The Class A Storage Facility contains strongly potentially acid generating waste rock and filtered flotation tailings, both of which have potential for ARD/ML generation. Industry experience in waste rock closure has shown that some form of multi-layer cover system is required to achieve this level of infiltration reduction. This would include a very low permeability layer, such as a geosynthetic liner material (e.g., HDPE), a geosynthetic clay liner (GCL), or a highly modified soil layer that achieve the same reduction in net percolation as the liners. The term “liner” has increasingly been used in the industry to describe the material which, in this case, is used as part of a cover system. As such, a three-layer cover system is recommended that includes a very low permeability layer. This cover system is described in greater detail in Appendix A.

The main components of the conceptual design of the Class A Storage Facility closure cover are:

- A three-layer cover system will be placed on the surface of the facility (2% grade) and the slopes (4H:1V). The very low permeability layer will be keyed into the bedding layer beneath the tailings and waste rock. This cover will comprise:
  - A surface layer of 0.3 m growth media from local topsoil and overburden to support revegetation, which will be graded at surface to blend with the natural topography;
  - A minimum of 3.0 m of Class C waste rock as a frost protection layer intending to prevent erosion or damage to the very low permeability layer as well as ensuring physical stability of the final slope; and,
  - A very low permeability layer with approximately 0.2 m of local till on both sides to serve as a bedding and a protective layer to prevent damage to the liner.

A constructed French drain at the toe will collect drainage during operation and active reclamation, until the cover is established to limit flux through the Storage Facility. Following closure, the non-contact water (run-off from the cover) will be directed away from the cover.

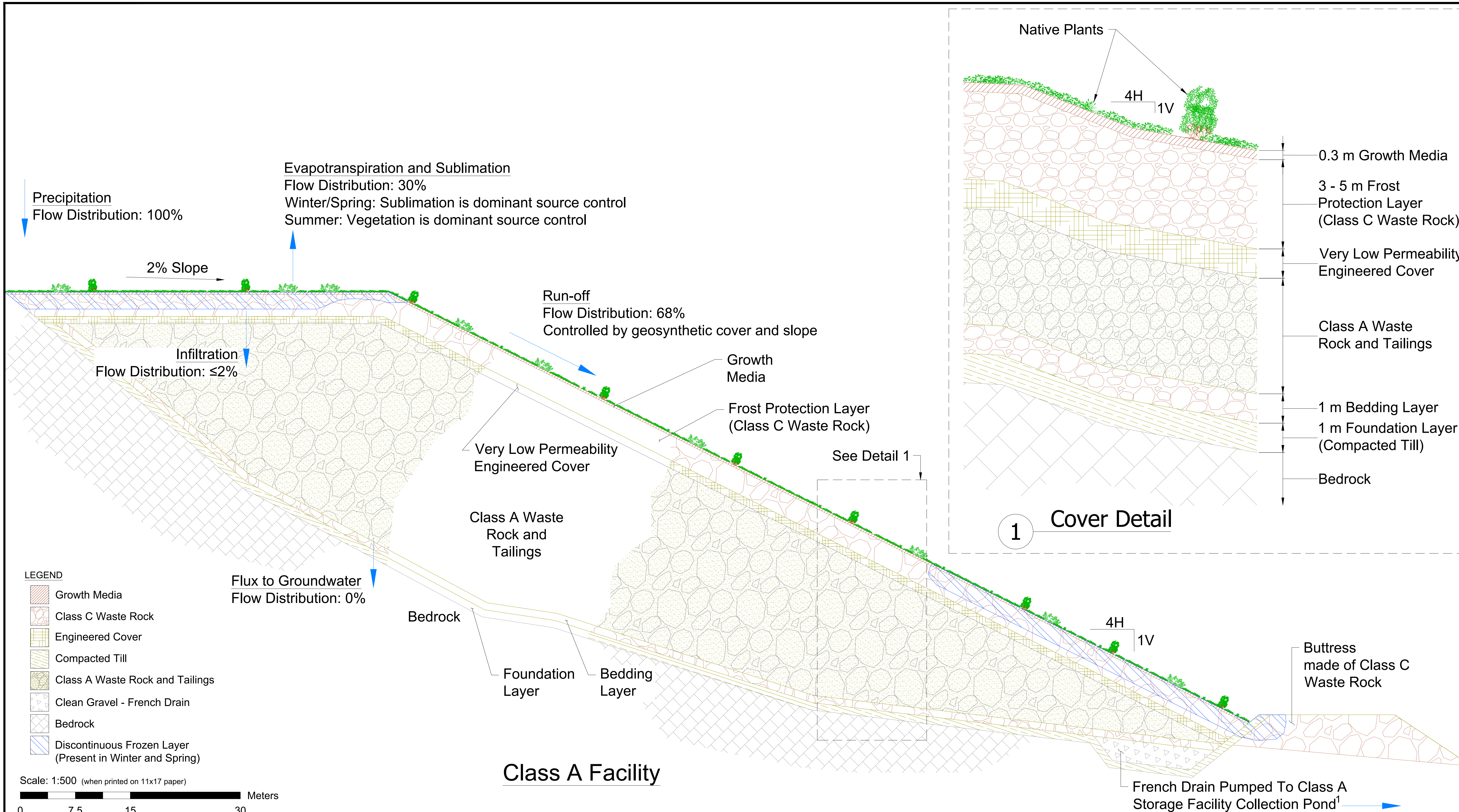
A summary of the conceptual cover designs, as well as material types and associated estimated borrow material volumes is provided in Table 7-8.

Table 7-8: Class A Storage Facility Conceptual Cover Specifications

Cover Layer	Material Type	Thickness (m)	Approx. Volume (m^3)
Growth Media	Topsoil/Overburden Blend	0.3	222,600
Frost Protection	Class C Waste Rock	3.0	2,448,200
Very low permeability layer	TBD	Dependant on material selected	Dependant on material selected
Bedding Layer around liner	Overburden (surrounding liner)	0.4	313,200

Based on the Waste Rock Management Plan (Ch. 4 of the Project Proposal) and the water balance calculations (KP, 2016) (including the loading balance), the required cover performance must achieve at least 98% reduction in net percolation. The expected long term net percolation for this conceptual cover design, based on the site characterization information, ranges from 0.5% to 2% net percolation. Figure 7-4 shows the Class

A Storage Facility Cover Schematic along with the seasonal mechanisms and cover water balance. To achieve net percolation performance of this cover system in the long term regular monitoring and maintenance must be conducted on the cover. Any contact water with the Class A material will remain separate from the clean surface run-off and be pumped to the Class A Storage Facility Collection Pond and treated at the water treatment plant during active reclamation and until cover performance has been achieved. The cover will be installed progressively during operations once the appropriate volume of waste has been stored in the facility as per the mine plan. Details on the revegetation plan for this facility are presented in Section 7.1.



Slopes shown do not reflect actual topography and are for illustration purposes.

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Notes:
Based on design information from 2016 Prefeasibility Design Report

[1]During operations and active closure only. Discharge to the environment upon acceptable closure monitoring results.

[2]Assumes no storage within waste rock

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Kudz Ze Kayah
Conceptual Reclamation and Closure Plan
Drawing No: BMC-15-02-B-1003

Figure 7-4

Class A Storage Facility Cover Schematic and Seasonal Water Balance Mechanisms

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DRAWN BY: KB	DESIGNED BY: CR	REVIEWED BY: LB

7.4.3 Class B Storage Facility

The Class B Storage Facility is also on the western Geona Creek valley slope, with the majority of the waste rock slope facing east. The facility will have an overall grade of 3H:1V with a crest elevation at 1,565 masl. The key Class B Storage Facility specifications are provided in Table 7-9.

Table 7-9: Class B Storage Facility Physical Specifications

Parameter	Class B Storage Facility
Elevation	1,425 to 1,565 masl
Aspect	East
Final Surface Area (m^2)	700,478
Overall Slope	3H:1V
Bench Height	15 m
Storage Capacity	25 Mm^3
Estimated Waste Volume	24 Mm^3

Section 2.1 outlines the planning approach to the development of Project closure objectives, and Sections 3.1 and 7.1 present the Project closure objectives and closure measures to meet those objectives. Table 7-10 presents refined closure objectives specific to the Class B Storage Facility, grouped by value categories (e.g., physical stability and safety, environment and land use). This table also summarizes relevant design criteria and closure measures that have been developed to achieve the objectives, and performance criteria which will be used to define achievement of the objectives in post-closure monitoring.

Table 7-10: Class B Storage Facility Closure Summary

Values	Specific Closure Objective	Closure Performance Criteria	Closure Design Criteria/Closure Measures
Physical Stability and Safety	• Ensure long-term physical stability to minimize erosion, subsidence and slope failure	• No signs of gully erosion or slope creep • Geotechnical monitoring program does not return unacceptable levels of slope movement	• Facility constructed at max 3H:1V overall slope • Facility faces constructed with benches, individual slope faces max 2.5H:1V • Enhanced store-and-release type cover: 1.0 of compacted till, with a minimum of 3.0 m Class C material and 0.3 m growth media • Progressive reclamation will limit waste surface area exposed to erosional forces, and will establish erosion control (revegetation) on reclaimed surfaces • Revegetation prescription and methods consider ecosystem unit and cover material properties to minimize erosion
	• Able to withstand severe climactic and seismic events	• No significant failure of facility	• Facility located on stable foundation – stripped to bedrock and till foundation • Minimum Factor of Safety (FOS): Static 1.5, Seismic 1.1; current design FOS are Static:2.3, Seismic: 1.6 (KP, 2016a) • Low permeability cover system and revegetation
Environment and Land Use	• Seepage volumes from the facility are minimized	• Cover system performance of 75% reduction in infiltration. • Seepage quantity will be at or below predicted volumes (28,370 m^3/year)	• Low permeability till foundation • Facility covered with Enhanced store-and-release type cover system • Progressive reclamation minimizes infiltration • Cover system performance of 75% reduction in infiltration
	• Ensure long-term chemical stability such that runoff and seepage quality meets water quality criteria, without long-term reliance on active water treatment	• Seepage quality will be at or below predicted concentrations	• Low permeability till foundation • Facility covered with low permeability cover system • Active water treatment systems maintained until performance objectives achieved • Passive treatment systems to yield water quality acceptable for discharge in long term

	• Restored capability for use by wildlife and traditional aboriginal use, and conditions are typical of surrounding area	• The following ecosystem attribute variables are similar to control sites:
		  • Diversity – Richness and abundance of different functional groups
		  • Vegetation structure – cover and biomass
		  • Ecological processes – nutrient availability and seedling density
		• Monitoring transects indicate signs of use by wildlife (e.g., sightings, browse, scat, burrows, trails) similar to control sites
			• Facility design maintains natural slopes, aspect and elevations, similar to surrounding area
			• Revegetation planned and executed in consideration of pre-existing vegetation communities and final facility features (elevation, slope, aspect) to maximize revegetation success and use by wildlife

Long Term Risk	• Minimize outstanding liability and risks in post closure, and minimize the need for long-term operations, maintenance and monitoring in post closure	• Monitoring surveillance and adaptive management programs are executed as planned without increasing maintenance demands	• Facility constructed at max 3H:1V overall slope • Facility faces constructed with benches, individual slope faces max 2.5H:1V • Facility covered with 1m compacted glacial till and 3 m Class C material • Facility is designed for closure, minimal re-grading required at closure. • Progressive reclamation minimizes reclamation work required at end of operations • Design/location on stable foundation minimizes long term risk associated with subsidence

7.4.3.1 Closure Measures

The Class B Storage Facility contains weakly potentially acid generating material (WPAG), as such it will require a low permeability cover. The main components of the Class B Storage Facility conceptual cover are:

- An "enhanced store-and-release" type cover system will be placed on the surface of the facility (2% grade) and the slopes (3H:1V). This cover will comprise:
    - A surface layer of 0.3 m growth media from local topsoil and overburden to support revegetation, which will be graded at surface to blend with the natural topography;
    - A minimum of 3.0 m of Class C waste rock to as a frost protection layer intending to prevent erosion or damage to the compacted till layer as well as ensuring physical stability of the final slope; and
    - A 1.0 m layer of compacted till directly on the Class B waste rock to minimize net percolation. The compacted till cover will be keyed into the foundation layer beneath the waste rock.

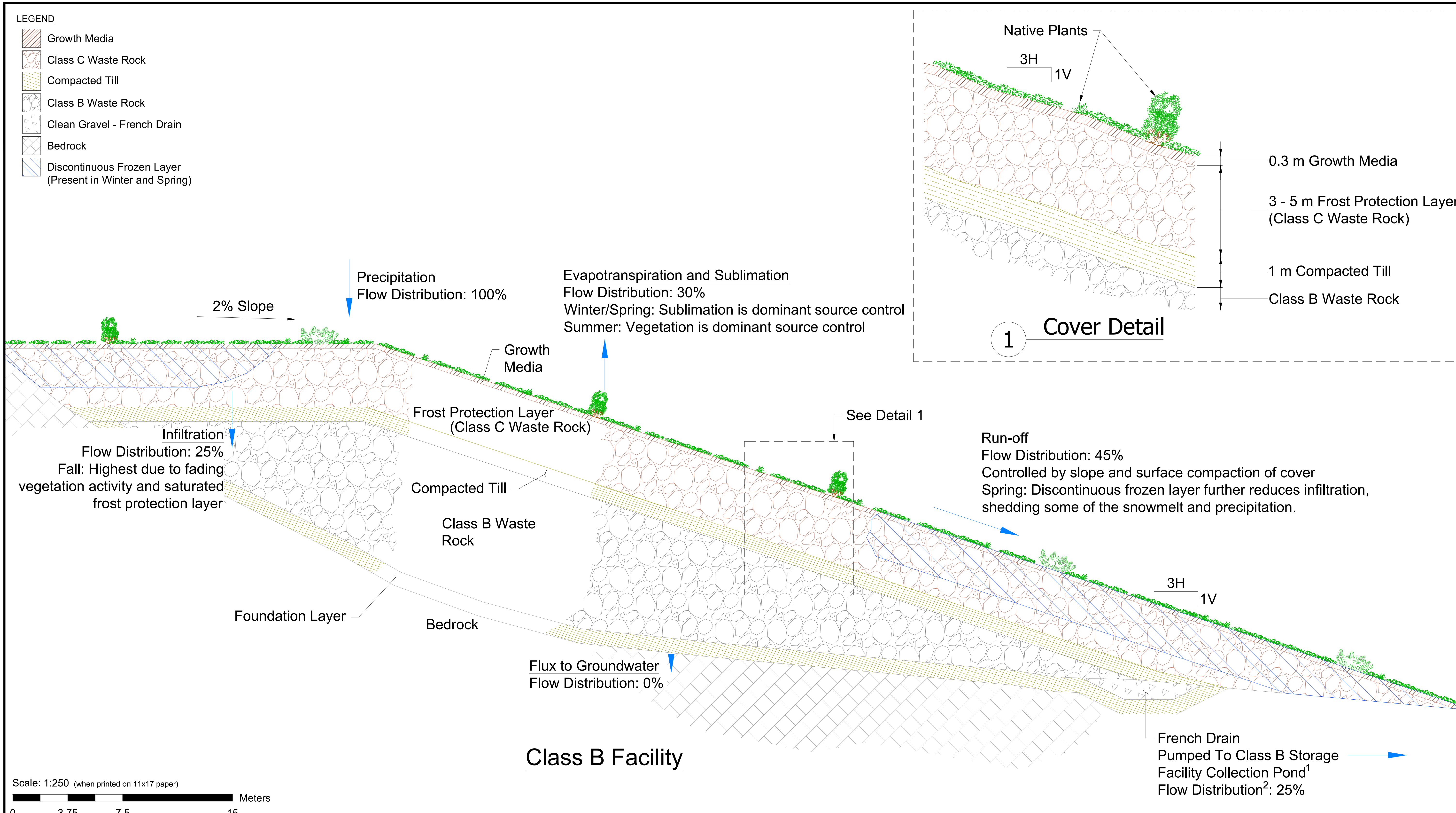
A constructed French drain built into the foundation will collect drainage during operation and active reclamation, until the cover is established to limit water flux through the waste rock. Following closure, the cover will shed surface water to the environment once monitoring demonstrates it is acceptable for discharge.

A summary of the conceptual cover designs, as well as material types and associated estimated borrow material volumes is provided in Table 7-11. This cover system is described in greater detail in Appendix A.

Table 7-11: Class B Storage Facility Conceptual Cover Specifications

Cover Layer	Material Type	Thickness (m)	Approx. Volume (m^3)
Growth Media	Topsoil/overburden Blend	0.3	210,200
Frost Protection	Class C Waste Rock	3.0	2,311,600
Compacted Till Layer	Till overburden	1.0	778,300

Based on the Waste Rock Management Plan (Chapter 4 of the Project Proposal) and the water balance calculations (KP, 2016) (including the loading balance), the required cover performance must achieve at least 75% reduction in net percolation. The expected long term infiltration into the waste rock for this conceptual cover design, and based on the site characterization information, ranges from 20 to 30%. Figure 7-5 shows the Class B Storage Facility Cover Schematic along with the seasonal mechanisms and cover water balance. To achieve net percolation performance of this cover system in the long term regular monitoring and maintenance must be conducted on the cover. Any contact water with the waste rock will remain separate from the clean surface run-off and be directed to the Class B Storage Facility Collection Pond during active reclamation and until cover performance has been achieved. Seepage water will be directed to the active water treatment plant and transitioned into passive treatment upon closure prior to release to the environment. The cover will be installed progressively once the appropriate volume of waste has been stored in the facility as per the mine plan.



Slopes shown do not reflect actual topography and are for illustration purposes.

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Notes:
Based on design information from 2016 Prefeasibility Design Report

[1]During operations and active closure only. Discharge to the environment upon acceptable closure monitoring results.

[2]Assumes no storage within waste rock

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Conceptual Reclamation and Closure Plan
Drawing No: BMC-15-02-B-1002

Figure 7-5

Class B Storage Facility Cover Schematic and Seasonal Water Balance Mechanisms

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DRAWN BY: KB	DESIGNED BY: CR	REVIEWED BY: LB

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7.4.4 Class C Storage Facility

The Class C Storage Facility is on the eastern Geona Creek valley slope, with the majority of the waste rock slope facing west. The facility will have an overall grade of 3H:1V with a crest elevation at 1,530 masl. The key Class C Storage Facility specifications are provided in Table 7-12.

Table 7-12: Class C Storage Facility Physical Specifications

Parameter	Class C Storage Facility
Elevation	1,450 to 1,530 masl
Aspect	West
Final Surface Area (m^2)	1,255,000
Overall Slope	3H:1V
Bench Height	15 m
Storage Capacity	34 Mm^3
Estimated Waste Volume	32 Mm^3

Section 2.1 outlines the planning approach to the development of Project closure objectives, and Sections 3.1 and 7.1 present the Project closure objectives and closure measures to meet those objectives. Table 7-13 presents refined closure objectives specific to the Class C Storage Facility, grouped by value categories (e.g., physical stability and safety, environment and land use). This table also summarizes relevant design criteria and closure measures that have been developed to achieve the objectives, and performance criteria which will be used to define achievement of the objectives in post-closure monitoring.

Table 7-13: Class C Storage Facility Closure Summary

Values	Specific Closure Objective	Closure Performance Criteria	Closure Design Criteria/Closure Measures
Physical Stability and Safety	• Ensure long-term physical stability to minimize erosion, subsidence and slope failure	• No signs of gully erosion or slope creep • Geotechnical monitoring program does not return unacceptable levels of slope movement	• Facility constructed at max 3H:1V overall slope • Facility faces constructed with benches, individual slope faces max 2.5H:1V • Facility covered with growth media • Revegetation prescription and methods consider ecosystem unit and cover material properties to minimize erosion
	• Able to withstand severe climactic and seismic events	• No significant failure of facility	• Minimum Factor of Safety (FOS): Static 1.5, Seismic 1.1; current design FOS are Static:2.3, Seismic: 1.6 (KP, 2016a)
Environment and Land Use	• Ensure long-term chemical stability such that runoff and seepage quality meets water quality criteria, without long-term reliance on active water treatment	• Seepage quality will be at or below predicted concentrations	• By definition and design, facility contains only clean, construction grade waste rock • Passive treatment systems to yield water quality acceptable for discharge in long term

	• Restored capability for use by wildlife and traditional aboriginal use, and conditions are typical of surrounding area	• The following ecosystem attribute variables are similar to control sites:
		  • Diversity – Richness and abundance of different functional groups
		  • Vegetation structure – cover and biomass
		  • Ecological processes – nutrient availability and seedling density
		• Monitoring transects indicate signs of use by wildlife (e.g., sightings, browse, scat, burrows, trails) similar to control sites
			• Facility design maintains natural slopes, aspect and elevations, similar to surroundings
			• Revegetation planned and executed in consideration of pre-existing vegetation communities and final facility features (elevation, slope, aspect) to maximize revegetation success and use by wildlife

Long Term Risk	• Minimize outstanding liability and risks in post closure, and minimize the need for long-term operations, maintenance and monitoring in post closure	• Monitoring surveillance and adaptive management programs are executed as planned without increasing maintenance demands	• Facility constructed at max 3H:1V overall slope • Facility faces constructed with benches, individual slope faces max 2.5H:1V • Facility covered with growth media • Facility is designed for closure, minimal re-grading required at closure • Progressive reclamation minimizes reclamation work required at end of operations • Design/location on stable foundation minimizes long term risk associated with subsidence

7.4.4.1 Closure Measures

The Class C Storage Facility will contain non-acid generating waste rock, and as such, a cover that reduces net percolation is not required. The key components of this cover are:

- A 0.3 m growth media from local topsoil and overburden to support revegetation.

The cover will be installed progressively once the appropriate volume of waste has been stored in the facility as per the mine plan.

7.4.5 Overburden Stockpile

Overburden stripped from the ABM open pit excavation is required (in part) for closure, and will be placed in a stockpile along the valley's east slope, north of the Class C Storage Facility. Test pits from 1995 encountered clayey silt and sand with gravel and minor cobbles and boulders, which is interpreted to be ablation till.

The Overburden Stockpile is anticipated to be a temporary structure as the overburden material will be used for the low permeability foundation and closure cover layers for the Class A and Class B Storage Facilities, and for construction of the Water Management and Seepage Collection Ponds. At closure, any remaining overburden will be placed on the Class C Storage Facility and growth media will be spread over the footprint of the Overburden Stockpile, and revegetated to match the surrounding natural vegetation.

Topsoil stockpile management is discussed further in Section 7.1.2 in relation to retention of nutrients and seed stock for revegetation.

7.5 ORE STOCKPILES AND PADS

Ore from the pit development will be stored in a stockpile on the constructed ROM and LGO pads near the processing facility.

Section 2.1 outlines the planning approach to the development of Project closure objectives, and Sections 3.1 and 7.1 present fundamental Project closure objectives and general closure measures to meet those objectives. Table 7-14 presents refined closure objectives specific to the Ore Stockpile and pads, grouped by value categories (e.g., physical stability and safety, environment and land use). This table also summarizes relevant design criteria and closure measures that have been developed to achieve the objectives, and performance criteria which will be used to define achievement of the objectives in post-closure monitoring.

Table 7-14: Ore Stockpile and Pads Closure Summary

Value	Specific Closure Objective	Closure Performance Criteria	Closure Design Criteria/Closure Measures
Physical Stability and Safety	• Ensure long-term physical stability to minimize erosion, subsidence and slope failure	• No signs of gully erosion or slope creep	• Features will be re-graded to promote positive drainage if required, covered with 30 cm growth media and revegetated
Environment and Land Use	• Ensure long-term chemical stability such that runoff and seepage quality meets water quality criteria, without long-term reliance on active water treatment	• Water quality objectives and/or effluent quality standards are not exceeded due to contributions from pad runoff/seepage	• Any remaining ore will be relocated to the Class A Storage Facility • Top layer of ROM Stockpile pad will be removed and relocated with any remaining ore to the Class A Storage Facility • Active water treatment systems maintained until performance objectives achieved • Passive treatment systems to yield water quality acceptable for discharge in long term

	• Restored capability for use by wildlife and traditional aboriginal use, and conditions are typical of surrounding area	• The following ecosystem attribute variables are similar to control sites:
		  • Diversity – Richness and abundance of different functional groups
		  • Vegetation structure – cover and biomass
		  • Ecological processes – nutrient availability and seedling density
		  • Monitoring transects indicate signs of use by wildlife (e.g., sightings, browse, scat, burrows, trails) similar to control sites
			• Features will be reclaimed to maintain natural slopes, aspect and elevations, similar to surrounding area
			• Revegetation planned and executed in consideration of pre-existing vegetation communities and final facility features (elevation, slope, aspect) to maximize revegetation success and use by wildlife

Long Term Risk	• Minimize outstanding liability and risks after reclamation activities are complete	• Closure risk assessment does not identify any moderate/high risks associated with pads	• Any remaining ore will be relocated to Class A Storage Facility or the bottom of the ABM open pit prior to closure of that facility

7.5.1 Closure Measures

At closure, any remaining ore stockpiles which have not been processed will be moved to either the Class A Storage Facility or the bottom of the ABM open pit prior to the closure of that facility. The stockpile pads will be excavated to a depth to remove residual mineral or residue from leaching from the stockpiles. The area will be re-contoured to promote positive drainage if required, and either covered with growth media or scarified and re-vegetated.

7.6 WATER MANAGEMENT STRUCTURES AND SYSTEMS

Section 2.1 outlines the planning approach to the development of Project closure objectives, and Sections 3.1 and 7.1 present fundamental Project closure objectives and general closure measures to meet those objectives. Table 7-10 presents refined closure objectives specific to the water management structures and systems, grouped by value categories (e.g., physical stability and safety, environment and land use). This table also summarizes relevant design criteria and closure measures that have been developed to achieve the objectives, and performance criteria that will be used to define achievement of the objectives in post-closure monitoring.

Table 7-15: Water Management Structures and Systems Closure Summary

Values	Specific Closure Objective	Closure Performance Criteria	Closure Design Criteria/Closure Measures
Physical Stability and Safety	• Closure water management facilities are physically stable and performing in accordance with designs	• No major repairs required due to instability of water management structures	• UWMP dam removed, LWMP dam lowered and not water retaining in post-closure, and wetland cell detainment structures are <2.5 m high, therefore no remaining Canadian Dam Association classified dams in post-closure • Site runoff patterns returned to pre-mining patterns/channels where possible and practicable • Most remaining diversions are retained from operations – stability issues will have been identified/addressed
	• Closure water management facilities can withstand severe climatic and seismic events	• No major repairs required due to seismic or severe climatic events	• Active Closure Period water conveyance and seepage collection features are unchanged from operational designs, and are designed to accommodate either a 1:10 year 24-hour event (Class C Facility and overburden stockpile) or a 1:200 year 24-hour runoff event (Class A and B Storage Facilities) • Transition/Post-closure period water conveyance and passive treatment structures will be designed to pass 1:200 year 24-hour events (e.g., wetland high flow bypass and spillway to act as a fuse for peak flows in excess of the design basis)
	• Reclamation eliminates or minimizes existing hazards to the health and safety of the public, workers and area wildlife by achieving conditions similar to local area features	• No significant injuries or casualties to humans or wildlife due to water collection, conveyance or passive treatment systems	• Constructed wetland treatment systems will mimic pre-mining wetland communities to the extent practicable • Site runoff patterns returned to pre-mining patterns/channels where possible/practicable
Environment and Land Use	• Reclamation and closure activities protect the aquatic, terrestrial and atmospheric environments from mine-related degradation and restore environments that have been degraded by mine-related activities	• Effluent Quality Standards will apply at final discharge locations during all closure periods • Water Quality Objectives at key receiving environment locations during all closure periods	• Operational waste rock management and mine waste facility design (e.g., filtered tailings, stacked out of watercourse) work to meet closure principles of reducing impacted water and controlling sources and contaminant mobilization • Mining waste encapsulation and infiltration reduction will minimize aqueous contaminant mobilization • ABM Lake treatment and constructed wetland treatment systems will provide primary and secondary treatment of contaminant concentrations prior to discharge from Project
Long-term Risk	• The need for long-term operations, maintenance and monitoring after reclamation activities are complete is minimized, and no active water treatment is required to achieve closure objectives	• Maintenance and monitoring efforts and durations do not significantly exceed planned levels • Active water treatment is maintained only during active closure and transition period as contingency • Constructed wetland treatment systems discharge to effluent quality standards during the post-closure period	• No classified dams will remain on site in the Post-Closure Period (Years 27-36) • Drainage and conveyance network are passive and mostly mimic pre-mining patterns • Water treatment in post-closure is passive in design

7.6.1 Closure Water Quality Objectives

Preliminary water quality objectives (pWQO) have been developed for a range of constituents of potential interest (COPI) associated with the Project (AEG, 2016f). The derivation of these pWQO has been performed following the methods outlined by CCME (2003) and is consistent with other permitted mining projects in Yukon.

The natural background concentration procedure (BCP) was used to develop site-specific water quality objectives (SSWQO) for those COPIs for which the 95th percentile concentration at each receiving environment monitoring stations (Geona Creek, Finlayson Creek and South Creek) in the Project study area exceeded the CCME (CCME, 2016) or British Columbia Ministry of Environment (BCMoE) water quality guidelines (BCMOE, 2016) for protection of aquatic life. This resulted in SSWQOs for aluminum, cadmium, copper, iron, fluoride, and zinc. Where the 95th percentile was lower than the generic CCME or BCMoE water quality guideline, then the most recent of the two guidelines was used. SSWQOs are based on the natural background water quality (pre-mining) for the Project RSA, which is the water chemistry to which the local aquatic species, and other fauna, are adapted, as such these are more suitable than the generic national or provincial guidelines.

A different approach was used to develop the pWQO for selenium. Selenium uptake by primary producers is a critical step in the accumulation of selenium in higher trophic levels of the freshwater food chain. Sulphate is documented to compete with selenium for uptake by primary producers. Laboratory testing using Finlayson Creek water demonstrated that selenium uptake by two primary producers was diminished in the presence of increasing sulphate concentrations. Therefore, a sulphate-dependent selenium SSWQO was developed. At baseline sulphate concentrations of 60 mg/L or less, the SSWQO was set equivalent to the BCMoE guideline (0.002 mg/L), but at higher sulphate concentrations, the selenium SSWQO is calculated using an equation based on the sulphate concentration.

The pWQOs for the Project are presented in Table 7-16.

Table 7-16: Project Preliminary Water Quality Objectives

Parameter	Preliminary Water Quality Objectives			
	KZ-9 (mg/L)	KZ-15 (mg/L)	KZ-13 (mg/L)	KZ-26 (mg/L)
Aluminum, total	0.19	0.10	0.58	0.15
Ammonia-N	BCMoE guideline (pH and temperature dependent)	BCMoE guideline (pH and temperature dependent)	BCMoE guideline (pH and temperature dependent)	BCMoE guideline (pH and temperature dependent)
Antimony, total	0.0090	0.0090	0.0090	0.0090
Arsenic, total	0.0050	0.0050	0.0050	0.0050
Cadmium, total	0.00029	CCME hardness dependent	CCME hardness dependent	CCME hardness dependent
Chloride, total	120	120	120	120
Copper, total	BCMoE hardness dependent	BCMoE hardness dependent	0.0048	BCMoE hardness dependent
Cyanide, Total	0.005	0.005	0.005	0.005
Cyanide, Weak Acid Dissociable	0.005	0.005	0.005	0.005
Fluoride	0.12	0.12	0.12	0.13
Iron, total	2.11	0.3	0.95	0.78
Lead, total	BCMoE hardness dependent	BCMoE hardness dependent	BCMoE hardness dependent	BCMoE hardness dependent
Manganese, total	BCMoE hardness dependent	BCMoE hardness dependent	BCMoE hardness dependent	BCMoE hardness dependent
Mercury, total	0.000026	0.000026	0.000026	0.000026
Molybdenum, total	0.073	0.073	0.073	0.073
Nickel, total	hardness dependent	hardness dependent	hardness dependent	hardness dependent
Nitrate-N	3.0	3.0	3.0	3.0
Nitrite-N	0.02	0.02	0.02	0.02
Selenium, total	0.002 or SSWQO equation	0.002 or SSWQO equation	0.002 or SSWQO equation	0.002 or SSWQO equation
Silver, total	0.00025	0.00025	0.00025	0.00025
Sulphate	BCMoE hardness dependent	BCMoE hardness dependent	BCMoE hardness dependent	BCMoE hardness dependent
Thallium, total	0.0008	0.0008	0.0008	0.0008
Uranium, total	0.015	0.015	0.015	0.015
Zinc, total	BCMoE hardness dependent	BCMoE hardness dependent	0.016	BCMoE hardness dependent
Aluminum, dissolved	0.050	0.050	0.050	0.050
Cadmium, dissolved	BCMoE hardness dependent	BCMoE hardness dependent	BCMoE hardness dependent	BCMoE hardness dependent
Iron, dissolved	0.35	0.35	0.35	0.35

7.6.2 Closure Measures

7.6.2.1 Predicted Water Quality Performance during Closure Periods

A water quality model (AEG, 2017c) was developed for the Project to estimate the water quality in mine discharge and receiving waters and to help guide water management for the Project with respect to water quality. Water quality modelling was performed on a monthly time step throughout the Project life to estimate seasonal variation. Additionally, three different precipitation scenarios were run to undertake a sensitivity analysis:

- Mean Annual precipitation (i.e., an "average" year);
- One in 50 (1/50) wet year; and
- One in ten (1/10) dry year.

Estimates of water quality for a range of COPI including fluoride, antimony, arsenic, cadmium, uranium, selenium, and zinc were produced at key monitoring locations located on site and in the downstream receiving environment, which includes:

- The ABM Lake that will form in the former open pit during closure;
- Geona Creek (receiving environment monitoring station KZ-37);
- Upper and lower Finlayson Creek (sites KZ-15 and KZ-26, respectively); and
- South Creek (KZ-13).

It must be emphasized that this predictive modelling can only predict a range of concentrations and, in some cases, relative changes in concentrations or loadings. The water quality modelling is attempting to simulate a range of complex natural processes that have inherent variability. This modelling is useful to understand the potential range of controls that are needed to safely meet the closure objectives and, in addition, to identify the monitoring program during operation and after closure that will provide information to update this modelling and the environmental controls required.

During Active Closure and Transition Closure, COPI concentrations are predicted to decline markedly as load sources from site were reduced due to cover placement over the Class A, B, and C Storage Facilities and the commissioning of the constructed wetland treatment system (CWTS). COPI concentrations in South Creek (KZ- 13) were estimated to return to baseline levels as the Fault Creek diversion is removed, allowing South Creek to revert to its pre-Project flow regime with no COPI water quality objective exceedances expected. Elsewhere, COPI concentrations in the Geona and Finlayson Creek receiving environments declined markedly such that no water quality objective exceedances were forecast for the mean precipitation scenario. Under the 1/10 dry year setting, active water treatment was retained for September and October of each year of Active and Transition Closure to address slight selenium exceedances for these months in Geona Creek (0.0024 and 0.0021 mg/L, respectively prior to treatment vs SSWQO of 0.002 mg/L).

During the Active and Transition Closure phases, flooding of the ABM open pit occurs due to the cessation of local groundwater dewatering and the removal of the Fault Creek diversions. It is anticipated that the ABM open pit will take 16 years to fill before the ABM Lake overflows into Geona Creek, via the CWTS. Modelling suggests that the ABM Lake will contain elevated concentrations of fluoride, antimony, arsenic, cadmium, selenium, and uranium due to solubilisation of the load accumulated on the pit walls; however, in situ treatment of the ABM Lake is anticipated to significantly lower the concentrations of all COPIs with the exception of fluoride (Table 7-17).

Table 7-17: Modelled Water Quality of ABM Lake with and without In Situ Treatment

Parameter	Units	pWQO	Initial ABM Lake Chemistry (Year 26) Total Concentration [a]	ABM Lake Chemistry After In Situ Treatment (Year 26) [a]
Sulphate	mg/L	429 [b]	302	302
Hardness (as $CaCO_3$)	mg/L	Not applicable	573	573
Nitrate-N	mg/L	3	0.19	0.019
Nitrite-N	mg/L	0.2 [c]	0.13	0.013
Ammonia-N	mg/L	1.1 [d]	0.16	0.080
Phosphorus	mg/L	0.035	**0.085**	**0.060**
Fluoride	mg/L	0.12	**0.23**	**0.23**
Aluminum	mg/L	0.1	0.069	0.069
Antimony	mg/L	0.009	**0.025**	**0.013**
Arsenic	mg/L	0.005	**0.020**	**0.020**
Cadmium	mg/L	0.00037 [b]	**0.0031**	**0.00077**
Copper	mg/L	0.01 [b]	0.0068	0.0068
Iron	mg/L	0.3	0.00037 [e]	**0.92** [g]
Lead	mg/L	0.0196 [b]	0.0141	0.0048
Manganese	mg/L	2.59 [b]	0.58	0.58
Nickel	mg/L	0.15 [b]	0.0133	0.0039
Selenium	mg/L	0.0066 [f]	**0.0162**	0.0050
Uranium	mg/L	0.015	**0.0714**	**0.023**
Zinc	mg/L	0.188 [b]	**0.296**	0.049

[a] Concentrations that exceed the pWQO are highlighted in **bold**
[b] Based on ABM Lake hardness subject to the hardness limits outlined in the pWQO report (AEG 2016f) for each hardness dependent pWQO. [c] Based on chloride concentration >10 mg/L in ABM Lake
[d] Ammonia-N pWQO calculated for pH 8 and 10°C
[e] Concentrations adjusted following equilibrium with ferrihydrite
[f] Site specific water quality objective: When sulphate >60 mg/L: total selenium (mg/L) = (0.1736*[sulphate]0.597)/1000)
[g] The pre-PHREEQC-equilibrated modelled iron concentration was for the in situ treatment setting since some iron solubilization may occur during in situ treatment, but expected to be limited by iron sulphide precipitation

The outflow of the ABM Lake marks the start of the Post-Closure phase. During this phase, no preliminary water quality objective (pWQO) exceedances of COPIs were modelled in Geona Creek (KZ-37) or upper and lower Finlayson Creek (KZ-15 and KZ- 26, respectively) other than fluoride. Fluoride was estimated to exceed its water quality objective in Geona Creek (KZ-37) and Finlayson Creek (KZ-15 and KZ-26), but such exceedances were fractional, occurred only in March and/or April of each year, and reflect the naturally elevated baseline concentrations of fluoride in Geona and Finlayson Creeks. Similar behaviour was observed for the 1/10 dry year scenario with slightly higher concentrations due to the lower flow volume. For the dry year conditions, fluoride water quality objective exceedances observed in Geona Creek (KZ-37) and Finlayson Creek (KZ-15 and KZ-26), but the exceedances were marginal (<10% greater than the water quality objective) and occurred in only one or two months of the calendar year. Conversely, lower concentrations were modelled for the 1/50 wet year scenario due to dilution in the higher flow conditions.

Fluoride is naturally elevated in KZK surface waters, particularly at East Creek (median fluoride concentration of 0.17 mg/L; AEG, 2016b), which is a significant tributary to lower Finlayson Creek. Which indicates why fluoride is the only COPI that was modelled to occasionally exceed its water quality objective in the receiving environment in Post-Closure. Furthermore, the BCMoE short term fluoride guideline for Geona Creek and Finlayson Creek ranges between 1.2 mg/L and 1.9 mg/L depending on the water hardness, which is approximately one order of magnitude higher than the slight pWQO fluoride exceedances estimated by the model in the receiving environment. Given that the fluoride water quality objective exceedances were typically only estimated for one month in the receiving environment, it is likely that a short term threshold such as the BCMoE guideline would be a more appropriate comparator for the peak fluoride concentrations that were modelled.

7.6.2.2 Dams and Ponds

The Upper and Lower Water Management Ponds and associated dams will be retained through Active Closure Period and will begin to be decommissioned in the Transition Closure Period. Once the covers for the Class A and B Storage Facilities are determined to be effective and meeting their design criteria the Lower Water Management Pond (LWMP) will no longer be required to manage contact water and will be decommissioned. The LWMP will be converted into the CWTS with the decommissioning of the LWMP dam and wetlands constructed during the Transition Closure Period. During the Transition Closure Period any contact water requiring storage will be directed to the upper water management pond or would be directed to the ABM open pit as a contingency measure.

Upon the successful commissioning of the CWTS and with the waste rock covers for the Class A and B Storage Facilities meeting their design criteria, the Upper Water Management Pond and dam will be decommissioned including the removal of its HDPE liner.

The Class C Storage Facility collection pond will be decommissioned during the transition closure period once the revegetated cover has been determined to be stable in the long term. Following the revegetation of the Overburden stockpile area and the area deemed stable from erosion the Overburden Stockpile Collection pond will be decommissioned. Runoff from the Class C Storage Facility and the reclaimed Overburden Stockpile will continue to be conveyed by ditching to Geona Creek, below the north wetland to attempt to minimize clean water entering the CWTS.

Following the cessation of mining the ABM deposit the Pit Rim Pond will be decommissioned. Decommissioning of the Pit Rim Pond will include removal of the HDPE liner, scarifying the surface and revegetating the pond area.

The Class A Storage Facility collection pond will be decommissioned following the determination that the cover is meeting its design criteria and the drain down of the Class A material is determined to have ceased and active pumping is no longer required. If required a horizontal drainage pipe will be installed at the bottom of the French drain to convey water to the CWTS. The Class A Storage Facility collection pond will be decommissioned by removing the HDPE liner, scarifying the surface and revegetating the pond area.

The Class B Storage Facility collection pond will be decommissioned as a water collection feature following the determination that the cover is meeting its design criteria. The Class B Storage Facility collection pond may be converted to a passive treatment system if the Class B Storage Facility seepage water quality is of lower quality than predicted. Upon the determination that the Class B Storage Facility water quality is stable in the long term the collection pond will be decommissioned by removing the HDPE liner, scarifying the surface and revegetating the pond area.

7.6.2.3 Water Conveyance Systems

Temporary (operational) water conveyance structures, including diversions, such as the Fault Creek diversion, will be removed at the cessation of mining. The decommissioning of the Fault Creek diversion and the Southern diversion ditches will redirect water back into the Geona Creek catchment and will contribute to the ABM open pit sub-catchment.

Additionally, flows will be conveyed into and throughout the mine footprint, and will exit the site in a controlled, stable fashion under a reasonable range of anticipated conditions during the Active Closure Period. This will be accomplished by maintaining diversions to reduce infiltration and erosion of reclaimed area. Diversions will be maintained during the Transition Closure Period to minimize contact of surface flow with mine influenced soils. Also, modifications will be performed to flow patterns at site to achieve enhanced stability or accommodate water quality objectives during the Transition Closure Period as mine features are reclaimed (e.g., Storage Facilities, Process Plant, paste plant). As an example, portions of the northwest diversion will be decommissioned in stages as the mine features along the western side of the Geona Creek valley have been successfully reclaimed to return drainages to pre-mining conditions to the extent possible.

7.6.2.4 Active Water Treatment Systems

The Class A and Class B Storage Facilities collection ponds will be pumped to the Water Treatment Plant throughout the active closure period and into the transition closure period until such time that the waste rock covers have been established. Upon the Class A and Class B waste covers and the CWTS have been determined to meet their design criteria, the Class A and B Storage Facility collection ponds will be passively released to the CWTS if the water quality is deemed suitable. Given the time required to construct the covers and wetlands it has been assumed that active treatment would be required for five years.

Once the water from the Class A and Class B Storage Facility collection ponds is routed through the CWTS, the water treatment plant will be placed on standby, but available to treat water if required for the remainder of the Transition Closure Period.

As the ABM open pit fills, lime and carbon sources will be added to the ABM open pit as described in Section 7.2.1 to treat the water as ABM Lake is formed. Once the ABM Lake reaches 1,380 masl (in year 26 following construction) it will begin to spill and discharge to Geona Creek. The pipeline from the ABM open pit to the Water Treatment Plant will remain in place until it has been determined that the ABM open pit does not require active treatment. It has been assumed that up to five years of active treatment may be required during the post-closure phase to integrate the ABM Lake discharge into the CWTS system and optimize performance to meet the design criteria. Upon the site determined to be geochemically stable in the post-closure period the active water treatment plant will be decommissioned. Sludge produced from the active water treatment plant during closure will be placed into the ABM open pit, which will provide additional alkalinity to the water.

7.6.2.5 Constructed Wetland Treatment Systems

As regulatory requirements do not allow for long term active treatment in reclamation and closure planning (Yukon Energy, Mines and Resources, 2006), and BMC recognizes that a "walk-away" condition my not be achievable, the Project design incorporates a long-term closure scenario in the form a constructed wetlands treatment system (CWTS). Along with waste source control (Section 7.4) and pit water management (Section 7.2.1), anaerobic horizontal surface flow CWTS were selected for the Project as they can operate long-term with minimal monitoring and maintenance (Appendix B).

CWTS have been successfully used in the successful treatment of mine influenced water in northern climates (Ness, 2014; Nordin, 2010), and can include benefits such as decrease of total suspended solids (TSS), treatment of total and dissolved metals, and neutralization of acidic waters. Using fundamental scientific principles such as thermodynamic laws, Stokes' laws (settling), stoichiometry, and concepts of coupled biogeochemical reactions, CWTS can be designed for a range of objectives and geographic locations. For optimal CWTS function, a typical design incorporates the phased integration (Section 2.5.3) of multiple cells connected in a treatment series with materials (soil and vegetation) sourced from site. Treatment will continue during cold periods and into freezing conditions, driven by "cold-loving" bacteria, as long as there is water in liquid form (CSL, 2016a). Additionally, the CWTS design incorporates the production of excess acid volatile sulphides (AVS) in the soils during summer months, to ensure treatment rates remain constant during colder temperatures. During freshet, the water will melt around the decaying vegetation in the CWTS, a zone for enhanced treatment, and also allowing for water exchange with the sediment to occur before the entire CWTS has thawed (Haakensen et al., 2013). To ensure ongoing performance, an adaptive monitoring and maintenance program will be developed during the phased development of the CWTS.

During a CWTS feasibility site assessment conducted on August 25 – 28th, 2015, it was determined that a CWTS would be feasible, and that several features of the natural environmental are favourable for successful water treatment. (CSL, 2016b). Based on water quality modelling estimates, done on water from the ABM Lake outflow at year 27 post mine closure, the treatable constituents of potential interested (COPIs) are antimony, arsenic, cadmium, nitrite, selenium, uranium, and zinc, as they are modelled to be in exceedance of their pWQOs. The theoretical concentrations of COPIs in the ABM pit water and the waste rock runoff in post-closure suggests that a passive treatment train design including CWTS would be suitable to improve water quality to meet the pWQOs (Appendix B). The design of the passive treatment train at the Project to achieve post-closure water quality objectives was refined through an iterative process of determining outflow concentrations of each element on a month to month basis in wet, dry and mean scenarios. After a series of design iterations, a multi-step passive treatment system was selected for the Project (Appendix B), including in situ treatment in ABM Lake, treatment in a South Wetland (17,000 m^2), then treatment in a North Wetland (16,500 m^2) before leaving the site. The South Wetland will be located in an area just north of ABM Lake, and

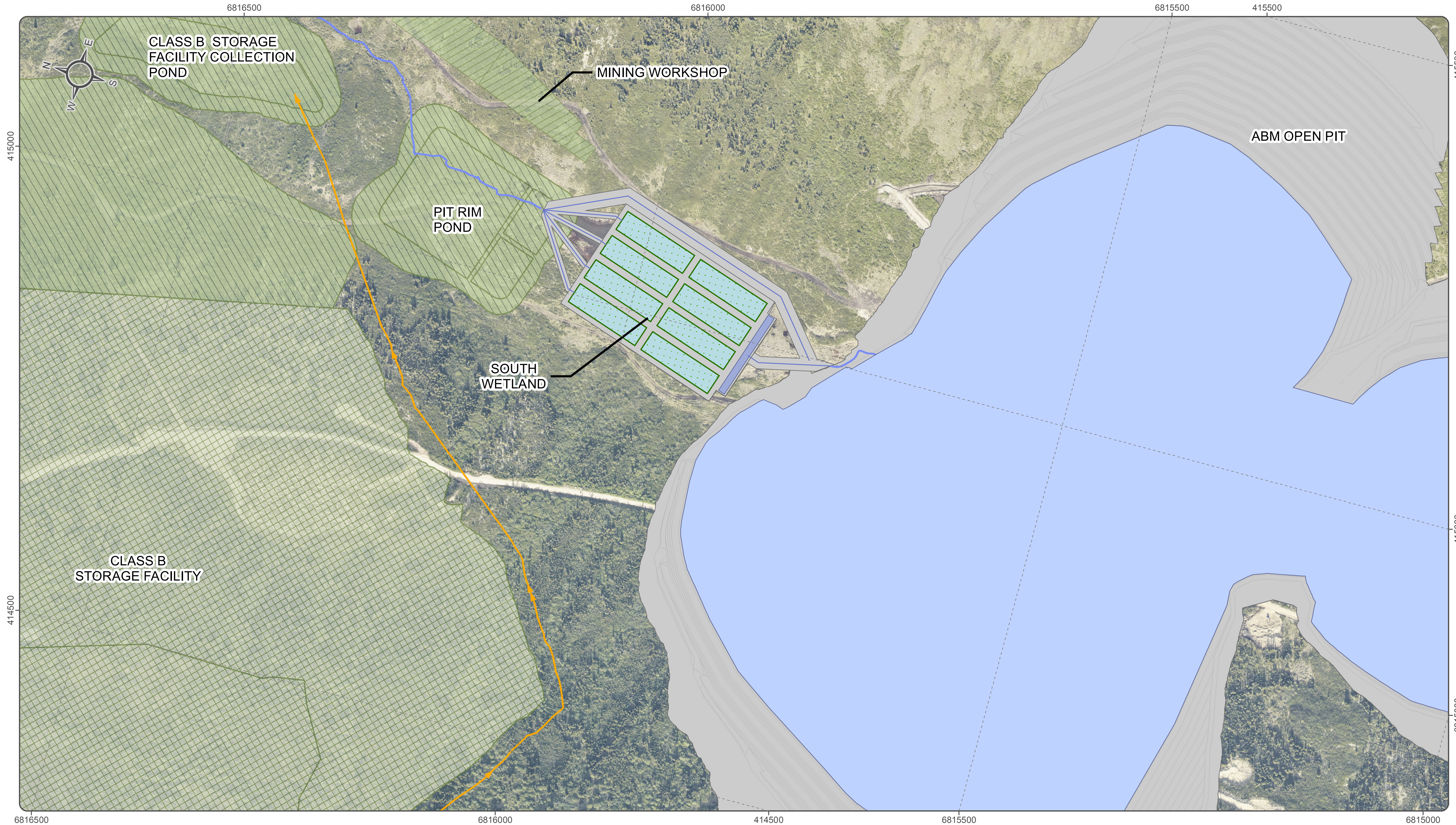
North Wetland will be located in the area of the LWMP. The conceptual layout of the South and North Wetlands are provided in Figure 7-6 and Figure 7-7.

To determine the conceptual outflow concentrations from each wetland at the Project, removal rate coefficients that were developed for projects with similar chemistry and conditions as the Project were used (Table 2 of Appendix B). The treatment rate coefficients that were applied are intended to be a conservative estimate for theoretical outflow concentration purposes, and will need to be refined through pilot-scale (off-site), and demonstration-scale (on-site) testing. Further information on the removal rate coefficients, and the equations used to determine the outflow concentrations are provided in Appendix B.

A theoretical linear flow velocity sensitivity analysis was completed for the narrowest point (which is in the North Wetland) to assess the treatment potential or risks associated with flow and COPI concentration variations (Appendix B). Although the linear flow velocity exceeds 10 cm/s in the June and July wet scenario, which is not conducive to settling (Rodgers and Castle, 2008), the water quality model does not suggest that there are inflow constituents that exceed pWQOs during those months. The maximum theoretical linear flow velocity at the site is 11.3 cm/s (Appendix B), and is not expected to scour the North Wetland during high flow events. Therefore, the flow velocity is not expected to adversely affect the treatment potential of the constituents of concern during the high flow periods of the wet scenario.

As a conservative approach, the outflow concentrations from ABM Lake and the South and North Wetlands were compared to the pWQO developed for Geona Creek to assess theoretical treatment of the COPIs. The expected treatment of COPIs by the South Wetland is provided in Table 3 of Appendix B. All COPIs were below the pWQO for Geona Creek (KZ-9) at the outflow of the North Wetland, except for selenium. Therefore, theoretical concentrations for only selenium are provided in Table 4 of Appendix B. The chemistry of water leaving the North Wetland results in a calculated pWQO for selenium in that water that is greater than the actual selenium concentration. Additionally, selenium concentrations are expected to be below the pWQO for Geona Creek by KZ-37. The treatment of each COPI is summarized below. Further details of the treatment of each COPI are provided in Appendix B.

The size, location, and design of the CWTS and passive treatment train will continue to be refined and optimized through a phased program throughout the Project design and during construction and operations, and as representative water quality becomes available. This phased program is further outlined in Section 2.5.3. The recommendations and next phases of work are outlined in Appendix B.



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0 50 100 150 Metres

AEG

- Inner Cell
- Footprint
- Primary Head Pond
- Covered with Engineered Low Permeability Cover, Surface Revegetated
- Constructed Wetland Treatment System
- Infrastructure Removed, Footprint Reclaimed and Revegetated
- ABM Open Pit Lakes at 1380 masl
- Contact Class A & B Diversion

BMC MINERALS

KUDZ ZE KAYAH PROJECT
CONCEPTUAL RECLAMATION AND CLOSURE PLAN

FIGURE 7-6

PLAN VIEW OF CONCEPTUAL LAYOUT OF SOUTH CWTS

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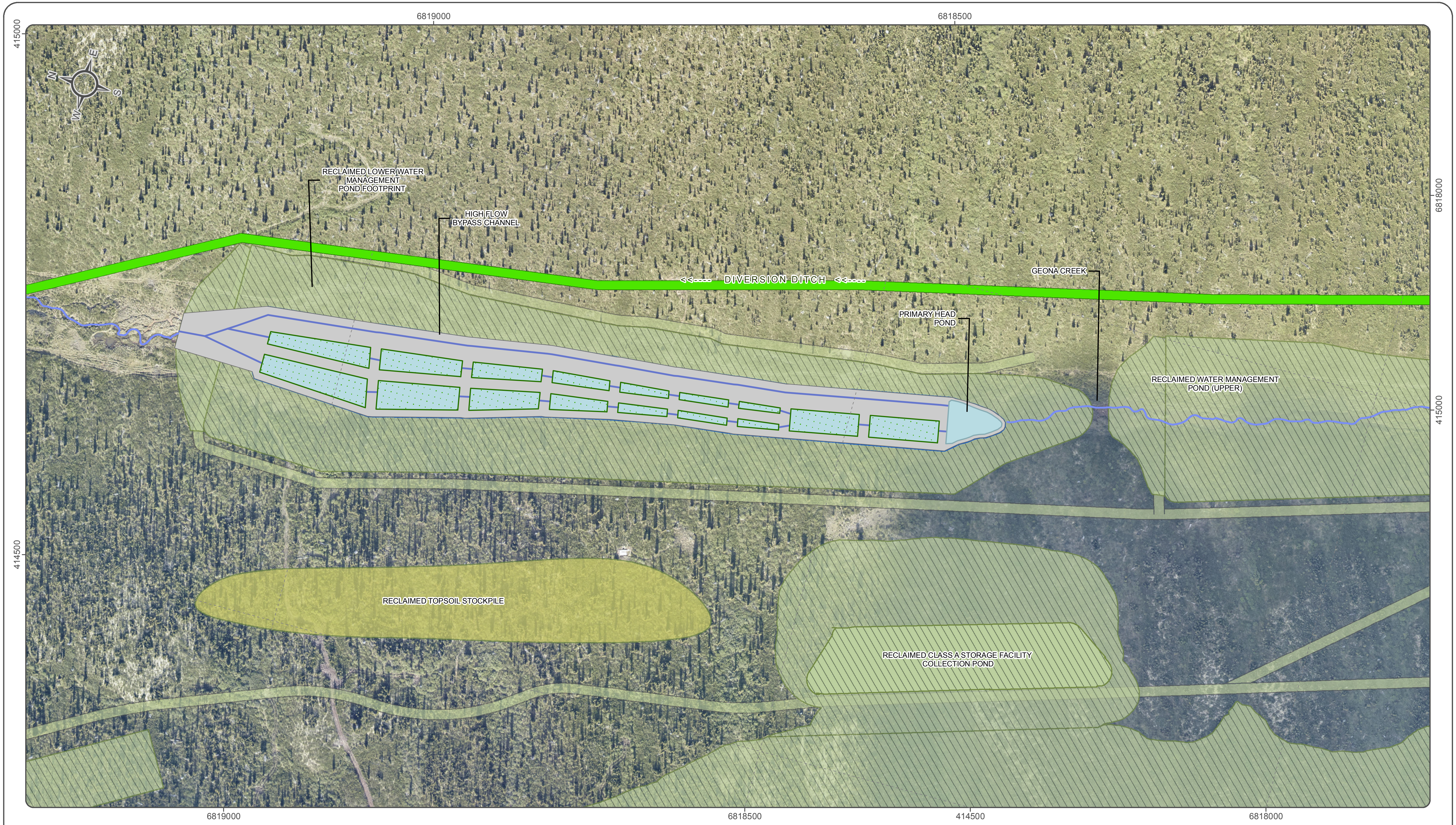

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0 50 100 150 Metres

AEG

- Footprint
- Materials used for Reclamation
- Covered with Engineered Low
- Covered with Overburden, Surface Revegetated
- Constructed Wetland Treatment System
- Infrastructure Removed, Footprint Reclaimed and Revegetated
- Primary Head Pond
- Proposed Mine Road
- Watercourse/Water Flow

BMC MINERALS

KUDZ ZE KAYAH PROJECT

FIGURE 7-7
PLAN VIEW OF CONCEPTUAL LAYOUT OF LOWER WATER MANAGEMENT POND CWTS

JANUARY 2017

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7.7 MINE INFRASTRUCTURE

7.7.1 Closure Objectives and Criteria

The general objectives guiding the decommissioning of the process plant and surface mining infrastructure are to:

- Remove potential sources of environmental contamination and minimize erosion;
- Minimize safety risks to people and wildlife; and
- Reclaim the site to an aesthetically acceptable level.

Table 7-18 summarizes the specific closure objectives, performance and design criteria and closure measures related to the decommissioning of the Project mining, processing, and support infrastructure. The rest of Section 7.7 provides more detail at the conceptual level for the decommissioning plans.

Table 7-18: Mine Infrastructure Closure Summary

Value	Specific Closure Objective	Performance Criteria	Design Criteria/Closure Measures
Physical Stability and Safety	• All mine-related structures and facilities are physically stable and performing in accordance with designs	• No signs of gully erosion or slope creep	• Features will be re-graded to promote positive drainage if required, covered with 30 cm growth media and revegetated
	• Reclamation eliminates or minimizes existing hazards to the health and safety of the public, workers and area wildlife by achieving conditions similar to local area features	• No remaining buildings on site which are not critical to the long term management of the site. All concrete footings and slabs broken and buried • All mobile equipment and ore concentration equipment removed from site at closure	• Demolition of buildings and revegetate and re-contour when applicable • Destroy concrete slabs areas, re-contour and revegetate when applicable • Mobile equipment will be sold on an "as-is, where-is" basis. The purchaser will be responsible for removal. Optionally sold as scrap. Any material left unsold will be landfilled on site • Sell ore concentration equipment. Recouped value estimate and cost of removing from site will need to be re-evaluated

Environment and Land Use	• Restored capability for use by wildlife and traditional aboriginal use, and conditions are typical of surrounding area	• The following ecosystem attribute variables are similar to control sites:
		  • Diversity – Richness and abundance of different functional groups
		  • Vegetation structure – cover and biomass
		  • Ecological processes – nutrient availability and seedling density
		• Monitoring transects indicate signs of use by wildlife (e.g., sightings, browse, scat, burrows, trails) similar to control sites
			• Areas re-graded to maintain natural slopes, aspect and elevations, similar to surrounding area
			• Revegetation planned and executed in consideration of pre-existing vegetation communities and final facility features (elevation, slope, aspect) to maximize revegetation success and use by wildlife

	• Prevent contaminated soils from damaging local environment.	• Results of soil sampling programs in acceptable levels for constituents of concern	• Treat fuel contaminated soils in the land treatment facility • Remove soils contaminated by hydrocarbons to the LTF. • Place any soils contaminated with processing reagents into Class A Storage Facility.
Long Term Risk	• No active water management required to maintain physical or chemical stability, or environmental compliance	• Monitoring surveillance and adaptive management programs are executed as planned without increasing maintenance demands • Passive treatment systems treating water to acceptable levels, and all active water treatment equipment removed from site	• Remove temporary (operational) structures include stream crossings, diversions • Remove water treatment tanks, clarifier, reagent mixing system, piping and electrical/instrumentation equipment • To be done 5 years after Post -Closure period commences since the plant may be needed while the pit fills with water (which takes approximately 16 years)

7.7.2 Closure Measures

7.7.2.1 Mine Camp and Related Infrastructure

Closure measures include dismantling and removing camp buildings, trailers, and related infrastructure. All materials will be salvaged, recycled, or landfilled in the waste storage facility, as appropriate. If materials to be landfilled cannot be disposed of in the on-site waste storage facility, they will be disposed off-site in an appropriate landfill facility. The graded campsite pad will be scarified and re-contoured as required to promote positive drainage, and suitably re-vegetated to provide erosion protection as well as to match the surrounding natural vegetation.

7.7.2.2 Process Plant, Warehouse, Administrative Complex, and Related Infrastructure

Closure measures for the Process Plant as well as the associated Warehouse and Administration Complex include dismantling and removing buildings, trailers, and related infrastructure. Prior to dismantling and removal, buildings will be inspected for hazardous materials. Any hazardous materials will be removed and disposed of either on or off site in an appropriate landfill or storage facility. Non-hazardous materials that have no salvage value will be disposed of in an approved landfill site on the mine site.

Prior to disassembly, buildings will be stripped of all non-attached equipment and materials such as shelving units, office furniture, equipment, etc. Wherever feasible, materials with salvage value will be sold for its value. Modular prefabricated trailer style buildings will, wherever economically feasible, be removed from the site and sold for their salvage value. The remaining service piping, cabling and skirting lumber will be removed and disposed of as either scrap or as salvageable material. Rigid steel frame buildings will be dismantled on site with the support steel being sold for salvage value wherever economically feasible.

Closure measures for the Process Plant building include salvage and removal of the process equipment, and dismantling of the engineered building.

Above grade concrete footings, foundations, concrete floor slabs and below grade concrete foundations will be broken to allow percolation of water and covered with suitable overburden to support re-vegetation. These covered slabs will be seeded with an appropriate vegetation mix to establish vegetative growth over these areas.

The gravel pad beneath the overall Process Plant area will be re-contoured as required to promote positive drainage, and suitably re-vegetated to provide erosion protection as well as to match the surrounding natural vegetation.

7.7.2.3 Fuel Farm Areas

LNG and diesel for power generation will be stored in two 132,000 l Type C vacuum insulated tanks and a facility with a capacity of 700,000 litres respectively, in a containment berm, either made of concrete or an earthen bund and lined with an HDPE liner, located adjacent to the power plant in the Process Plant area. Diesel for mining operations will be stored in a separate bulk fuel storage facility located adjacent to the truck shop. It will include four 100,000 litre tanks in a containment berm, either constructed with concrete or an earthen bund lined with an HDPE liner. A 30,000 litre gasoline tank will also be stored in this lined area for ancillary gasoline use. Diesel will also be used for heating of air entering the underground mine during the winter months. Diesel for this purpose will be stored in a 5,000 litre tank, located adjacent to the underground mine portals. A small supply (nominally 5,000 litre) of aviation fuel will be maintained on site for exploration activities requiring helicopter support. It will also serve as a fuel supply for emergency helicopter evacuation should the need arise. Aviation fuel will be stored adjacent to the helipad, at camp, in a single fuel tank in a lined containment berm.

Closure measures for fuel farm areas include draining tanks of any remaining fuel and salvaging or recycling as appropriate. The liner will be removed from the area and disposed of in an appropriate landfill. Any fuel contaminated soils, as determined by a field sampling program, will be excavated and disposed of in the land treatment facility.

7.7.2.4 Sewage Treatment Plant

The sewage treatment plants will be decommissioned by draining and flushing any tanks and piping with clean water to remove any residual treatment sludge and effluent. The plants will be disassembled and salvaged or recycled as appropriate.

7.7.2.5 Water Treatment Plant

The water treatment plant will remain in place during the active and transition closure periods while passive treatment systems are constructed and brought online to treat site water. The water treatment plant will be maintained in operational form until water quality objectives can be achieved and maintained through the use of passive treatment systems.

Closure measures for the water treatment plant include disconnection of piping and equipment, which will be salvaged or recycled as appropriate. The treatment plant building will be disassembled with any salvageable materials collected. Debris will be placed in the site landfill, or should it be closed, to an off site landfill facility.

7.7.2.6 Land Treatment Facility

The land treatment facility is expected to be required for accepting contaminated soils during site closure. As such it will remain operational until such time as all soils requiring treatment are fully treated. As it is unknown the volume and contamination level of soils to be treated, closure of the land treatment facility will be developed as the closure activities commence.

Generally, treated soils will be spread throughout the site at approved locations. The liner will be disposed of in either the site landfill, or an off site facility if the on site landfill is closed at the time of decommissioning. The area will be regraded and revegetated to match the surrounding topography.

7.7.2.7 Solid Waste Facility

The solid waste facility will receive waste throughout the closure of the site. As such, it will not be closed until the active closure period has completed. A decommissioning plan will be submitted to YG for the solid waste facility. Once approved, the facility will be closed with a soil cover and the area will be re-vegetated.

7.7.2.8 Explosives Compound

Explosives will be stored in secure, fenced facilities separate from the main activity areas, adjacent to the Overburden Stockpile. Bulk explosives for open pit blasting purposes will be stored in the bulk explosives compound. A packaged explosive magazine will store all explosive requirements for the underground mine as well as cast boosters and other explosive products required for open pit operations. A separate detonator magazine will be available for storage of all detonators.

At closure, any unused explosives, magazines, and other equipment will be returned to their respective suppliers or otherwise disposed of in accordance with Federal regulations. The prill and emulsion silos will be decommissioned and salvaged as appropriate. The garage and office will be dismantled and salvaged. Any fuel contaminated soils will be excavated and placed in the land treatment facility. The area will be re-contoured to match local topography and re-vegetated.

7.7.2.9 Mobile Equipment

Mobile equipment such as vehicles, compressors, mobile electricity generators, self-contained storage tanks, etc. will be decommissioned and removed from site for sale, salvage, or recycling as appropriate.

7.7.2.10 Truck Shop

A truck shop will be located north east of the ABM open pit for maintenance of mining equipment.

Equipment will be decommissioned and salvaged or recycled as appropriate. The truck shop building will be dismantled and materials salvaged or recycled as appropriate. Debris which cannot be salvaged will be placed in the site landfill for disposal. Concrete footings, foundations, and floor slabs will be broken to allow percolation of water and covered with suitable overburden to support re-vegetation. These covered slabs will be seeded with an appropriate vegetation mix to establish vegetative growth over these areas.

7.7.2.11 Paste Fill Plant

Closure measures for the paste fill plant will include the removal of equipment for salvage, and the dismantling of the building. Materials will be salvaged or recycled as appropriate, and debris placed in the solid waste facility. Concrete footings and floor slabs will be broken and buried in place. The area will be recontoured and re-vegetated.

7.8 HAZARDOUS MATERIALS

7.8.1 Closure Objectives and Criteria

The overall objective for hazardous materials management at closure is to remove all unnecessary hazardous materials off site to minimize liabilities. Specific objectives for hazardous materials management include:

- Maintain a register of all hazardous materials at site to ensure all materials are accounted for and removed;
- Ensure proper storage, handling, and transport to minimize the specific hazards associated with each material;
- Reuse and recycle all possible hazardous materials and return materials to vendors where possible to minimize waste;
- Collect and manage hydrocarbon contaminated soils in an on site land treatment facility to the extent possible to minimize transportation and disposal costs and retain usable soils at site for reclamation;
- Incinerate used oil and filters, and hydrocarbon soaked absorbents where waste management permits allow; and
- Use only certified transportation companies and disposal facilities for hazardous materials.

Table 7-19: Hazardous Materials Closure Summary

Value	Specific Closure Objective	Performance Criteria	Design Criteria/Closure Measures
Chemical Stability and Safety	• Eliminate risk to human and wildlife health and safety	• No access to hazardous materials • No hazardous materials incidents or spills	• Remove all non-essential hazardous materials • Proper storage and handling for hazardous materials
Environment and Land Use	• Eliminate risk of hazardous materials spills	• No hazardous materials on site	• Incineration of hazardous wastes and residual ash disposed in the on-site landfill • Remove all remaining hazardous materials from site using certified waste transport companies and disposal facilities
Long Term Risk	• Eliminate risk of hazardous materials spills • No residual liabilities from hazardous materials	• No hazardous materials on site	• Incineration of hazardous wastes and residual ash disposed in the on-site landfill • Remove all remaining hazardous materials from site using certified waste transport companies and disposal facilities

7.8.2 Closure Measures

During closure, all hazardous materials will be removed from site. Table 7-20 lists the potential hazardous materials on site at closure and handling requirements for disposal and or removal. Incompatible substances will be stored separately to prevent contamination, fires, explosions, gaseous emissions, leaching or other discharges, or other dangerous conditions according to the Material Safety Data Sheets (MSDS). Any unused hazardous materials will be returned to vendors or sold where possible. Some residual hazardous wastes can be incinerated on site and the residual ash disposed of in the on site landfill. Residual hazardous materials will be transported off site by certified hazardous materials transport companies and disposed of at certified facilities. When transporting hazardous materials, the containers will be labelled following *Transportation of Dangerous Goods Regulations* (SOR/2008-34).

Table 7-20: Potential Hazardous Materials at Closure and Disposal Requirements

Hazardous Material	Removal / Disposal Requirements
Mill reagents (e.g., lime, flocculants, activators, depressants, collectors, frothers)	Return unused reagents to vendors Transport residual reagents and containers to certified disposal facilities
Waste diesel	Burned on site if permit allows
Fuels	Transported off site and used elsewhere or sold
Aviation fuel (at Finlayson Lake airstrip)	Managed by air service contractors for use on other contracts; no residual fuels or waste barrels are to be left at the Finlayson Lake airstrip
Solvents and lubricants (e.g., paint thinners and strippers, varsols, degreasing fluids, mineral spirits and petroleum distillates)	Shipped to licensed recycle and/or disposal facility
Used oil and filters	Incinerated on site under valid permit with ash disposed of in on site landfill or transported to used oil disposal facility
Propane	Shipped to licensed recycle or disposal facility
Compressed gas	Shipped to licensed recycle or disposal facility
Antifreeze soaked absorbents	Incinerated with ash disposed of in on site landfill
Used batteries	Stored appropriately on wooden pallets with plastic wrap and shipped to a licensed recycle or disposal facility
Aerosol containers	Shipped to licensed recycle or disposal facility
Medical wastes (e.g., syringes, bandages)	Collected in purpose-built sharps containers and incinerated
Hydrocarbon contaminated soils	Managed in on site land treatment facility while the on site facility is permitted, then removal and disposal

7.9 ACCESS ROAD

7.9.1 Closure Objectives and Criteria

Closure of the Access Road will be guided by the following objectives:

- Limited effect on wildlife, in particular caribou breeding and migration path; and
- Reclaim roads to limit negative mining legacy.

Success in meeting these objectives will be achieved when closure monitoring programs indicate that impacts to wildlife from the existence and use of the access road are not significant. Also, there are zero health and safety incidents or instances of impact to company reputation and social licence from the post-closure condition (and use, if any) of the access road.

7.9.2 Closure Measures

Once a decision has been made to permanently close the road, BMC will retain a Qualified Professional who will:

- Inspect the road and identify any site-specific road closure requirements (including any terrain hazard areas that may need specific closure prescriptions);
- Prepare a detailed road reclamation and closure plan based on the condition of the road;
- Inspect the site during reclamation, closure and post-closure to ensure the reclamation objectives have been met; and
- Provide final professional assurance that all deactivation activities have been completed as described in the detailed road reclamation and closure plan.

A Qualified Professional is considered a Registered Forest Technician (RFT), Registered Professional Forester (RPF), Professional Engineer (PEng) or a Professional Geoscientist (PGeo) with experience in the subject matter.

During reclamation and closure activities, public access will be restricted to the same extent as it currently is. The security station and gate at the access to the road from the Robert Campbell Highway will be manned and maintained and only authorized vehicles will be allowed on the road. Over the winter period, if there are limited site operations, the gate will be locked. Post-closure the access restriction strategies may include: additional gates, signs and barriers.

Road reclamation will involve the removal of the culverts and drainage structures and decommissioning of the roadbed. The roadbed will be contoured and rounded throughout its length, and will include the following activities:

- In smaller cuts and fills, ditches will be filled in, and the soils shaped to match the surrounding topography;

- In large cuts and fills, the embankment or excavation footprint will be reshaped to a lesser extent, but all slopes will be flattened or rounded to better suit the surrounding terrain; and
- Surfaces of gradients less than 25% will be scarified where necessary using scarifiers on bulldozers, excavators and graders to better accept seeding.

All culverts, bridges, and drainage structures will be removed and disposed of off site at an appropriate location. The following activities are planned:

- Trenches resulting from the removal of culverts will be swaled or contoured to match the surrounding terrain;
- Where warranted due to fine grain soils, erosion protection will be installed in the remaining swales, to a point where the reclaimed watercourse meets with its original path in undisturbed soil;
- If ditches are to be left intact (potentially required in steeper sections) existing ditch erosion protection may be left in place; and
- The bridge at km 17 will be removed, and the abutments will be excavated to the level of the rip-rap placed during construction.

All exposed soils along the length of the road will be stabilized and contoured to prevent surface erosion, then seeded with an appropriate seed mix (Section 7.1).

7.10 BORROW MATERIALS PLANNING

A preliminary investigation into available material for covers and construction purposes has been conducted. Table 7-21 presents the volumes of material for the cover systems described in Section 7.4 and detailed in Conceptual Cover Deign Report (AEG, 2017d), included as Appendix A, and the Geotechnical Site Investigation Data Report (KP, 2016c).

Table 7-21: Borrow Materials and Volumes for Covers

Material Type	Source	Estimated Volume Required (m^3)	Estimated Volume Available (m^3)
Class C Waste Rock for Frost Protection at Class A and B Storage Facility	Class C Waste Rock	4,836,000	32,000,000
Compactable Till for Class B Storage Facility	ABM Overburden	778,000	9,000,000
Growth media for vegetation on all Storage Facilities	Topsoil and overburden from facility preparation	809,000	954,000
Bedding Layer Till for Class A Storage Facility	Material Stripped from Class A & B Facility Foundation Areas	313,000	698,000

The estimated growth media volume available for reclamation is assumed to be a combination of topsoil as well as the upper layer of till. This material will be readily available for closure as it will be excavated and stored next to the facilities where it was stripped. The Class C material required is currently estimated based on a 3.0 m frost protection layer; however, if further field studies determine the thickness needs to be increased there is currently sufficient volumes available.

The volume of till required to compact a low permeability cover layer on the Class B waste rock will likely be a selection of the best available material between the open pit overburden and the overburden stripped from the ABM open pit and Class B Storage Facility footprint. The volume is currently calculated from the ABM pit footprint.

The estimated available material is assumed to meet all of the requirements for the conceptual cover design.

7.11 MONITORING AND MAINTENANCE

The closure monitoring program builds on the operational monitoring program for the Project (AEG, 2017a). The active closure period (active decommissioning and reclamation activities) is expected to last three years and will have regular monitoring, maintenance, and reporting in addition to monitoring plans developed in the execution plans for the closure component. The Transition Closure Period lasts for a further 13 years while the ABM open pit fills and any constructed wetlands are developed. When monitoring has shown that closure performance objectives have been met less frequent monitoring and maintenance will occur. Post-closure monitoring will last until all reclamation objectives are met and the property can be relinquished.

It should be noted that the monitoring and maintenance plan presented here is conceptual in nature based on currently available information that will change through construction and operation as new data are collected and programs change through adaptive management. Closure monitoring program updates will be discussed and agreed with YG, RRDC and LFN as the Project moves into the closure phase. The term “monitoring” is used herein to describe both sampling activities as well as visual inspections.

This section discusses the monitoring activities that will continue during active closure, transition closure, and post-closure to ensure reclamation objectives are met. The different components proposed for monitoring during the closure periods are:

- Physical and chemical stability of engineered facilities;
- Surface and groundwater quantity and quality;
- Reclamation and wildlife use; and
- Aquatic resources (benthic invertebrates and fish).

The closure period monitoring programs are based on the current monitoring programs and modified based on the anticipated Project development changes during and after reclamation. The approach to closure monitoring will be to continue with the operational monitoring programs until decommissioning and reclamation measures have been completed and then to reduce the frequency of site monitoring and the number of monitoring stations over time as satisfactory closure performance is confirmed.

The objectives of the monitoring programs are to:

- Provide qualitative and/or quantitative characterizations of important conditions over time through the various closure phases;

- Allow for the comparison of these conditions with performance criteria established to evaluate if closure measures are meeting identified closure objectives; and

- Allow for the comparison of these conditions with thresholds established in the closure adaptive management plan (Section 7.12.2).

Closure monitoring results and closure progress will be included in annual reporting to EMR, RRDC and LFN. Reporting will include:

- Presentation of monitoring results;

- A discussion of the effectiveness and success of reclamation;

- Development and implementation of supplemental or corrective measures to successfully reclaim sites where the initial measures were not successful (if any); and

- Identification and documentation of outstanding environmental issues along with, where warranted, the plans and a schedule for resolution. Issues that have been successfully mitigated will be listed as resolved.

Table 7-22: Summary of Closure Period Monitoring Networks and Frequencies

Monitoring Program	Monitoring Locations	Timing	Summary	Active Closure Year 11-13	Transition Closure Year 14-26	Post -Closure Year 27-35
Surface Water	KZ-2, KZ-9, KZ-13, KZ-15, KZ-16, KZ-17, KZ-18, KZ-26, KZ-37, KZ-3, KZ-5, KZ-30, KZ-31, KZ-36	Variable	Field and laboratory analysis	Monthly	Monthly (Year 14-15) Quarterly (Year 16-26)	Monthly (Year 27-29) Quarterly (Year 30-35)
	KZ-8, KZ-12, KZ-34	Variable	Field and laboratory analysis	Weekly	Monthly (Year 14-15) Quarterly (Year 16-26)	Monthly (Year 27-29) Quarterly (Year 30-35)
	ABM Lake (KZ-38)	Variable	Field and laboratory analysis	Monthly (June – Sep) Quarterly (Oct – May)	Monthly (June – Sep) Quarterly (Oct – May)	Monthly (June – Sep Year 27-29) Quarterly (Oct – May Year 27-29) Quarterly (Year 30-35)
Groundwater	MW15-09S, MW15-09D, MW15-10S, MW15-10D, MW15-07S, MW15-07D, MW16-13, MW16-14D, BH95G-15D, MW16-12S, MW16-12D, BH95G-33S, BH95G-33D, MW16-16D, MW15-06, BH95G-29 BH95G-30, BH95G-31, MW16-15S, MW16-15D, MWF-01S, MWF-01D	Variable	Field and laboratory analysis	Quarterly	Quarterly	Semi-annually
Aquatic Resources: Benthos/Sediment/Toxicity	KZ-9, KZ-13, KZ-15, KZ-16, KZ-17, KZ-26	Low flow (fall)	Field sampling and lab analyses	Every 3 years	Every 3 years	TBD
Terrestrial Resources: Revegetation Success	Specific locations where reclamation/re-vegetation occurred and other discrete locations	Mid-summer	Seedling survival, height growth, germination success, composition, natural succession	Annually	Annually (for 3 years) then TBD	TBD
Terrestrial Resources: Metals Concentrations	Specific locations where soil covers were applied and other discrete locations	Mid to late summer	Monitoring of metals in soil and biota	Every 3 years	*TBD	*TBD
Terrestrial Resources: Wildlife	Established transects on reclaimed facilities; annual rut and late winter ungulate surveys	October rut, March late winter, summer during reclamation survey	Quantify species use from sightings and signs	Annually	TBD	TBD
Physical and Chemical Stability	Engineered facilities	Summer	Engineering inspections performed by a Qualified Person	Annually	Annually	Annually

Notes:
TBD - to be determined based on results from previous monitoring
* Timing of initial terrestrial metals concentrations monitoring to be confirmed based on revegetation success monitoring

7.11.1 Physical and Chemical Stability of Engineered Facilities

To ensure the effectiveness of the closure measures for landforms that remain on site after closure the physical and chemical stability of these engineered facilities needs to remain intact. Natural processes such as wind and water erosion, settlement, and permafrost degradation can affect geotechnical stability. The design basis for physical stability is described in the Prefeasibility Design Report (KP, 2016a) and the Pre-Feasibility Study – Class A Storage Facility Assessment (KP, 2017a). The design engineers will also specify the monitoring program and action levels for each structure.

Geotechnical monitoring will be performed by a qualified person and occur for the following facilities:

- Class A, B, and C Storage Facilities until stability criteria are met;
- Foundations of decommissioned process plant and infrastructure until fully reclaimed;
- Water collection ponds, spillways, and conveyance systems until fully reclaimed;
- Underground mine areas until all equipment and personnel are removed and flooding begins;
- Open pit ramp and walls until flooded; and
- Site roads and the Access Road until open cross drains are constructed to convey water in original watercourses.

General monitoring activities for geotechnical physical stability include:

- Completion of consistent monitoring records from established points of observation from construction through to post-closure; and
- Inspection for deformation of any landforms that could affect closure objectives or closure criteria.

General monitoring activities for geochemical stability include:

- Observations of changes that could indicate chemical instability (e.g., seeps and stains); and
- This will be complimented by the chemical sampling and testing included in the water quality monitoring program.

There will be a minimal amount of maintenance required for closure infrastructure. Likely maintenance activities will include erosion control on destabilizing slopes and debris removal from spillways, channels, and culverts.

Additional detail for monitoring specific facilities is provided below.

7.11.1.1 Engineered Facilities

The key objective of monitoring engineered facilities is to ensure long-term physical and chemical stability. The focus is on the facilities that present significant consequences is they do not perform a to the closure design, namely the Class A and B Storage Facilities as well as the water management structures. Monitoring Class A, B, and C Storage Facilities will occur annually during active closure and transition closure, with reduced frequency post-closure if previous monitoring provides sufficient evidence of stability determined by the Project engineer.

Monitoring will be undertaken by Professional Engineer with expertise in the subject matter:

- Inspection and assessment of physical stability of Class A, B, and C Storage Facilities;
- Inspection and assessment of geochemical containment performance of Class A and B Storage Facilities including testing performance of cover and liner systems as necessary;
- Inspecting root systems of vegetation that are colonizing the surface of cover systems to determine if roots are contained in the growth media (e.g., soil, rock fill) and are not penetrating underlying cover materials;
- Inspection of reclaimed process plant and ancillary facilities areas, and site roads to ensure all slopes are stable and not eroding;
- Inspection of diversion ditches and berms;
- Inspection of ground conditions to confirm predicted permafrost conditions are being established; and
- Identification of unanticipated water discharge areas (including volume and quality).

Continuous monitoring equipment will be employed where needed to assess physical and chemical stability of the Class A and B Storage Facilities. Instrumentation may include:

- Extensometers to measure axial displacement which provides information on the displacement of the rock mass;
- Inclinometers to measure horizontal displacement; and
- Piezometers such as a vibrating wire piezometer will allow for continuous monitoring of the pore-water pressure to determine the stability of slopes.

Observation, surveying, and photographic image analysis will be used to monitor slope stability on lower risk facilities such as the Class C Storage Facility.

7.11.1.2 Constructed Wetland

The key objective of monitoring the constructed wetland is to ensure that water quality running through the wetland is being treated effectively and meeting the water quality objectives for discharge. The plants and substrates will be monitored in the wetland to determine where the metals are accumulating in the substrate and plants during the treatment process.

Monitoring of the constructed wetland will continue with the same schedule as during the mining phase (for the demonstration scale wetland), as described in Appendix B. This monitoring involves an annual soil and vegetation metal monitoring program. Once performance criteria are met the monitoring frequency and parameters will be reduced, depending on results from previous monitoring.

7.11.1.3 ABM Open Pit

The key objectives for monitoring the ABM open pit in closure are to check the progress of pit wall stability once dewatering has ended and to manage water quality in the ABM Lake in preparation for discharging to Geona Creek. One risk of pit wall failure is that the ground stability around the pit rim is compromised beyond the area protected by the perimeter berm. Other risks are that a failure could produce waves in the ABM Lake that might result in an uncontrolled release of water from the pit or result in physical mixing of the ABM Lake strata that could adversely affect water quality. Water quality monitoring will be conducted to ensure that mitigation measures are effective and the ABM Lake and releases meet water quality criteria.

Monitoring of the open pit during and after flooding will involve water quality and physical inspections to meet closure objectives and performance criteria. Activities for monitoring include:

- Monitoring geotechnical stability of pit walls;
- Installation of survey control points to enable precise measurements for distortion of pit wall;
- Monitoring water level in pit during flooding and outflow rates once the pit is fully flooded;
- Water quality monitoring in pit through depth and at the discharge point once fully flooded; and
- Inspecting the integrity of barriers including the perimeter berms and signs.

Water quality monitoring of the ABM Lake will begin approximately one year after the pit has started to fill with water (i.e., year 11) to allow sufficient volume to conduct sampling by boat. Sampling will be conducted on a monthly basis between June and September during the open water season and quarterly for the remainder of the year (e.g., sampling in December and March). Separate samples will be collected at the surface (i.e., top 2 m), and mid depth, and in 5 m of the pit floor to assess how well mixed the ABM Lake is and track the development of any stratification. Water quality data will inform any in situ treatment that may be necessary to limit the ABM Lake metal concentrations.

The parameters measured in the water quality samples are the same as those listed for surface and groundwater monitoring in Section 7.11.2. Once the pit starts to overflow (year 27) that indicates the transition from Transition Closure to Post-Closure. Sampling of the ABM Lake water quality will continue for a further five years into the Post-Closure period for monitoring and adjustment, including possible active water treatment. If stable water quality is observed, the sampling frequency will be reduced to quarterly for the remainder of the post-closure period.

7.11.2 Surface and Groundwater Monitoring

Water quality monitoring will be performed to determine the progress and efficacy of site reclamation with a view to meeting the water quality objectives in the receiving environment. It is anticipated that surface water and groundwater quality monitoring will occur at the sites indicated in Figure 7-8 and Figure 7-9. The water quality monitoring locations, schedule, parameters and QA/QC procedures for operations are set out in Chapter 19 of the KZK Project Proposal (AEG, 2017a).

Briefly, surface water and groundwater quality monitoring will occur on a monthly and quarterly schedule, respectively (Table 7-22). Exceptions include the discharge from the Class A Storage Facility water collection pond, the water treatment plant, and the Lower Water Management Pond, which will all be monitored on a weekly basis. It is anticipated that monitoring of these sites will continue at that sampling frequency for the first five years following closure (i.e., years 11 to 15). For the remainder of the transition closure period (i.e., years 16 to 26), the frequency of water quality monitoring at the surface water stations will be stepped down to quarterly. Upon entering the post-closure period when the pit starts to overflow, the frequency of surface water quality monitoring will return to monthly for three years (i.e., years 27 to 29) before transitioning to quarterly sampling from year 30 until the end of the post-closure period (year 36).

Groundwater monitoring stations will be sampled on a quarterly basis throughout the active and transition closure periods, and for the first three years of the post-closure period (i.e., years 11 to 29). Semi-annual sampling will be performed from year 30 to year 36.

Samples collected for water quality monitoring will be analyzed in the field for in situ parameters pH, conductivity, temperature, dissolved oxygen, and ORP. Samples will be collected and appropriately preserved for the laboratory analysis of:

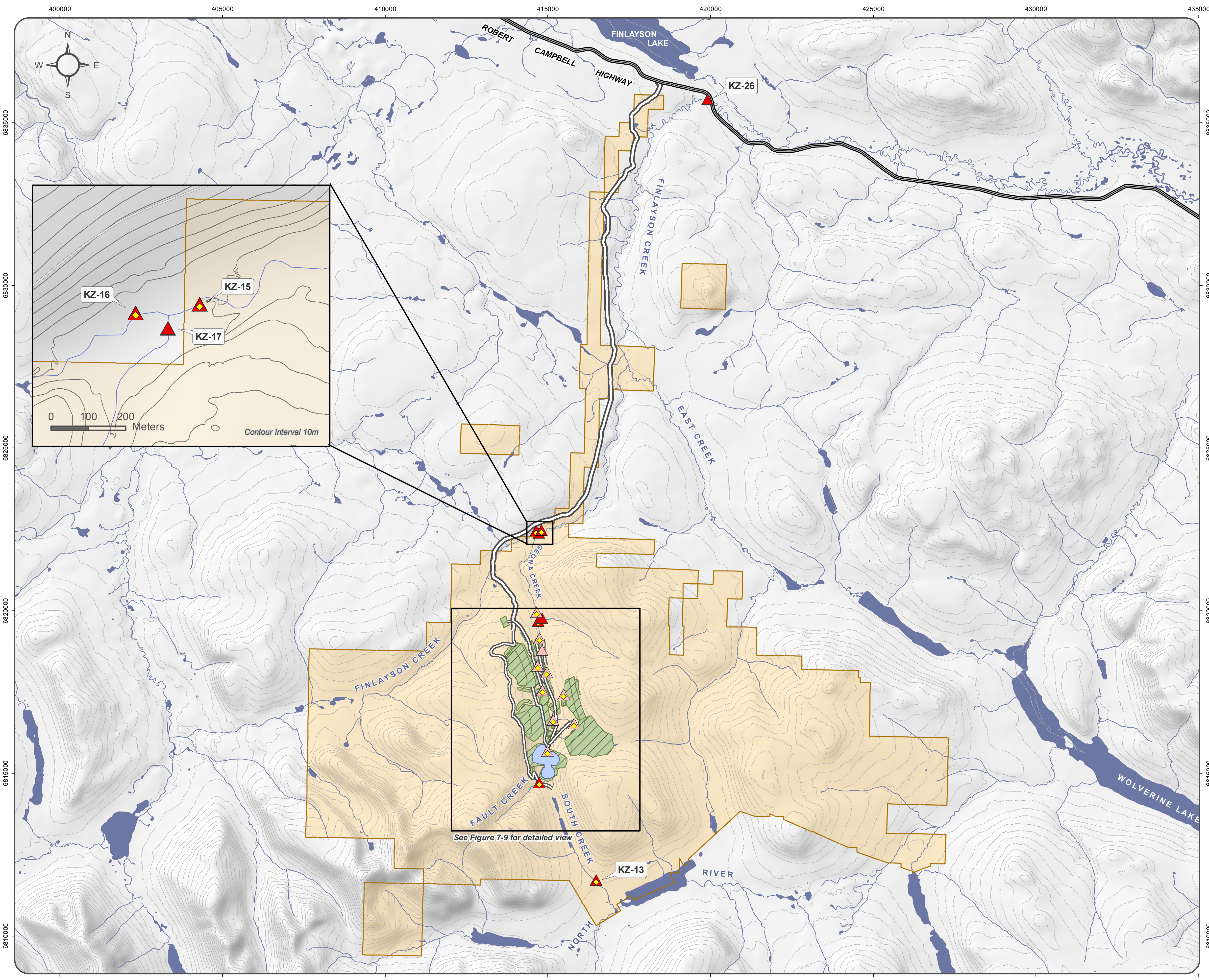
- pH;
- Specific conductivity;
- Total suspended solids;
- Anion scan (chloride, fluoride, sulphate, nitrate, nitrite, phosphate);
- Alkalinity and acidity;
- Ammonia;
- Dissolved organic carbon;
- Total metals (ultra-low level metals package including hardness, phosphorous and mercury);
- Dissolved metals (ultra-low level metals package including hardness, phosphorous and mercury); and
- Total and Weak Acid Dissociable (WAD) cyanide.

BMC MINERALS

KUDZ ZE KAYAH PROJECT
CONCEPTUAL RECLAMATION AND CLOSURE PLAN

FIGURE 7-8
POST-CLOSURE SURFACE WATER QUALITY MONITORING LOCATIONS

JANUARY 2017



Existing Water Quality and Hydrometric Station

Existing Water Quality Sampling Location

Proposed Water Quality and Hydrometric Station

Proposed Water Quality Sampling Location

Tote Road/Proposed Access

Proposed Mine Road

Contour (40 m interval)

Watercourse

Waterbody

Location of Reclaimed Mine Infrastructure

BMC Minerals (No.1) Ltd. Mineral Claim Areas

ALEXCO ENVIRONMENTAL GROUP

Digital elevation model created by the Yukon Department of the Environment interpolated from the digital 1:50,000 Canadian National Topographic Database (NTDB Edition 2) contour and watercourse layers. Obtained from Geomatics Yukon.

Datum: NAD 83; Projection UTM Zone 9N

1:115,000 when printed on 11 x 17 inch paper

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Kilometres

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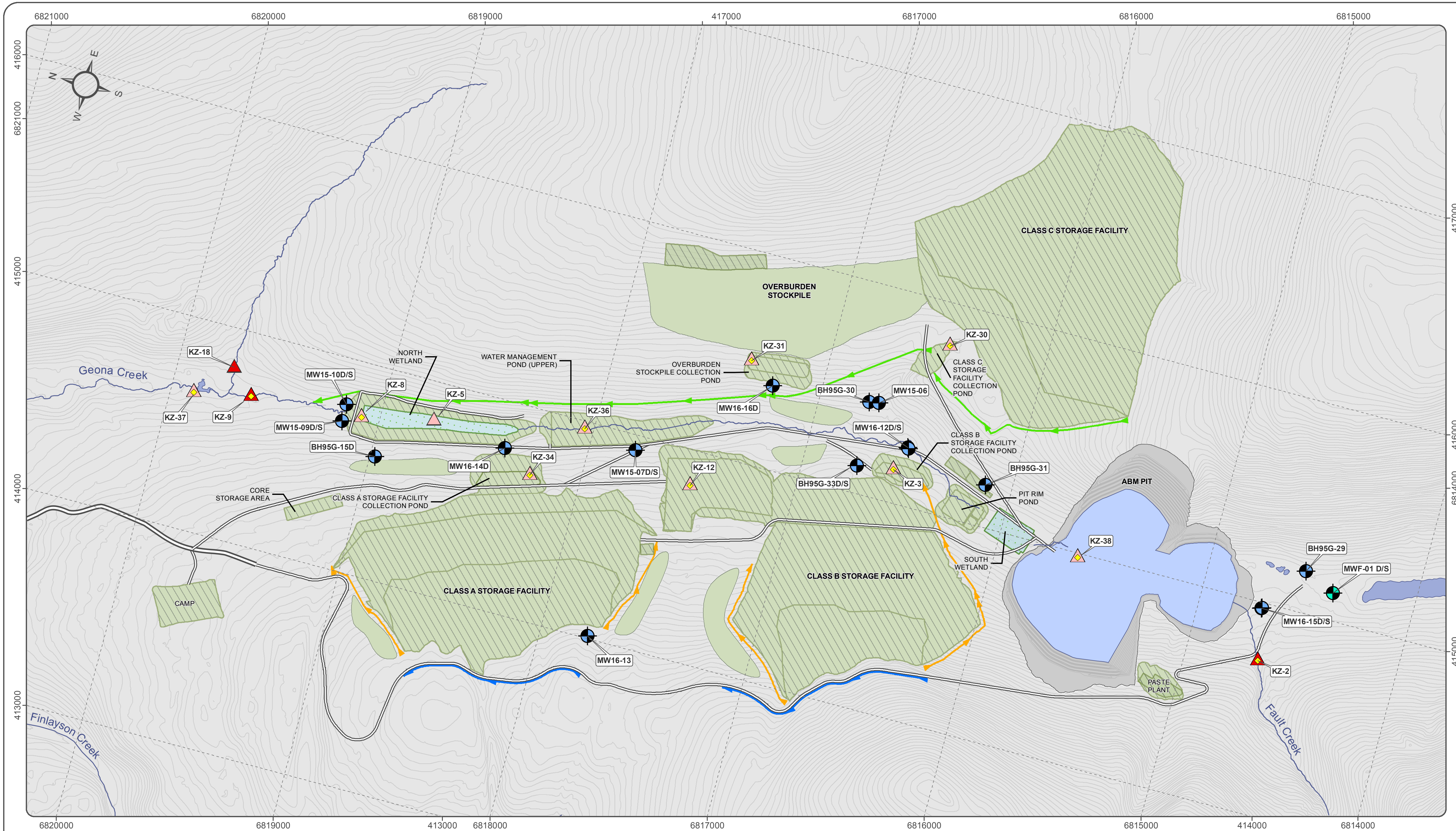

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- Water Quality and Hydrometric Station
- Water Quality Sampling Location
- Proposed Water Quality and Hydrometric Station
- Proposed Water Quality Sampling Location
- Groundwater Monitoring Well
- Proposed Groundwater Monitoring Well
- Wetland
- Reclaimed
- Materials used for Reclamation
- ABM Open Pit Lakes at 1380 masl
- Non Contact Diversion
- Contact Class A & B Diversion
- Contact Class C Diversion
- Tote Road/Proposed Access Road
- Proposed Mine Road

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CONCEPTUAL RECLAMATION AND CLOSURE PLAN

FIGURE 7-9

POST-CLOSURE SURFACE AND GROUNDWATER MONITORING LOCATIONS WITHIN THE PROJECT AREA

JANUARY 2017

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7.11.3 Reclamation and Wildlife Use Monitoring

The purpose of the closure and post-closure monitoring is to determine if the reclamation prescriptions have met the closure objectives (to reclaim the land as near as possible to its original state). Areas of the Project that have been actively reclaimed will require monitoring to ensure the continued success of the closure program. The reclamation and monitoring programs will involve Kaska members, to the extent possible. Further details about the revegetation program are presented in Section 7.1.2.

Monitoring of reclaimed areas will take place annually during active closure, transition closure, and post-closure to evaluate the revegetation establishment and the effectiveness in controlling erosion. An aerial reconnaissance is an effective method for the initial years and will be completed to identify any locations where severe erosion or drainage alteration has occurred as well as any additional locations warranting ground reconnaissance, further monitoring and additional reclamation prescriptions. Potential issues that may be identified through aerial reconnaissance include terrain instability (e.g., slope movement and trench subsidence), soil erosion or drainage alteration, poor vegetation cover establishment, watercourse crossings, and condition of access control management structures. As the site is reclaimed, the program may be modified to only include ground reconnaissance of key areas that still require monitoring and maintenance to meet closure criteria.

Through monitoring and evaluation, additional reclamation measures will be employed in areas that have not revegetated successfully. Maintenance activities to support revegetation include scarifying, fertilizing, planting, reseeding, and erosion control measures. Brushing may be used for maintenance if vegetation (deep rooting species) are damaging cover materials. Post-closure, monitoring frequency will be reduced to only areas that still need to meet closure criteria. Maintenance requirements are expected to be minimal post-closure.

Revegetated areas will be inspected annually following initial planting until vegetation is successfully established and self-sustaining in accordance with performance criteria. The monitoring program will include measurements along established transect lines and plots to provide a detailed record of vegetation growth (including succession of species) and groundcover over time. The following components will be monitored to assess reclamation success:

- Soil for analysis of nutrients and pH until the vegetation is successfully established and self-sustaining in accordance with agreed criteria;
- Metals uptake in vegetation measured periodically to determine if uptake poses unacceptable risk to human, wildlife, and environmental health;
- Monitor revegetation progress such that they meet technical needs (e.g., maintaining physical stability), aesthetic needs (e.g., blends with surroundings), and future use targets, and do not impact the effectiveness of selected closure activities or become a source of metals due to uptake;
- Monitoring for propagation of non-native or undesirable species;
- Monitoring areas where growth of vegetation may be impacting the ground thermal regime;
- Monitoring expansion of growth areas outside planted zones and determine if the effects are beneficial or detrimental to performance of closure measure; and

- Monitor wildlife use of revegetated areas to determine if viable wildlife habitat has been re-established.

7.11.4 Aquatic Resources

The objective of closure monitoring aquatic resources is to ensure that downstream aquatic resources are being protected in the long-term. It is assumed that the success of the fish habitat offset program under a *Fisheries Act* authorization will be proven and no further fish population monitoring will be required.

Aquatic resource monitoring will include the Yukon permit requirements by water licence conditions and Environmental Effects Monitoring (EEM) as required by the federal *Metal Mining Effluent Regulations* (MMER). During closure, it is proposed that the water licence conditions be aligned with the EEM program. Details of the Water Licence and EEM monitoring program are outlined in Chapter 19 of the KZK Project Proposal (AEG, 2017a) and include monitoring the following components:

- Benthic invertebrate communities;
- Stream sediment quality; and
- Toxicity testing on aquatic plants, invertebrates, and fish.

7.12 PERFORMANCE UNCERTAINTY AND RISK MANAGEMENT

The planning for reclamation and closure of any mine development project relies upon a number of assumptions and predictive undertakings (e.g., water quality modelling, waste cover performance, water treatment performance) related to anticipated future conditions and closure measure performance. By its very nature, planning for future events and performance involves varying degrees of uncertainty. Some elements of mine closure planning have a higher degree of certainty (e.g., performance of erosion control measures) than others (e.g., long term site runoff water quality).

Successful mine closure planning therefore requires planning and management tools which acknowledge this uncertainty and take appropriate measures to reduce the risk associated with uncertain outcomes in the closure periods. This section summarizes some key efforts both already undertaken and planned to reduce this risk, as planning for reclamation and closure of the Project moves along the closure planning continuum.

7.12.1 Risk Management

As monitoring of baseline and environmental conditions continues leading up to mine construction, and as data collection from the monitoring programs continues through mine operations, closure planners will have the ability to use these data to calibrate predictive models used as the basis of closure planning and design. As closure approaches, closure measures can be adjusted if required if the predictive work changes through the calibration process. This will reduce risks to the Project in closure associated with uncertainty regarding future conditions.

As part of the initial mine re-design work for the Project, KP (2016a) undertook a mine waste alternatives assessment using a qualitative multiple accounts assessment. The best option with the least risk was selected and taken forward as the base case for the Project Proposal design (AEG, 2017a).

Further reclamation and closure planning will benefit from a formalized risk assessment process that looks at potential failure modes of the closure concepts in this plan and their potential effects. This can effectively be undertaken with a Failure Modes and Effects Analysis (FMEA) exercise. This will be conducted as a multi-stakeholder (including Kaska members) exercise in a workshop setting. In the first part of the FMEA workshop, participants identify all the potential failure modes (i.e., the 'what ifs') for closure design options. The potential technical, environmental, social, and economic consequences are then identified and discussed by all workshop participants and then ranked along with an assessment of the likelihood of the consequences.

The results of the FMEA are used to choose the best closure options and as a Project closure risk register. This exercise and planning tool will help the closure planning team revise and/or strengthen the proposed closure measures and mitigations to ultimately reduce those risks. The goal for the application of the risk assessment work will be to adjust the closure and reclamation plan such that all residual risks are acceptable to all stakeholders.

Many risks can be addressed through mitigations and closure measures for which there is a high degree of certainty. Some of the remaining risks associated with a higher degree of performance uncertainty can be addressed in an adaptive management framework as discussed in the following section.

7.12.2 Adaptive Management Plan

This section provides the proposed framework for a closure period adaptive management plan (AMP).

Adaptive management is an approach to environmental management that is appropriate when a mitigation measure may not function as intended or when broad-scale environmental change is possible. Adaptive management plans are precautionary in nature, and provide a level of security in long term environmental planning. Adaptive management plans also allow for the inclusion of improved science into mitigation measures as they are continually revised.

Adaptive management practices have been evolving since their emergence in the 1970s. Adaptive approaches include an ability to incorporate knowledge into the management plan as the knowledge is gleaned and circumstances change. Embedding adaptation into environmental plans involves thinking about how the results of monitoring will change management actions. AMPs are a way to acknowledge uncertainties and build a structures framework to respond to changing conditions. Adaptive management conducts a flexible path with actions to take when specific triggers occur. AMPs are a formalization of a plan for performance monitoring and Project re-evaluation in the future.

This section will outline the proposed structure of the Project Closure AMP and will identify the AMP components (sections) which will be incorporated into the draft AMP for the next phase of development planning.

7.12.2.1 AMP Approach and Structure

The approach for development of the Project Closure AMP will follow the Environmental Code of Practice for Metal Mines, Section 4.1.17 on Adaptive Management:

> *Mine owners/operators should use adaptive management methods to revise and refine the environmental management strategy. Adaptive management should consider a wide range of factors, including:*

- *The results of environmental audits or other evaluation activities;*
- *The results of environmental monitoring;*
- *The results of monitoring of the performance or condition of environmental infrastructure, such as containment structures, water management systems or treatment facilities;*
- *Technological developments; and*
- *Changing environmental conditions." (Environment Canada 2009)*

The general structure of adaptive management is presented in Figure 7-10 as a decision-making flowchart.

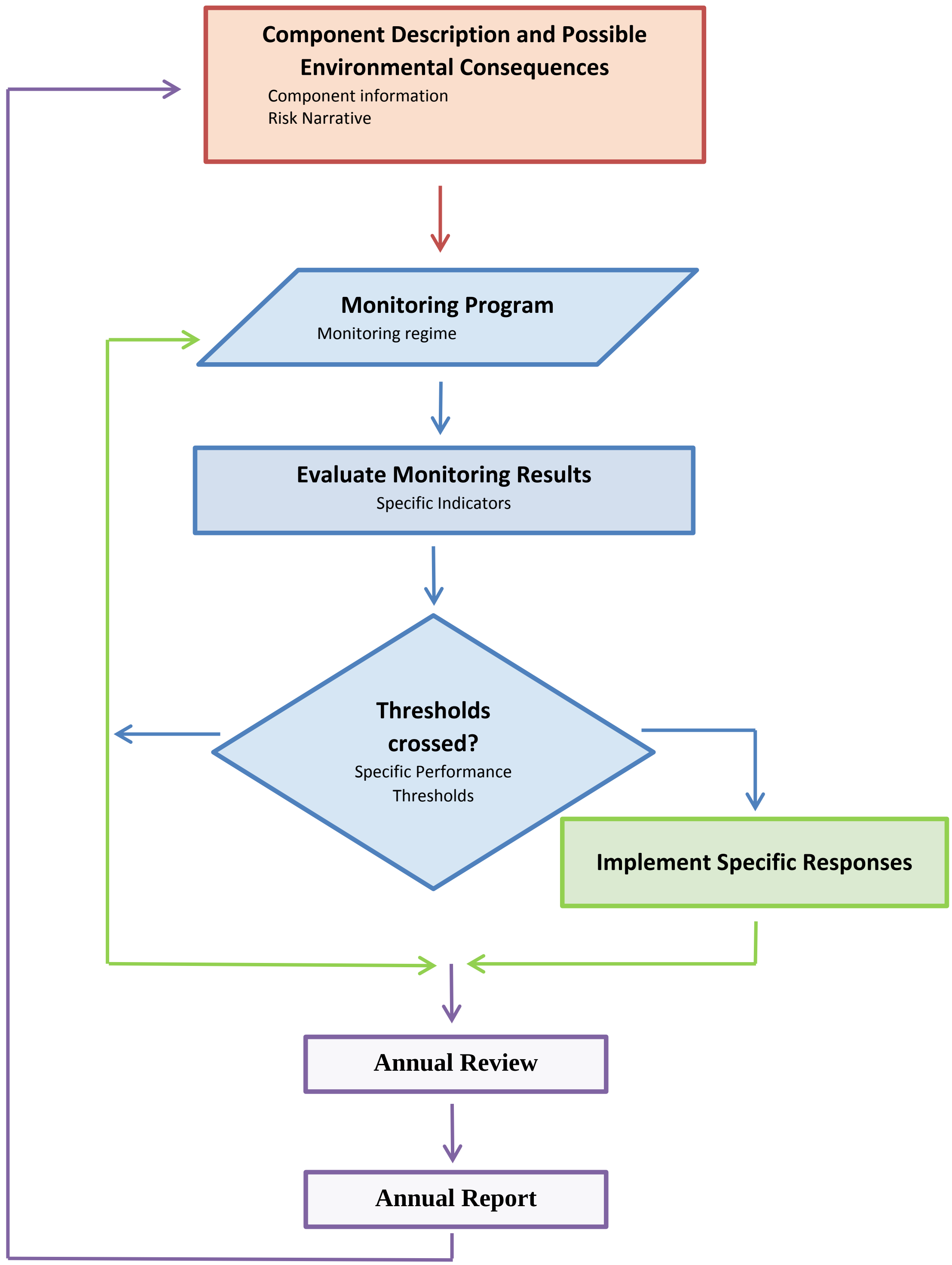


Figure 7-10: Sequential Components of the AMP (Adapted from AECOM 2010)

The AMP for each component will be structured using this common element approach to create consistency in implementation of the AMP protocol. These common elements are:

Description of the component

- Description - description and understanding of the component leads to risk narrative and specific performance thresholds.
- Risk Narrative describe the possible environmental effects and environmental conditions that implementation of the AMP will prevent.

Monitoring the component

- Specific Indicators are the environmental or physical parameters to be monitored and assessed. Specific indicators are measurable or observable, and are indicative of changes from the designed or expected condition.
- Monitoring Requirements describes the monitoring regime for the component including frequency, type of data required and interpretation of results.
- Specific Performance Thresholds define the conditions, in terms of specific indicators, when action is triggered. Performance thresholds are staged to accommodate levels of concern and a diversity of actions. To the extent possible, specific performance thresholds will include early warning thresholds.

Responding to unexpected conditions of the component

Specific Responses are staged according to specific performance thresholds describes the actions to be implemented if specific performance thresholds are crossed. They will be provided in the following categories:

- Notification;
- Review;
- Evaluation; and
- Action.

Annual Reporting and Review

Annual Reporting reflects annual changes made to the AMP as the site conditions change. The AMP should be modified whenever unexpected circumstances are encountered and the protocol is implemented or when additional proven science or technology becomes available. The annual review will include a review of the relevant monitored data and AMP elements. Updates, amendments, performance thresholds crossed, and trigger(s) activated will be provided to the appropriate governmental (including RRDC and LFN) organizations as required and will be part of the annual report.

7.12.2.2 AMP Components

The following AMP components have been identified in the preliminary planning stages as having some degree of performance uncertainty associated with closure measures during post-closure. Performance that is poorer than expected or modelled for these measures has the potential to result in effects to the environment or human health and safety:

- Surface water quality;
- Groundwater quality;
- Wetland treatment performance;
- ABM Lake water quality;
- Waste rock and tailings cover performance;
- Water collection and conveyance structures performance;
- Administrative management; and
- General reclamation measures.

These are the proposed components for which detailed AMPs will be developed in subsequent planning stages.

7.12.2.3 Review and Advancement of the AMP

An AMP is an iterative process. This implies that an AMP is never complete in nature, but in a continuous state of refinement in response to feedback from monitoring, analysis of data and changing conditions. Until final closure, the Project is anticipated to continue to evolve and change. The various components and activities related to the phases do not occur in isolation, and plans such as the Closure AMP must be dynamic to deal with change effectively. Thus the AMP is considered a “living document,” and subsequent iterations of the Closure AMP will take Project changes into account.

The AMP will continue to be further developed upon results of site specific reclamation research (Section 2.5) to be conducted at the Project. The ongoing reclamation research is intended to help refine closure objectives and to develop threshold values, predictions, and optimized reclamation options for the closure and reclamation processes. The AMP will be updated and improved as further knowledge of the closure and reclamation systems are developed.

8 RECLAMATION AND CLOSURE SCHEDULE AND EXECUTION STRATEGY

Three distinct closure phases, or 'periods' have been identified for the Project reclamation and closure. These have been identified for planning purposes because:

- In some cases, there are different closure objectives for different periods of time following the cessation of mining activities;
- There are distinct physical activities required in each stage to meet the closure objectives;
- The filling of the ABM open pit to create the ABM Lake delays the final water drainage and discharge condition, and creates a transition period prior to the pit water spilling to Geona Creek; and
- These separate periods are outlined below with the details regarding the associated closure schedule and execution strategy. Table 8-1 summarizes the mine development and closure phase schedule and execution strategy.

Figure 8-1 shows the expected Project layout, or configuration, at the end of the operational mining period (Year 10). As this figure presents the expected layout details such as the land treatment facility and solid waste management facility are shown together as the Waste Management Facility.

8.1 ACTIVE CLOSURE PERIOD (YEAR 11 TO 13)

The active closure period is the three-year period immediately following cessation of operations, where most consequential decommissioning and reclamation work is done. Mining equipment will be removed, most infrastructure will be decommissioned, and the Fault Creek diversion will be removed to allow Fault Creek to return to its pre-mining channel and to begin filling the ABM open pit. ABM open pit in situ water treatment will begin in year 11 and continue through the Transition Closure Period.

Most major earthworks will be completed during this period. The portions of the Class A and B Storage Facilities not reclaimed progressively during operations will have their reclamation completed, with the cover placement being finalized. The camp will be partially decommissioned. All operational water treatment and management systems (i.e., seepage collection and conveyance) are retained and functional, and monitoring and inspection regimens will remain in place, unchanged from the operational period. The general arrangement in year 13 in the Active Closure Period is shown on Figure 8-2.

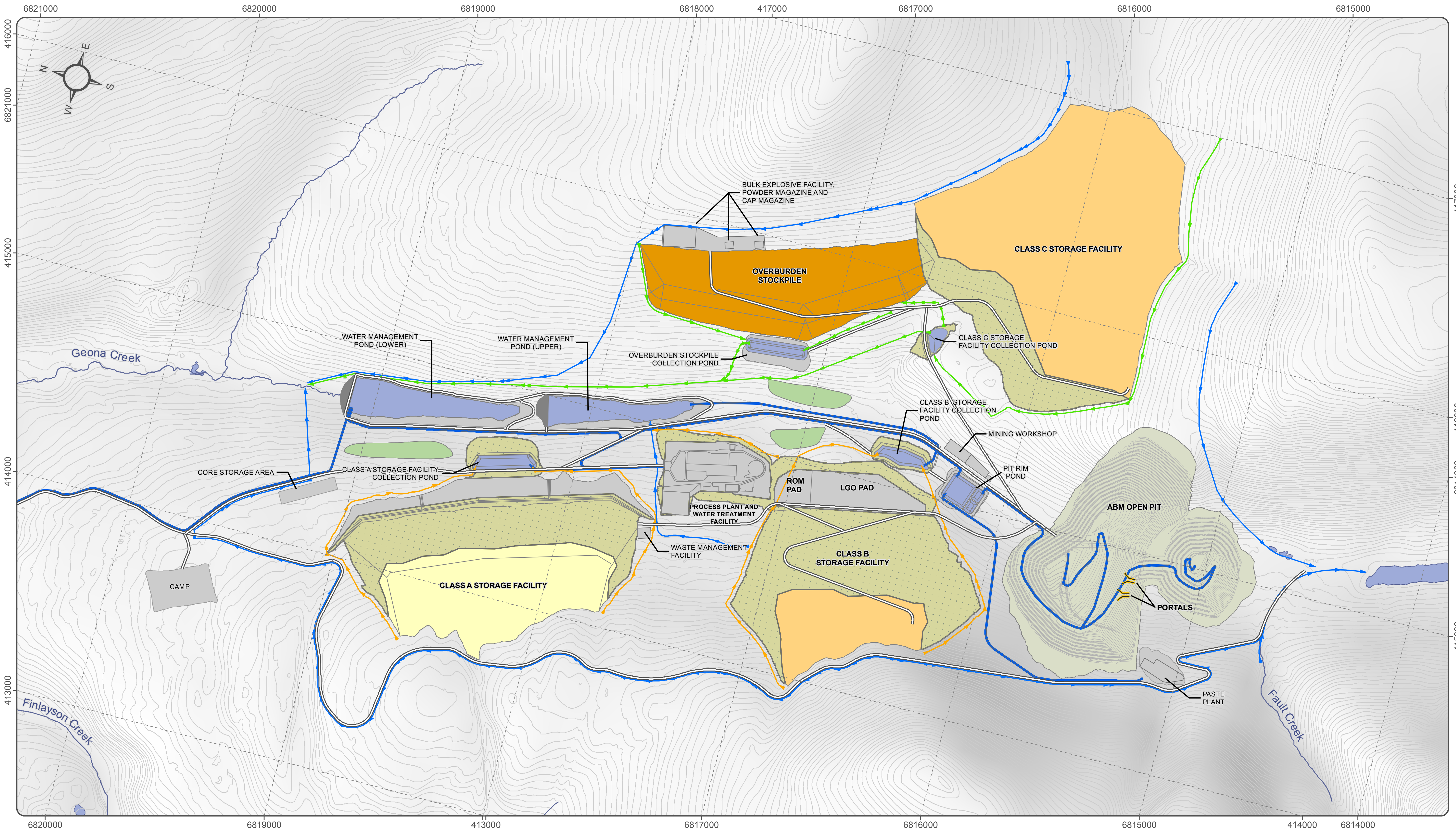
8.2 TRANSITION CLOSURE PERIOD (YEAR 14 TO 26)

This period is a 13-year period during which the ABM open pit continues to fill, ending when the ABM Lake begins to outflow to Geona Creek. The constructed wetland treatment systems will be constructed and commissioned at the start of this period, and the operational water management systems (i.e., seepage collection and conveyance) will remain on site and functional until such time as the CWTS is performing as required to meet water quality objectives and effluent discharge standards. Additionally, following the confirmation of CWTS and covers meeting performance objectives the UWMP will be decommissioned. The active treatment plant and system will be retained in a ready state as a contingency.

Monitoring and maintenance of the reclamation earthworks will be undertaken during this period as the waste cover systems and revegetation establish. The Project layout in year 20 is shown on Figure 8-3.

8.3 POST-CLOSURE PERIOD (YEAR 27 TO 36)

The Post-Closure period commences with the spilling of the ABM Lake water into Geona Creek. It is currently planned to be a 10-year period of primarily monitoring and maintenance. It is expected that a year or two will be required to ensure that the passive water treatment systems are achieving performance expectations with the new water contribution from the ABM Lake. Once these objectives and performance criteria are achieved, the active water treatment plant and remaining infrastructure will be demobilized/decommissioned, and site water management will be passive in nature. The Project layout in years 27 to 36 is shown on Figure 8-4.



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CONCEPTUAL RECLAMATION AND CLOSURE PLAN

FIGURE 8-1

PROJECT LAYOUT AT END OF MINING OPERATIONS (YEAR 10)

JANUARY 2017

- Class A Storage Facility
- Class B and C Storage Facility
- Overburden Stockpile
- Topsoil Stockpile
- Progressive Reclamation
- Pond/Water
- Non Contact Diversion
- Contact Class A & B Diversion
- Contact Class C Diversion
- Pipeline
- Proposed Mine Road

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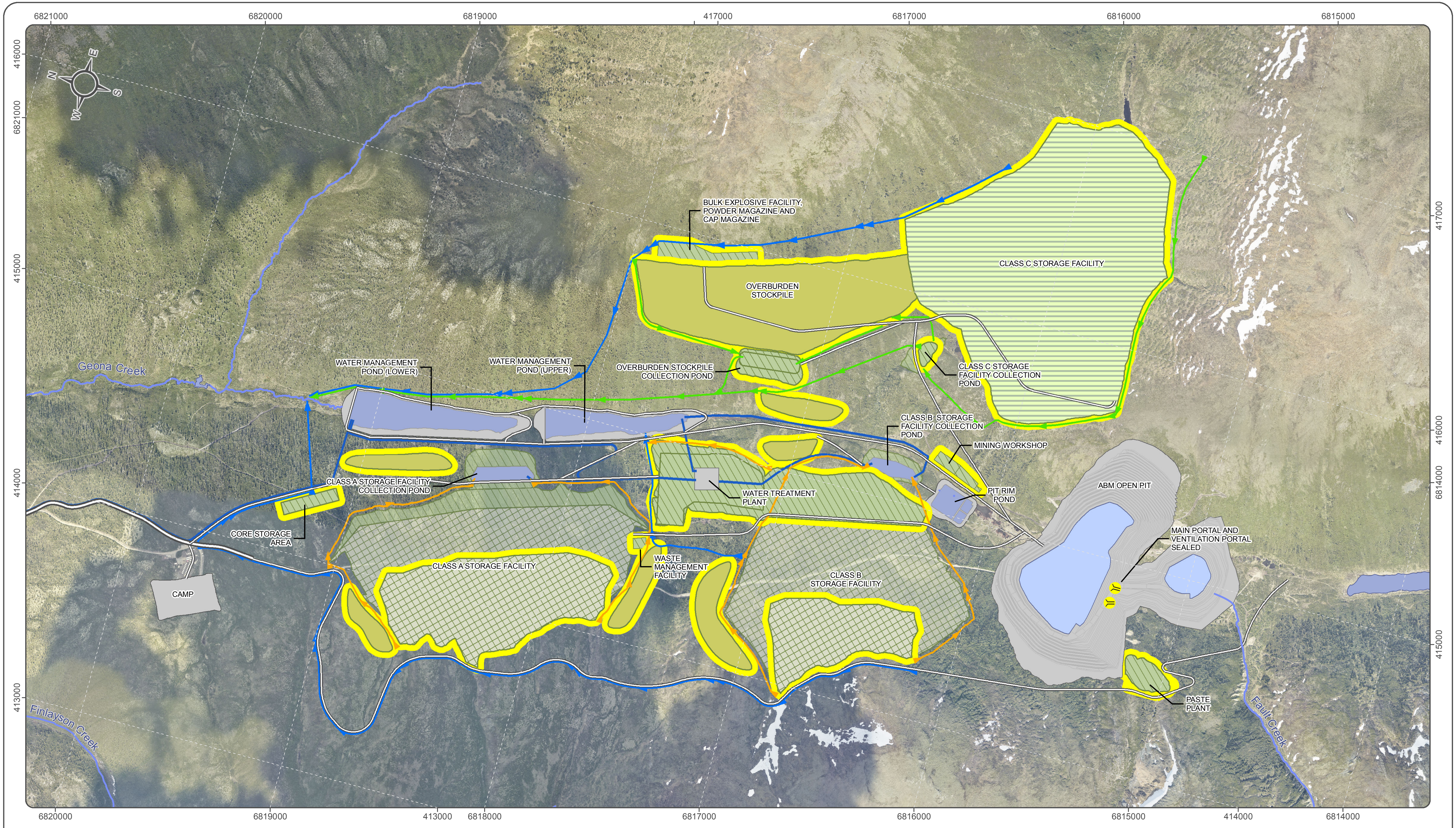

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- Closure Activities Occurring in This Closure Period
- Mine Footprint
- Covered with Engineered Low Permeability Cover, Surface Revegetated
- Covered with Overburden, Surface Revegetated
- Infrastructure Removed, Footprint Reclaimed and Revegetated
- Materials used for Reclamation, Footprint Reclaimed and Revegetated
- Pond/Water
- ABM Open Pit Lakes at 1300 masl
- Tote Road/Proposed Access Road
- Proposed Mine Road
- Pipeline
- Non Contact Diversion
- Contact Class A & B Diversion
- Contact Class C Diversion

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CONCEPTUAL RECLAMATION AND CLOSURE PLAN

FIGURE 8 - 2
GENERAL ARRANGEMENT IN ACTIVE CLOSURE PERIOD (YEAR 13)

FEBRUARY 2017

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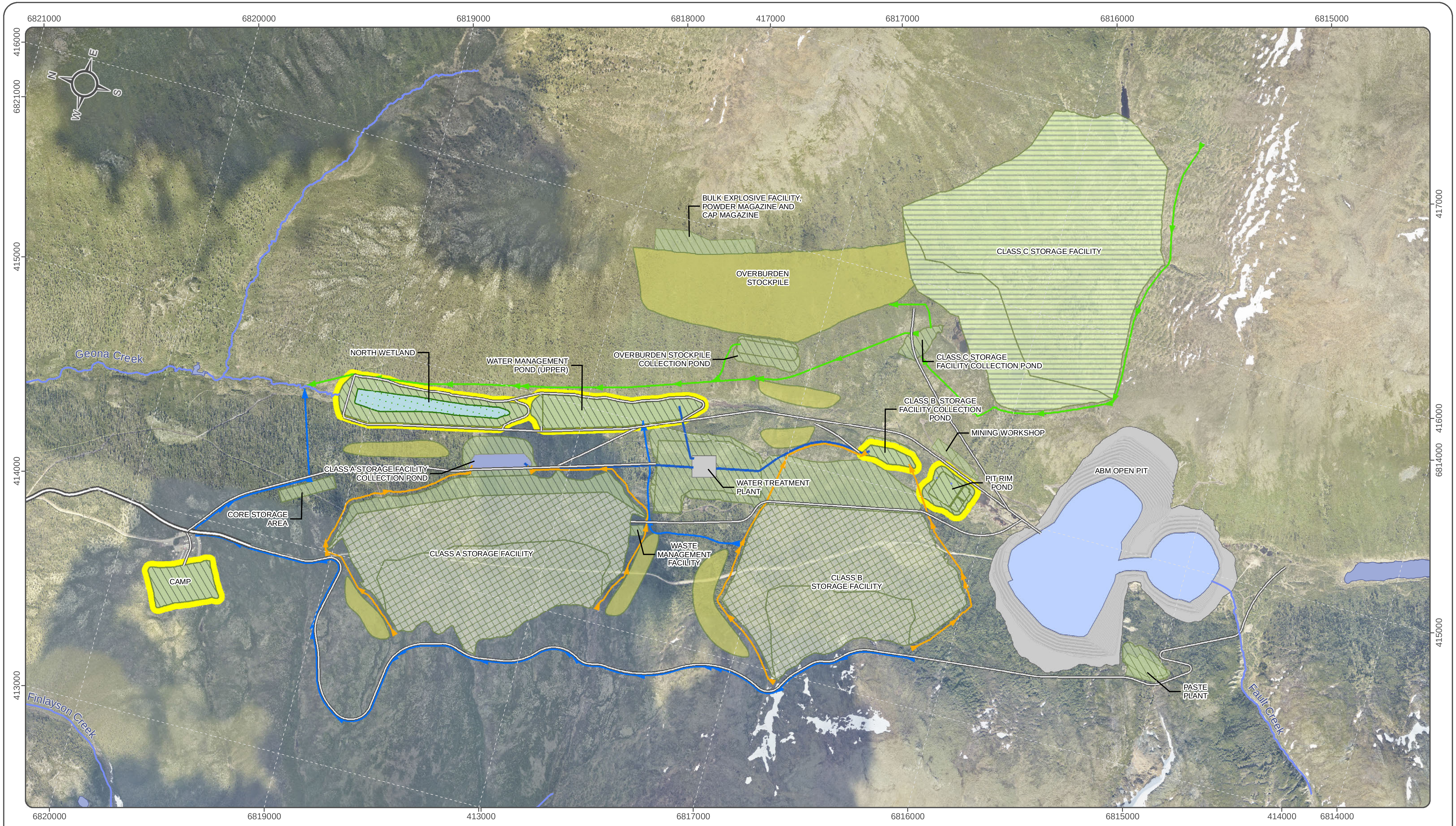

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Legend

- Closure Activities Occurring in This Closure Period
- Mine Footprint
- Materials used for Reclamation, Footprint Reclaimed and Revegetated
- Covered with Engineered Low Permeability Cover, Surface Revegetated
- Covered with Overburden, Surface Revegetated
- Constructed Wetland Treatment System
- Infrastructure Removed, Footprint Reclaimed and Revegetated
- Water/Pond
- ABM Open Pit Lakes at 1350 masl
- Tote Road/Proposed Access Road
- Proposed Mine Road
- Pipeline
- Non Contact Diversion
- Contact Class A & B Diversion
- Contact Class C Diversion

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CONCEPTUAL RECLAMATION AND CLOSURE PLAN

FIGURE 8 - 3
GENERAL ARRANGEMENT IN TRANSITION CLOSURE PERIOD (YEAR 20)

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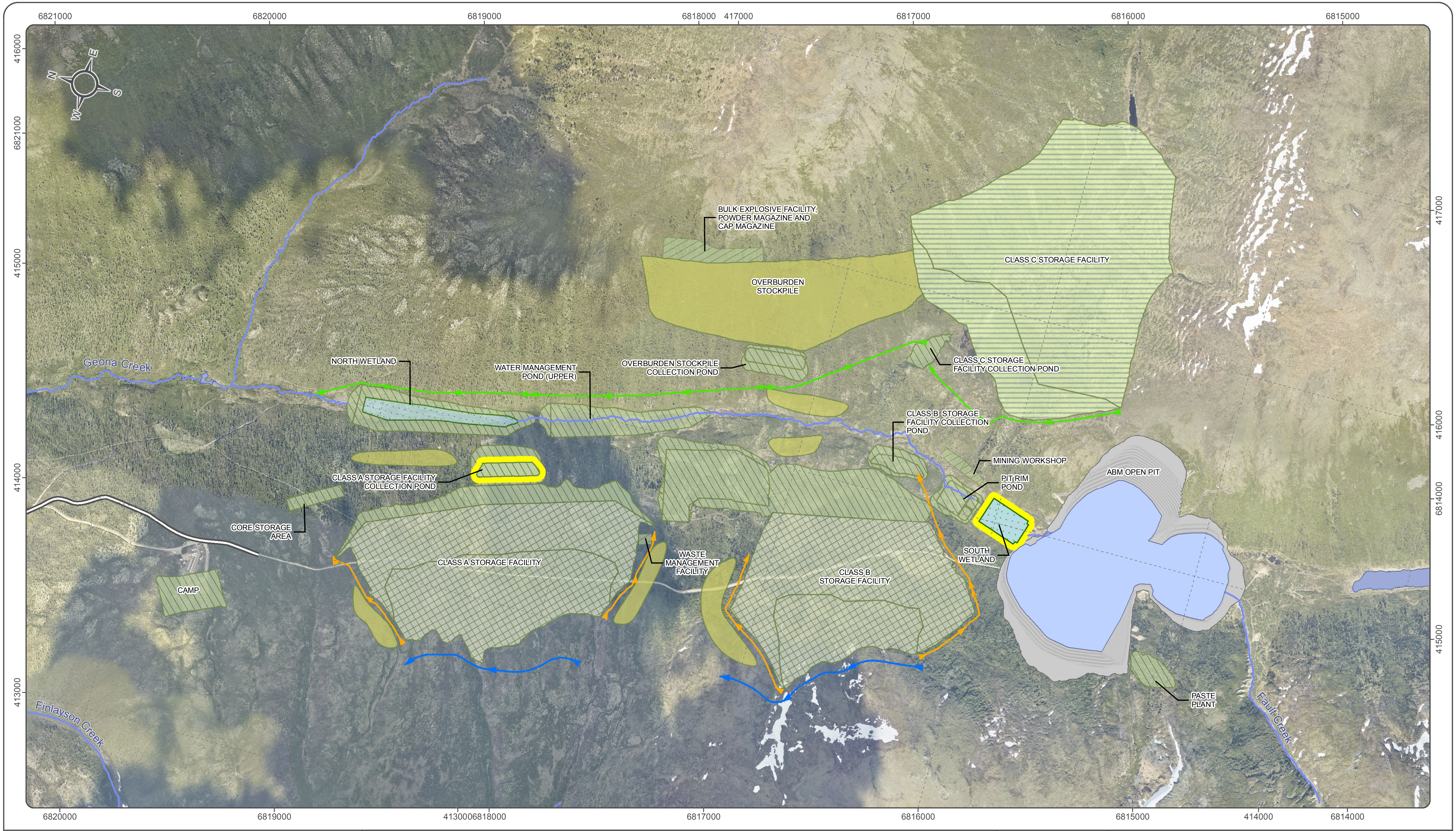

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AEG

- Closure Activities Occurring in This Closure Period
- Mine Footprint
- Materials used for Reclamation, Footprint Reclaimed and Revegetated
- Covered with Engineered Low Permeability Cover, Surface Revegetated
- Covered with Overburden, Surface Revegetated
- Constructed Wetland Treatment System
- Infrastructure Removed, Footprint Reclaimed and Revegetated
- Water/Pond
- ABM Open Pit Lakes at 1380 masl
- Tote Road/Proposed Access
- Non Contact Diversion
- Contact Class A & B
- Contact Class C Diversion

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KUDZ ZE KAYAH PROJECT
CONCEPTUAL RECLAMATION AND CLOSURE PLAN

FIGURE 8 - 4

GENERAL ARRANGEMENT IN POST-CLOSURE PERIOD (YEAR 27+)

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Table 8-1: Closure Schedule and Execution Strategy Summary

Development Period	Years (after Construction)	Site Conditions	Closure Activities
Mine Construction	-2 to -1	Construction of mine facilities and stripping of pit and waste facility footprints	• Removal and stockpiling of topsoil/overburden from ABM open pit and Waste Storage Facility footprints
Mining Operations	1 to 10	Active mining operations underway	• Continued removal and stockpiling of topsoil/overburden from Waste Storage Facility footprints • Construction of demonstration scale treatment wetland near Process Plant and water treatment plant • Progressive reclamation of Class A and Class B Waste Storage Facilities
Active Closure	11 to 13	Active mining operations completed	• Removal of pit equipment and infrastructure • Removal of underground infrastructure and equipment, and sealing of portals • Remove Fault Creek diversion, direct Fault Creek into ABM open pit, pit lime/carbon water treatment begins, active water treatment if/as required • Place waste covers • Decommission infrastructure and remove from site
Transition Closure	14 to 15	Pit filling	• LWMP Wetland constructed and commissioned – stabilization period • ABM Lake water treatment continues as required using lime and carbon sources; active water treatment if/as required • ABM open pit spillway constructed • Some roads decommissioned • Routine monitoring and maintenance
	16 to 26	Pit finishes filling	• Routine monitoring and maintenance • ABM Lake water treatment continues as required using lime and carbon sources; active water treatment if/as required • CWTS preparation for pit water • UWMP decommissioned following confirmation that storage facility covers and the CWTS are meeting performance criteria
Post-Closure	27 to 36	ABM Lake Outflow to Geona Creek	• Routine monitoring and maintenance • Active water treatment if/as required until closure water quality objectives achieved

9 RECLAMATION AND CLOSURE LIABILITY

Reclamation and closure liability was estimated for the Project in the form of a high-level estimate. The cost estimate assumes the use of third party contractors and equipment for implementation of major earthworks and terrestrial tasks.

Third party unit rates were established using a combination of published rates for Yukon contractors, as well as experience using local contractors. Personnel rates as well as other contractor rates and camp costs were adopted from those used on other local projects. Additionally, load, haul, dump rates for materials were also adapted from other local projects.

Using prefeasibility designs (KP, 2016a), and ArcGIS, disturbance areas were calculated for closure cost estimate purposes. Additionally, linear distances such as haul routes were also measured. Estimated quantities for earthworks such as regrading, scarifying, etc. were calculated from the measurements provided by ArcGIS. Similarly, quantities of required materials for covers were calculated based on the measured surface areas and assumed thicknesses. Quantities were then multiplied by appropriate unit rates for equipment, materials, and personnel to determine the estimated cost of remediation.

Water treatment costing was estimated based on a comparison to the average treatment costs at similar local projects. Active treatment costs were included for ten years and include both the treatment costs and a capital replacement cost. Passive treatment is included in the form of a capital cost for the construction of CWTS and maintenance of the CWTS into post-closure.

The annual costs for post-closure care, maintenance, and monitoring costs were estimated, and applied for 26 years of Closure. These costs included the monitoring programs as described in Section 7.11 as well as the cost of a pre-closure, and post-closure site environmental assessment. Additionally, instrumentation, vegetation maintenance, erosion maintenance, and transportation costs were included.

An overall rate of 15% was added to the cost of implementation and post-closure care, maintenance, and monitoring (PCCMM) to cover indirect costs such as insurance, taxes, and other administrative costs. Additionally, a contingency allowance of 20% was added to the total cost of closure implementation and PCCMM to account for uncertainties in the level of design to date.

This estimate should be considered preliminary, and will be further refined in accordance with the continual review and revision of the Plan required by the Quartz Mining Licence.

The total financial security, including contingency is estimated at CAD$ 90,500,000. The allocation of costs is shown in Table 9-1 below.

Table 9-1: Summary of Estimated Reclamation and Closure Liability

Cost Area	Estimated Cost	Typical Description of Costs
Closure Implementation		
General & Administration	$3,500,000	Onsite management, camp costs, transport, mob/demob, health & safety
Closure Planning	$2,244,000	Reclamation research, adaptive management planning, materials testing
Open Pits	$1,500,000	Equipment removal, access control, wall and crest stabilization, lime amendment
Waste Rock and Tailings	$37,000,000	Re-grading, cover placement, revegetation
Surface Facilities	$1,500,000	Building and concrete demolition, debris removal, chemical removal, soil excavation
Water Storage Ponds	$750,000	Removal of embankments, pumping of water, placement of rip-rap and soils, slope stabilization
Infrastructure	$500,000	Disconnection of services, removal of equipment, site clean-up, hauling of scrap
Waste Disposal / Remediation	$100,000	Preparation of facility closure plan, recontouring, placement and compaction of cover
Roads and Trails	$250,000	Recontouring, scarification, erosion barriers
Water and Solutions Management	$11,650,000	Reclaim site diversions, active treatment costs, passive treatment costs
Quarries and Borrow Pits	$50,000	Access control, resloping, scarification
Sediment and Erosion Control	$100,000	Erosion barriers, silt fencing, sediment ponds
Post-Closure Care Maintenance, and Monitoring Costs	$6,300,000	Monitoring programs, instrumentation, environmental assessments
Sub-total	$65,444,000	
Indirect Costs (%)	15%	
Indirect Costs	$9,816,600	Insurance, taxes, administrative costs
Total Closure Implementation Costs	$75,260,600	
Contingency Allowance	20%	
Contingency Amount	$15,052,120	Contingency due to uncertainty of current level of design
Approximate Total Financial Security (including Contingency) for environmental assessment purposes	$90,500,000	

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APPENDIX A

CONCEPTUAL COVER DESIGN REPORT

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ALEXCO ENVIRONMENTAL GROUP

CONCEPTUAL COVER DESIGN REPORT

KUDZ ZE KAYAH PROJECT

BMC-15-02-2970_042_CoversReport_RevC_170217

February 17, 2017

Prepared for:

BMC MINERALS

BMC MINERALS (NO.1) LTD.

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EXECUTIVE SUMMARY

The Conceptual Reclamation and Closure Plan (CRCP) is required for submission to the Yukon Environmental and Socio-Economic Assessment Board (YESAB). This report is a supporting document to that closure plan, specifically discussing the measures for reclamation and closure of the waste rock and tailings storage facilities. The overall objective for the waste rock and tailings storage facilities for the Kudz Ze Kayah (KZK) Project (the Project) is to have safe and stable facilities that have limited environmental impacts (particularly for water quality) and respect traditional land use.

This report presents the technical analysis of the covers for these facilities including a summary of the available borrow material types for the covers, an evaluation of geotechnical and geochemical characteristics of the locally available materials, a borrow material balance, and the conceptual cover designs for the Class A, B, and C Storage Facilities. The development of the conceptual cover designs was directed by operational decisions by BMC Minerals (No.1) Ltd. (BMC) so that waste storage facilities would be reclaimed with established technologies to ensure performance in the long term and reduce risk.

Key considerations for cover design are presented in Section 2 of this report, which includes descriptions of the proposed waste storage facilities, site climate, and permafrost. The three storage facilities are characterised as follows:

- Class A Storage Facility – A co-disposal facility for waste rock and filtered reactive tailings that are strongly Potentially Acid Generating (PAG) and requires a cover that reduces net percolation by 98%;
- Class B Storage Facility – A facility for weakly (PAG) waste rock and requires a cover that reduces net percolation by 75%; and
- Class C Storage Facility - A facility for non-Potentially Acid Generating (non-PAG) waste rock, which does not require a cover that reduces net percolation.

Geotechnical and geochemical characteristics of the potential cover materials are described in Section 3 of this report. The geotechnical characteristics of the cover materials were evaluated. The particle size distributions (PSDs) for available till were evaluated using a soil texture ternary diagram for erodibility, which indicates that the majority of till material on-site is suitable for moderate slopes without risk of substantial erosion. In terms of hydraulic conductivities, the till is insufficient to reduce the infiltration enough to achieve a very low permeability cover; however, these permeability rates are sufficient to achieve a low permeability layer combined with a store-and-release layer.

The geochemical characteristics of the potential cover materials were also evaluated. The available till is considered non-PAG and suitable for use for appropriate cover and construction applications. The Class C material is expected to be non-acid generating. Drainage from the Class C Storage Facility is expected to remain circumneutral to mildly alkaline during operations and post-closure, so specific acid rock drainage (ARD) mitigation measures are not required, considering these factors the Class C waste rock is suitable for use for cover construction.

The conceptual cover designs for the Class A, B, and C Storage facilities are described in Section 4 of this report. For the Class A Storage Facility a three-layer cover system is recommended. Within this multi-layer cover system one of the layers should have very low permeability, options for this include a geosynthetic liner material (e.g., HDPE), a geosynthetic clay liner (GCL), or a highly modified soil layer that could achieve the same reduction in net percolation as a liner. The term "liner" has increasingly been used in the industry to describe the material that, in this case, is used as part of a cover system. For the Class B Storage Facility an "enhanced store-and-release" type cover system is recommended to achieve a minimum of 75% reduction in net percolation. The Class C Storage Facility will contain waste rock that is non-PAG and has a low potential for metal leaching, will have a 0.3 m layer of growth media applied to encourage revegetation, as will the Class A and B facilities. All Storage Facilities will be reclaimed progressively during operations.

A preliminary investigation into the volume of borrow material required to construct the covers is presented in Section 5 of this report. The excavation of just the ABM open pit footprint during construction is expected to produce approximately 9 Mm^3 of till suitable for a compacted low permeability cover, which is significantly more than required. Similarly, the volume of Class C waste rock available from the excavation of the ABM open pit (approximately 32 Mm^3) is significantly more than required. Overall, the estimated available material is assumed to meet all of the requirements for the conceptual cover designs.

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Acronyms

ABA	Acid Base Accounting
AP	Acid Generating Potential
ARD/ML	Acid Rock Drainage and Metal Leaching
AWSC	Available Water Storage Curve
BMC	BMC Minerals (No.1) Ltd.
CA	Calcite
$CaCO_3$	Calcite
CL	Chlorite
COPI	Constituents of Potential Interest
CRCP	Conceptual Reclamation and Closure Plan
CWTS	Constructed Wetland Treatment System
EBA	Tetra Tech EBA Inc.
ET	Evapotranspiration
GCL	Geosynthetic Clay Liner
_H:_V	Height Length: Vertical Length Ratio
I	Infiltration
ICP-MS	Inductively coupled plasma mass spectrometry
K_{sat}	Saturated Hydraulic Conductivity
KP	Knight Piésold Ltd.
KZK	Kudz Ze Kayah
MAF	Mafic
masl	metres above sea level
mbgs	metres below ground surface
NP	Neutralization Potential
P	Precipitation
PAG	Potentially Acid Generating
PSD	Particle Size Distribution
Q	Flux
R	Run-off
SFE	Shake Flask Extraction

SWCC	Soil Water Characteristic Curve
SWE	Snow Water Equivalent
YESAB	Yukon Environmental and Socio-Economic Assessment Board

GLOSSARY

Acid Base Accounting (ABA): a screening procedure whereby the acid-neutralizing potential and acid-generating potential of rock samples are determined to estimate its potential to produce acid over time.

Acid Generating Potential (AP): total acid a material is capable of generating which is used in acid base accounting to estimate potential future acidic drainage.

Acid Rock Drainage (ARD): drainage with acidic pH from material having an insufficient capacity to neutralize acidic products of sulphide and elemental sulphur oxidation and dissolution products of acidic minerals.

Aqua regia: a mixture of 1 part nitric acid (HNO_3) to 3 parts hydrochloric acid (HCl).

Atterberg Limits: a measure of soil water contents that defines the shrinkage limit, the plastic limit, and the liquid limit of a fine grained soil. Fine grained soils exist in four states (solid, semi-solid, plastic, and liquid) depending on water content.

Borrow Material: geological material (i.e. soil, gravel) removed from one location and used as fill material in different location.

Hydraulic Conductivity (K): a soil property that describes how water moves through the pore spaces and/or fractures in soils and rocks. Saturated hydraulic conductivity (K_{sat}) describes water flow through soil pores that are completely filled with water.

Low permeability cover system: A cover system with properties that reduce the net percolation to 10 to 25% of mean annual precipitation, depending on closure objectives for the waste facility.

Potentially Acid Generating (PAG): Net-neutral material that is predicted to become net acidic over time assuming exposure to oxidizing weathering conditions and sufficient time for sulphide mineral oxidation to occur.

Soil Water Characteristic Curve (SWCC): a relationship between soil pore water content and suction, which produces a curve that can be used to describe unsaturated soil characteristics.

Thermistor: a resistor that measures change in electrical resistance when subjected to change in soil or rock temperatures.

Thermokarsts: terrain features that occurs when warmer surface temperatures start to melt the upper layers of ice-rich permafrost creating irregular mounds, hummocks, and depressions. These terrain features can also occur in response to anthropogenic activity, such as removing vegetation, changing drainage flow paths, and constructing roads.

Very low permeability: A cover system with properties that reduce the net percolation to 10% or less of mean annual precipitation, depending on closure objectives for the waste facility.

1 INTRODUCTION

For submission to the Yukon Environmental and Socio-Economic Assessment Board (YESAB) a Conceptual Reclamation and Closure Plan (CRCP) is required for the Kudz Ze Kayah (KZK) Project (the Project). A component of the KZK CRCP is the development of conceptual cover system designs for the reclamation of the storage facilities storing the Class A, B, and C materials. At this stage of the project, the designs are conceptual and based on the site test pit data described in the 2016 Geotechnical Site Investigation Data Report (Knight Piésold Ltd. (KP), 2016a) and the Prefeasibility Design Report, Kudz Ze Kayah Project (KP, 2016b). The next stage of design work will require more detailed testing and site specific data collection.

This report provides a review of the key assumptions made in conducting conceptual cover designs, a review of available borrow material types and volumes, estimated ranges for net percolation through the different conceptual cover systems, and ultimately provides conceptual cover designs for the Class A and B Storage Facilities. The geochemical characterization of the waste materials is discussed in the report Acid Rock Drainage and Metal Leaching Characteristics of Material from the Kudz Ze Kayah Project, Yukon (Alexco Environmental Group Inc. (AEG) (AEG, 2017c). The design of the facilities for operations are provided in the Prefeasibility Design Report, Kudz Ze Kayah Project (KP, 2016b), the Kudz Ze Kayah Pre-Feasibility Study – Class A Storage Facility Stability Assessment (KP, 2017a), and Kudz Ze Kayah Pre-Feasibility Study – Design of Class B and C Storage Facilities and Overburden Stockpile (KP, 2017b), and governs the required performance of the reclamation and closure measures for these facilities.

1.1 BACKGROUND

The development and mining for the Project will require three facilities to handle the waste materials produced from the ABM open pit. Waste rock will be segregated to minimize the generation of "contaminated" drainage and therefore to minimize short-term and long-term water treatment requirements:

- Class A Storage Facility – A co-disposal facility for strongly PAG waste rock and filtered reactive tailings. Note the term "strongly PAG" includes consideration of both acid generating and metal leaching characteristics;
- Class B Storage Facility – A facility for weakly PAG waste rock; and
- Class C Storage Facility - A facility for non-PAG waste rock.

The Class A Storage Facility will be constructed, and strongly PAG waste deposited, such that the facility has a maximum overall slope of 4H:1V to ensure long term stability. Based on the site water balance, water quality modelling and geochemical characterization of the waste rock and tailings, the Class A Storage Facility requires a very low permeability cover (e.g., geosynthetic or other multi-layer cover) to reduce the flux of water through the facility and the transport of dissolved metals and oxidation products to the receiving environment. There are several alternatives for this very low permeability cover, ranging from a multi-layer cover with a geosynthetic or geosynthetic clay liner (GCL) to a modified multi-layer soil cover.

The Class B Storage Facility will be constructed, and waste deposited, such that it has an overall slope of 3H:1V to ensure long term stability. This facility contains weakly PAG waste rock, which will require a low permeability cover that decreases net percolation into the facility to reduce potential loading to the environment.

The Class C Storage Facility will contain waste rock that is non-PAG and has a low potential for metal leaching, this category of waste rock will be suitable for construction material for use around the Project site. This Storage Facility will store Class C material not used for construction and will be progressively reclaimed to support establishment of vegetation.

1.2 SCOPE OF WORK

The scope of this report is to provide a review of available material types, an evaluation of geotechnical and geochemical characteristics of the locally available materials, a borrow material balance, and conceptual cover designs for the Class A, B, and C Storage Facilities. Each waste storage facility (A, B, and C) requires a different cover design due to the required cover performance (ingress of water), the final configuration of the facility at the end of operation, and the associated risks. The objective is to use the preliminary material characterization to create appropriate conceptual cover designs for reclamation and closure of the Project to meet net percolation targets for each of the facilities. Additionally, recommendations have been developed for identifying areas that will require further testing to confirm the performance of the conceptual design.

At closure, the overall objective for the waste rock and tailings facilities for the Project is to have safe and stable facilities that have limited environmental impacts (particularly for water quality) and respect traditional land use. The development of the conceptual cover designs was directed by operational decisions by BMC with the criteria that waste rock storage facilities would be reclaimed progressively with known technology to ensure acceptable performance in the long term and reduce risk. It is understood that the Class A Storage Facility will require control of drainage in perpetuity due to the ARD/ML materials being stored, as such a very low permeability cover is required, with a design requirement to meet a net percolation of less than 2%. The Class B Storage Facility will also require drainage control in perpetuity, but with a net percolation design requirement of 25%, since the material being covered is weakly PAG. Another assumption for the conceptual cover designs was that landform design and slopes were set by KP, as described in the Prefeasibility Design Report (2016b) to ensure long-term geotechnical stability. The conceptual design presented herein meets these design specifications and the closure objectives specified by BMC Minerals (No.1) Ltd. (BMC).

2 DESIGN BASIS

The covers presented in this report were designed based on the information detailed in the following subsections.

2.1 PHYSICAL DESIGN FOR THE FACILITIES

The physical characteristics of the waste storage facilities, such as elevation, aspect, and slope, play an important role in the design and effectiveness of the covers. The slope aspect and elevation of a waste rock storage area will influence evapotranspiration potential of a cover system as well as the available water storage capacity (AWSC). Southern and westerly slopes (facing toward 135° to 285°) would have warm aspects and northerly and easterly slopes (facing toward 285° to 135°) would have cool aspects. Slope plays a key role in erodibility but also directly affects net percolation through the amount of run-off expected (Straker et al, 2015).

The key characteristics and landform design of each facility for closure cover design are provided in the Prefeasibility Design Report and update letters (KP, 2016b; KP, 2017a; KP, 2017b) and summarized in Table 2-1 below. The proposed Class A Storage Facility is on the western Geona Creek valley slope, with the majority of the slope facing northeast. The facility will have an overall grade of 4H:1V with a crest elevation at 1,495 masl (metres above sea level). The facility foundation will be graded to convey flow via a French drain system into a collection pond at the base of the Class A Storage Facility. The proposed Class B Storage Facility is also on the western Geona Creek valley slope, with the majority of the waste rock slope facing east. The Class B Storage Facility will have an overall grade of 3H:1V with a crest elevation at 1,565 masl. The Class B Storage Facility foundation will be graded to convey flow via a French drain system into a collection pond at the base of the Class B Storage Facility. The proposed Class C Storage Facility is on the eastern Geona Creek valley slope, with the majority of the waste rock slope facing west. The Class C Storage Facility will have an overall grade of 3H:1V with a crest elevation at 1,530 masl.

A summary table of the relevant storage facility characteristics for each facility are summarized in Table 2-1 below:

Table 2-1: Storage Facility Physical Characteristics

Parameter	Class A Storage Facility	Class B Storage Facility	Class C Storage Facility
Elevation (masl)	1,400-1,495	1,425-1,570	1,450-1,530
Aspect	Northeast	East	West
Final Surface Area (m^2)	741,858	700,478	1,255,000
Overall Slope	4H:1V	3H:1V	3H:1V
Bench Height (m)	n/a	15	15
Available storage volume (Mm^3)	15	25	34

2.2 GEOCHEMICAL CLASSIFICATIONS AND WASTE ROCK MANAGEMENT PLAN

Geochemical characterization of potential cover materials was completed and is described in this section. Characterization of the underlying waste and tailings was also completed and discussed in the Acid Rock Drainage and Metal Leaching Characteristics of Material from the KZK Project (AEG, 2017c). Overburden samples were collected as part of KP's geotechnical program in May 2016, including sampling from the footprint of the ABM deposit overburden and the overburden at the proposed locations of the storage facilities. Sixteen samples were selected from these locations and sent for acid base accounting (ABA) and aqua regia ICP-MS multi-element analysis. Shake flask extraction (SFE) testing was also performed on a subset of eight overburden samples. All the samples returned neutral to slightly alkaline paste pH (7.3 to 8.6) and contained negligible sulphur (typically below detection <0.01 wt.%). The NP was also generally low, but measurable, with the majority of samples in the 4.0 to 13 kg $CaCO_3$/t range, suggesting that that acid generation is considered unlikely.

Overburden samples collected from the ABM open pit area tended to have higher lead, cadmium, and zinc concentrations compared to overburden samples collected from other areas of the Project. SFE testing of these samples also showed slightly higher soluble metal levels than overburden samples collected from the ABM open pit; however, the leachable metal concentrations were generally not considered high enough to cause any significant impact to the water quality of the downstream receiving environment. Copper concentrations in SFE leachate from the ABM overburden were also slightly elevated relative to the preliminary water quality objectives. These copper concentrations showed no geographic trend and are likely mobilized by dissolved organic carbon, which would ameliorate some of the copper toxicity to fish.

Acid base account testing shows that the overburden is non-PAG and suitable for use for appropriate cover and construction applications. A more detailed discussion of the geochemical properties of the overburden material can be found in Acid Rock Drainage and Metal Leaching Characteristics of Material from the KZK Project (AEG, 2017c).

Geochemical testing developed classification criteria that categorized waste rock according to its potential for acid generation and trace element leaching (AEG, 2017c). Three classes of material were identified:

Class A is strongly PAG material with an associated high potential for metal leaching. Waste rock with a total sulphur content greater than 2.9 wt.% or a NP less than 10 kg $CaCO_3$/t were placed in this category. Drainage from this storage facility requires management and treatment during operations and closure;

Class B is mildly PAG with a more moderate potential for metal leaching. Following satisfaction of the Class A criteria, waste rock is Class B if it has an NP/AP ratio that is less than 1.9. All of the calcite(CA)-chlorite(CL) mafic (MAF) (CA CL MAF) material that would otherwise be assigned to Class C is identified as Class B due to its tendency to leach arsenic at elevated concentrations. Drainage from this storage facility is expected to become acidic in the long term, but unlikely during operations. Trace element leaching from this waste rock may require management and treatment as needed during operations; and

Class C is non-PAG and has a relatively low potential for metal leaching. Waste rock with an NP/AP ratio greater than 1.9 is placed in this class (apart from CA CL MAF). Drainage from this storage facility is expected to remain circumneutral and is not anticipated to require treatment during operations or post-closure.

Given the non-acid generating nature of Class C waste rock and its limited potential for sustained metal leaching, it is geochemically suitable for use as a construction material.

2.3 MATERIALS AVAILABLE ON-SITE

Fifty-three test pits were excavated by KP in the footprint of the proposed Class A and B Storage Facility Areas, Process Plant Facility Area, ABM Open Pit Area (from both ABM and Krakatoa zones), and in the Fault Creek Diversion Area (KP, 2016a). Test pit depths ranged from 1.3 to 5.1 metres below ground surface (mbgs) and were typically terminated due to bedrock or wall instability from groundwater. Particle size distribution (PSD) curves were analysed for select samples that represent the typical overburden materials available across the site.

Four main materials have been identified to be used as covers for the Class A, B, and C waste material: a compactable low permeable till, a bedding material, a frost protection material, and a growth media material. A description of the known geotechnical characteristics and their suitability as cover material is described in the following subsections.

2.3.1 Compactible Till Material

Particle size distribution (PSD) data was available for till from seven construction sites: Fault Creek, ABM Open Pit (from both ABM and Krakatoa Zones), Class A Storage Facility, Class B Storage Facility and Process Plant Facility as well as samples that represent the topsoil available. Summary statistics for the PSDs, and estimated hydraulic conductivities are presented in Table 2-2. For the conceptual design the hydraulic conductivities (K_{sat}) have been estimated using a soils database to compare PSD data from the test pits with other soils. For future design work it is recommended site specific values be determined through material testing.

Borrow materials from the areas of the proposed ABM Open Pit (ABM and Krakatoa zones) and the Class A and Class B Storage Facilities sites were compared to the soil database since physical characteristics (particle size distributions had higher fines contents) and material volume estimates appear suitable for cover construction. Minimizing the hydraulic conductivity is a key aspect for designing a low net percolation cover.

The result of this assessment is that there is till onsite that would be an effective compacted layer in a low permeability cover system, but that this material cannot meet the hydraulic conductivity to make a suitable very low permeability layer. Industry experience in the North indicates that an appropriate K_{sat} of a low infiltration cover is around $1x10^{-8}$ m/s (SRK, 2013). In general, the estimated K_{sat} values from the database tended to be higher than this threshold value. At a mean annual precipitation of 612 mm (1.9×10^{-8} m/s) a 98% reduction is 12 mm (or 3.9×10^{-10} m/s) of infiltration through the cover, and a 75% reduction is 150 mm (or 4.9×10^{-9} m/s). The lowest permeabilities estimated for the till on site range between $3.0x10^{-9}$ and $2.8x10^{-6}$ m/s, with an average of $9.1x10^{-7}$ m/s, which is insufficient to reduce the necessary precipitation to achieve a very low permeability cover. Additionally, it has been found that it is not realistic to expect compacted till covers to have saturated hydraulic conductivities of less than 10^{-7} m/s (SRK, 2013). However, the values presented are conservative as the covers will not be saturated and will be on a slope to encourage run-off, increasing performance.

Table 2-2: Site Particle Size Distribution Summary

Material Type	Estimated k_{sat} Range based on PSDs Minimum – Maximum (Average) (m/s)	Particle Size Distributions Minimum – Maximum (Average)		
		% Coarse (>4.75 mm)	% Sand (4.75 – 0.075 mm)	% Fines (<0.075 mm)
Fault Creek	-	38 - 54 (45)	36 - 44 (40)	10 - 21 (15)
ABM Zone of ABM Open Pit	$3x10^{-9}$ - $2.8x10^{-6}$ ($9.1x10^{-7}$)	15 - 43 (23)	25 - 51 (39)	17 - 59 (38)
Class A Storage Facility	$3.3x10^{-8}$ – $9.1x10^{-5}$ ($1.2x10^{-5}$)	14 - 48 (28)	38 - 56 (44)	13 - 41 (28)
Class B Storage Facility	$3x10^{-9}$ – $9x10^{-6}$ ($2.1x10^{-6}$)	12 - 35 (22)	36 - 48 (41)	24 - 50 (38)
Class C Storage Facility*	-	0 - 41 (18)	19 - 62 (44)	19 - 77 (38)
Mill Site	-	22 - 27 (24)	40 - 50 (44)	27 - 38 (32)
Krakatoa Zone of ABM Open Pit	$4.3x10^{-6}$ – $2.8x10^{-5}$ ($1.6x10^{-5}$)	12 - 46 (32)	34 - 67 (49)	7 - 29 (19)
Topsoil Stockpile	-	21 - 24 (23)	36 - 41 (38)	38 - 41 (40)
KZK Overall	-	0 - 54 (25)	20 - 67 (41)	7 - 77 (33)

*No test pits available at this site; PSD data is from overburden samples in drill holes

Erosion

The till material has been plotted in a ternary diagram shown in Figure 2-1. The purpose of this diagram is to provide a high level assessment for determining the erosive potential of particular borrow material and its suitability for placement on different slope angles. Assuming the silt fraction of the cover material falls below 40%, the material can be used on some slopes (high silt content soils tend to erode readily). In this diagram mild slopes have angles shallower than 3H:1V. Based on the test pit data collected at KZK, the majority of the material is best suited for slopes no steeper than 3H:1V.

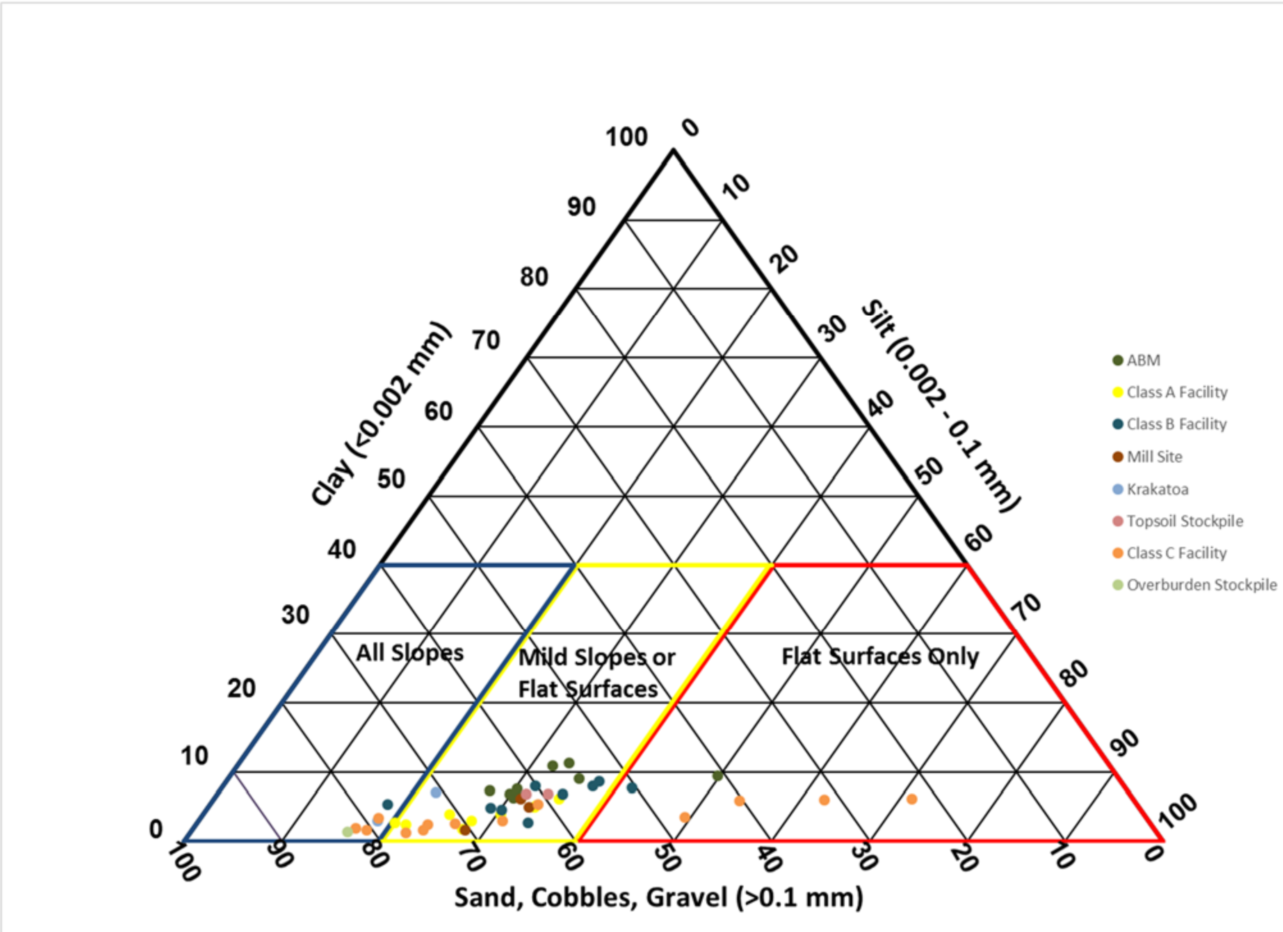


Figure 2-1: Soil Texture Ternary Diagram of Cover Material from KZK

Based on this general overview, the material most suited for constructing a compactible layer is the till from the footprint of the proposed ABM open pit, Class A Storage Facility and Class B Storage Facility material.

Class A Facility Overburden Characteristics

The proposed Class A Storage Facility footprint overburden is a till with an average fines content of less than 30%, and a sands content of 44%. This material is too sandy to be compacted to a low permeability layer for a cover but would be suitable to use as a protection layer against traffic during construction. Table 2-2 summarizes the range in fines and coarse fractions for this material and Figure 2-2 provides the PSD curves for the Class A Storage Facility area test pit samples.

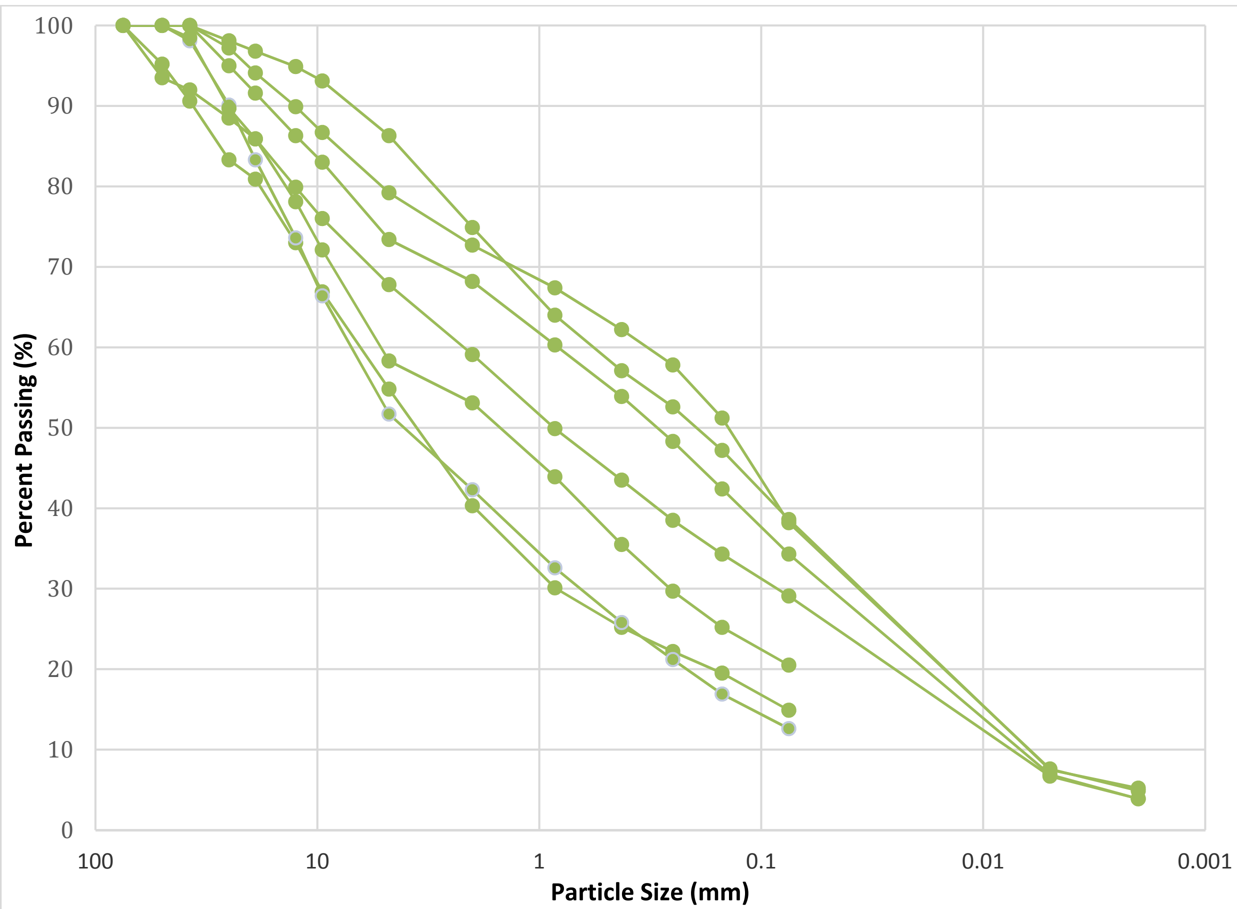


Figure 2-2: Class A Storage Facility Area Overburden Material Particle Size Distribution

Class B Storage Facility Overburden Characteristics

The material available from the footprint of the proposed Class B Storage Facility contains a till with average fines of greater than 35%, with a range of 24% to 50% fines, as shown on Table 2-2 and Figure 2-3. This material would be suitable for a compacted low permeability layer.

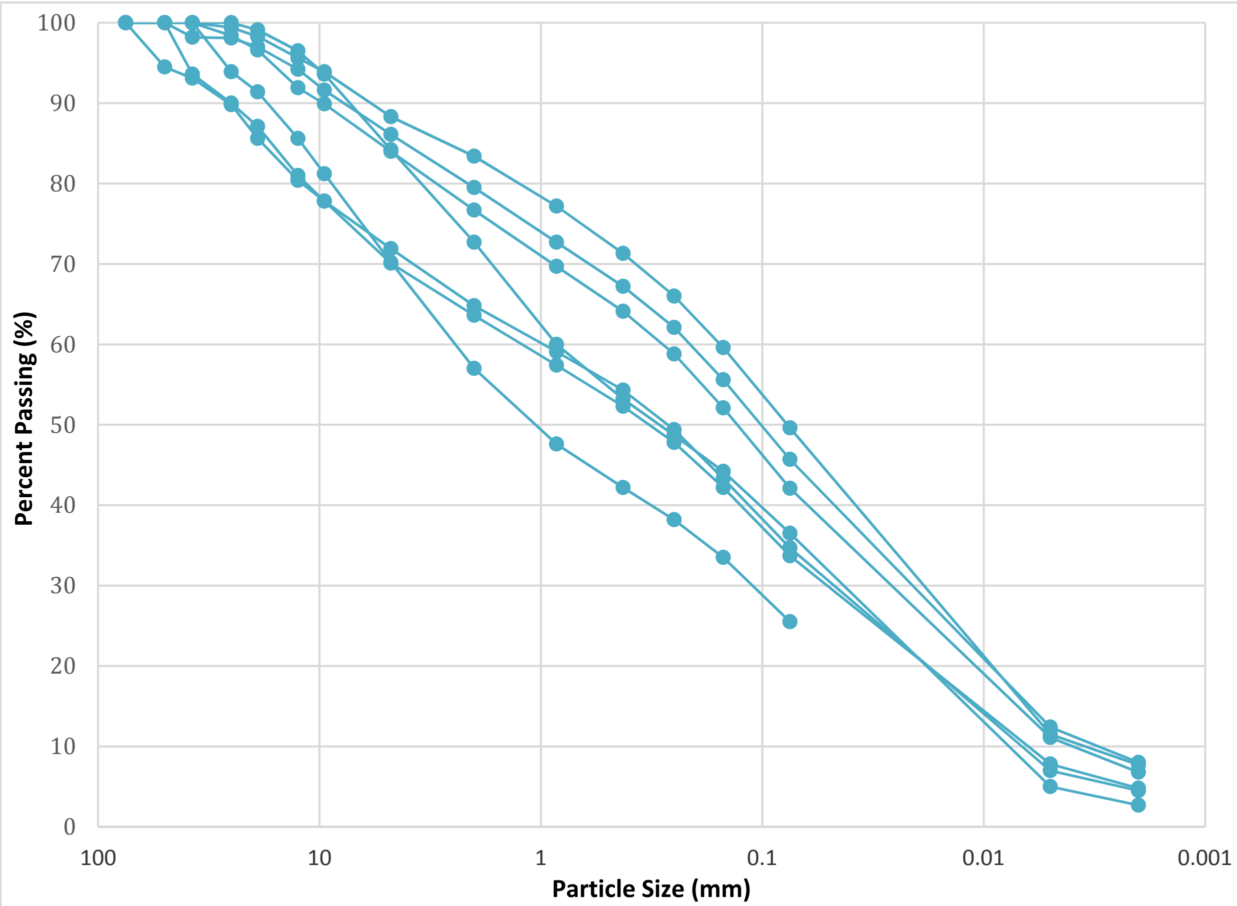


Figure 2-3: Class B Storage Facility Area Overburden Material Particle Size Distribution

ABM Open Pit Overburden Characteristics

The ABM zone area test pit samples indicate a till with a fines content ranging from 17 to 59%, with an average of 38%. The three Krakatoa zone area samples have a much lower fines content of 7 to 29%, with an average of 19%, as shown on Table 2-2, and on Figure 2-4. The Krakatoa zone area till would not be suitable as a compacted low permeability layer, but the ABM zone area till is a suitable material to construct a compacted low permeability layer based on its higher fines content.

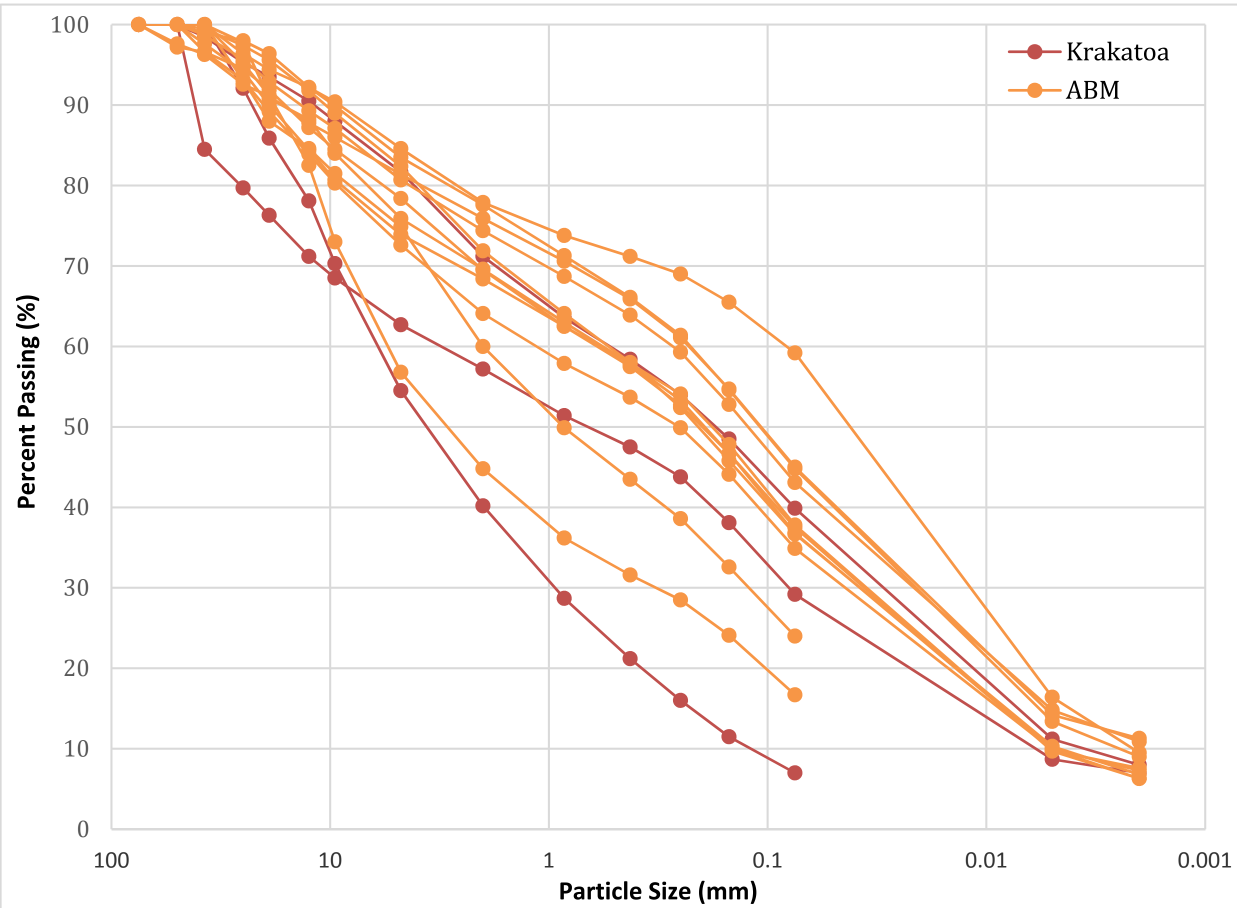


Figure 2-4: ABM Open Pit Area Material Particle Size Distribution

2.3.2 Bedding Material

A protective layer of material above and below the very low permeability layer has been included in the design to protect this material from damage during construction due to heavy equipment or from waste rock. There is a range of material on site that could be suitable for this protective layer, however it would need to be screened to ensure there are no large or sharp cobble/boulders. Suitable material identified in the previous section includes the salvaged till from the Class A Storage Facility and the Krakatoa zone of the ABM Open Pit.

2.3.3 Frost Protection Material

Based on available site information and on experience with other mine sites in similar climates, a low permeability compacted cover layer would require a cap to protect it from seasonal freeze/thaw cycles. The frost penetration depth is dependent on soil porosity, water content, and bulk density. The low permeability layer should not be in the "thermal active zone" as hydraulic conductivities can increase significantly in the first five years of cover life due to this activity (MEND, 2012). Industry experience and initial calculations by the Knights Piésold design engineers indicate the thickness required is a minimum of 3.0 m (KP, 2016b). This will be finalized for the detailed design. Waste rock is suitable for this frost protection layer; geochemically stable waste rock from the Class C Storage Facility and available overburden will be used.

KP has produced estimates of the upper and lower ranges in grain size. The estimated coarse limit of the Class C waste rock is 60 mm to greater than 800 mm (cobble and boulder) and the fine limit is 0.50 mm to 100 mm (primarily gravel with coarse sand) (KP, 2016b). Particle size distributions will be determined for the next level of design. These are important as they determine the stability of the frost protection layer, as well as the hydraulic properties.

2.3.4 Growth Media Material

As described in the Prefeasibility Design Report (KP, 2016b), all topsoil will be salvaged from the construction footprints and stored beside the facilities to be used during progressive reclamation. Test pitting indicates that the average topsoil thickness is approximately 0.2 m thick with localized areas increasing to 0.5 m. This soil, shrub, and woody debris topsoil material will likely be mixed with underlying till during stripping due to l equipment and operator limitations. Therefore, this blend of material is referred to as "growth media".

Ideally, the growth media material will be a combination of topsoil and till with a fines content (i.e., material finer than 0.075 mm) that does not exceed 30%. Any material with fines greater that 30% could be susceptible to higher rates of erosion and frost action, both of which could affect revegetation success and lead to higher rates of net percolation.

Soil characterization from 2015 and 2016 baseline studies (AEG, 2016b) showed that existing topsoil in the Project area are generally low in nutrient availability. Additionally, when soil is stripped during construction and stockpiled for use in reclamation the soil loses its structure, nutrients, and microbial communities, seeds in the soil lose their viability, and anaerobic conditions form that degrade the soil further (Strohmayer, 1999). Total nitrogen, phosphorus, potassium (NPK), and sulphur were analyzed for 12 soil samples taken in or around the proposed feature disturbance area. Analysis results showed 11 samples below the detection limit for nitrogen and 8 samples below the detection limits for sulphur. The average pH was 5.6 and cation exchange capacity was 23.3 for the samples analyzed. Samples were tested for percentage of sand, silt, and clay (averaging 68%, 27%, and 5%, respectively) with described texture ranging from loamy sand to silt loam. This is consistent with the samples analysed for grain size by KP in 2016.

Research reclamation trials on vegetation will include the assessment and classification of materials suitable for use in revegetation. Particle size and nutrient availability are key characteristics that will be evaluated for final design to determine the suitability of material for revegetation (AEG, 2017a). Trials will provide insight on the viability of the growth media material and the potential need for additional amendments.

2.4 ENVIRONMENTAL IMPACTS AND POTENTIAL MITIGATION

2.4.1 Site Climate

The hydrometeorological character of the Project is described through analysis of regional data in relation to those data collected on site. A more detailed discussion of the climate and meteorological data for the site can be found in Hydrometeorology Baseline Report, Kudz Ze Kayah Project (AEG, 2016a).

The Project is located in the eastern Yukon, on the Yukon plateau, and is characterized by cold dry winters and wetter summers. The mean annual temperature recorded at the KZK site for the period September 2015 to August 2016 was -0.5°C and extremes ranged from -26 to 20°C. When comparing to both long term regional averages and to regional data for the same period, the single season 2015-2016 record at KZK generally shows warmer winter temperatures (October to April), cooler summer temperatures (May to September), and reduced diurnal range.

Total precipitation measured at KZK site for the period September 1, 2015 to August 31, 2016 was 343 mm. Using the concurrent regional data and comparing to long term records, mean annual precipitation is estimated to be 616 mm at the KZK meteorology station. Mean annual precipitation varies by 9 mm per 100 m of elevation change and the receiving environment water balance completed by AEG used 612 mm for upper Geona Creek (AEG, 2017d). The estimated natural ground run-off coefficient is 0.73. When compared to long-term regional annual means, the 2015-2016 data collected at KZK generally shows lower total amounts than at most regional stations studied, except for Ross River and Faro which have lower long-term averages. When compared to regional data for the same period, KZK has a higher annual precipitation than both Faro and Watson Lake, but the difference does not account for the expected amount associated with the elevation difference between the stations. However, regional data are sparse and do not cover a wide range of elevation. The data suggest that the site receives less precipitation than would be expected based on the elevation. Other factors, such as the geographic position on the northeast side of the Pelly Mountains, likely play a greater role in determining the precipitation received on site.

Snow surveys conducted at KZK in January, February, and March 2016 seem to indicate lower snow water equivalent (SWE) values than at regional stations, although sampling was not carried out at the same time of year. Similarly, the 2016 snow survey data at KZK generally indicates a lower snow year when compared to the 1995 site snow survey results. The calculated percent snowmelt distribution for the site is: 5% April, 65% May, 10% June, and 20% July.

Winds at the KZK site blow predominantly from the northwest to northeast quadrant, and maximum wind speeds are relatively high. Pan evaporation measurements and evapotranspiration calculations at KZK for the 2015-2016 period are generally consistent with 1995 measurements and estimates. The 2016 site evaporation pan results yield evapotranspiration (ET) results that are very similar to the ET values obtained with the Penman-Monteith equation, such that the average annual evaporation for the site is estimated to be 304 mm.

2.4.2 Permafrost

The Project is located in a discontinuous permafrost zone. Permafrost is generally present above 1,400 masl on the northern and western facing valley slopes, but was noted at 1,250 masl (Cominco, 1996). On eastern facing walls and in the proposed open pit area permafrost was generally absent. Work conducted by Tetra Tech EBA Inc. (EBA) suggests that permafrost across the KZK site is largely warm permafrost with temperatures just below 0°C and therefore easily disturbed (EBA, 2016).

Thermistors were installed by EBA in 2015 and KP in 2016. Initial data suggest that permafrost is absent from all of the thermistor locations, although not all of the thermistors had enough time to equilibrate to natural ground conditions. Drill hole K16-410, supervised by KP in summer 2016, found frozen soil and ice in the samples at approximately 1.5 and 5.0 m depths. This Class C Facility drill hole had only one day of thermistor data at the time KP published their report, but thermistor data was suggesting a colder subsurface layer where the samples were collected (KP, 2016b).

A monitoring well installed by KP in the design footprint of the proposed Class A Storage Facility, MW16-13, was found to be frozen 6 mbgs soon after installation. Other thermistors installed in the Class A facility are at a much lower elevation and none indicated the presence of permafrost (KP, 2016b).

Preliminary thermistor data collected by EBA to characterise permafrost across the site suggests seasonal frost in the top five meters. Additionally, information from drilling, test pitting, and knowledge of similar sites across the Yukon it is very likely to be in the top 3 m. Further work will be undertaken in the detailed design phase to confirm depths of the freeze/thaw active layer so that a sufficient protective layer can be designed for the low permeable covers.

2.4.3 Other Considerations

Vegetating the surface of the covers will provide the benefit of increased evapotranspiration, as well as resistance to erosion; however, due to the climatic conditions, the growing period is very limited and vegetation will not mature quickly. Additionally, spring freshet will result in site specific challenges with erosional stability. Relying on vegetation in the short term to provide this stability is not recommended. Erosion and damage to the cover can be mitigated through landform design (conducted by KP (2017b) and through progressive reclamation and active revegetation during operations.

2.5 WATER BALANCE AND WATER QUALITY MODELLING

The water balance through the cover systems is driven by precipitation, which includes all meteoric water as rain and snowpack. Precipitation (P) is the only source of water into the cover system, as all non-contact run-on will be re-directed with diversion channels around the covered waste storage facilities. The water can leave the cover systems in three ways:

- Evapotranspiration (ET), which includes sublimation;
- Run-off (R), which includes surface run-off and interflow run-off within the more porous upper cover layers; and
- Net percolation, which is the amount of meteoric water that infiltrates through the cover layers into the waste rock (and tailings).

This mean annual simplified water balance is described as the following formula:

Net Percolation = $P - R - ET$

Net percolation directly relates to the amount of storage in the waste rock and the amount of contact seepage leaving the storage facility. At this level of assessment, the water balance (ΔS) does not account for water storage within the cover system, as this is an optimization for a later stage once more site specific information has been obtained. Additionally, the water balance does not account for the change in run-off due to the freeze/thaw layer during spring, which would prevent further water from infiltrating due to the discontinuous ice in the frost protection layer of the cover systems.

The simplified water balance describes the mean annual conditions. Also considered in the design are seasonal mechanisms that can change the water balance in the short term. At KZK there are three main seasons during the frost free period: Freshet (late April to May), Summer (June and July), and Fall (August and September).

Freshet is characterised by the following mechanisms:

- Precipitation is a combination of rain and the snowpack that has accumulated over the winter, generally peaking in April. During the winter, wind erosion will move some of the snow off the top of the storage facilities;
- Evapotranspiration is primarily driven by sublimation due to long daylight hours. Evaporation and transpiration are not as large contributors as there is minimal vegetation; and
- Run-off may be increased by the freeze/thaw zone that may have a discontinuous frozen zone acting as a barrier. There is potential for this layer to be a continuous frozen zone if the material used in the frost protection layer contains sufficient fines. The effect of this frozen layer will progressively decrease throughout the spring as it melts.

Summer is characterised by the following mechanisms:

- Precipitation is generally low during the summer, reducing the infiltration; and

- Evapotranspiration is now primarily driven by evaporation and transpiration as there is significant daylight and vegetation is at its peak.

Fall is characterised by the following mechanisms:

- Precipitation falls as snow and rain, saturating the cover layers;
- Evapotranspiration is not a significant aspect of the water balance as vegetation is going dormant and daylight hours are getting shorter; and
- Infiltration increases as cover layers become saturated and ET is reduced.

The relationship between net percolation and the complexity of cover system design is highlighted in Figure 2-5.

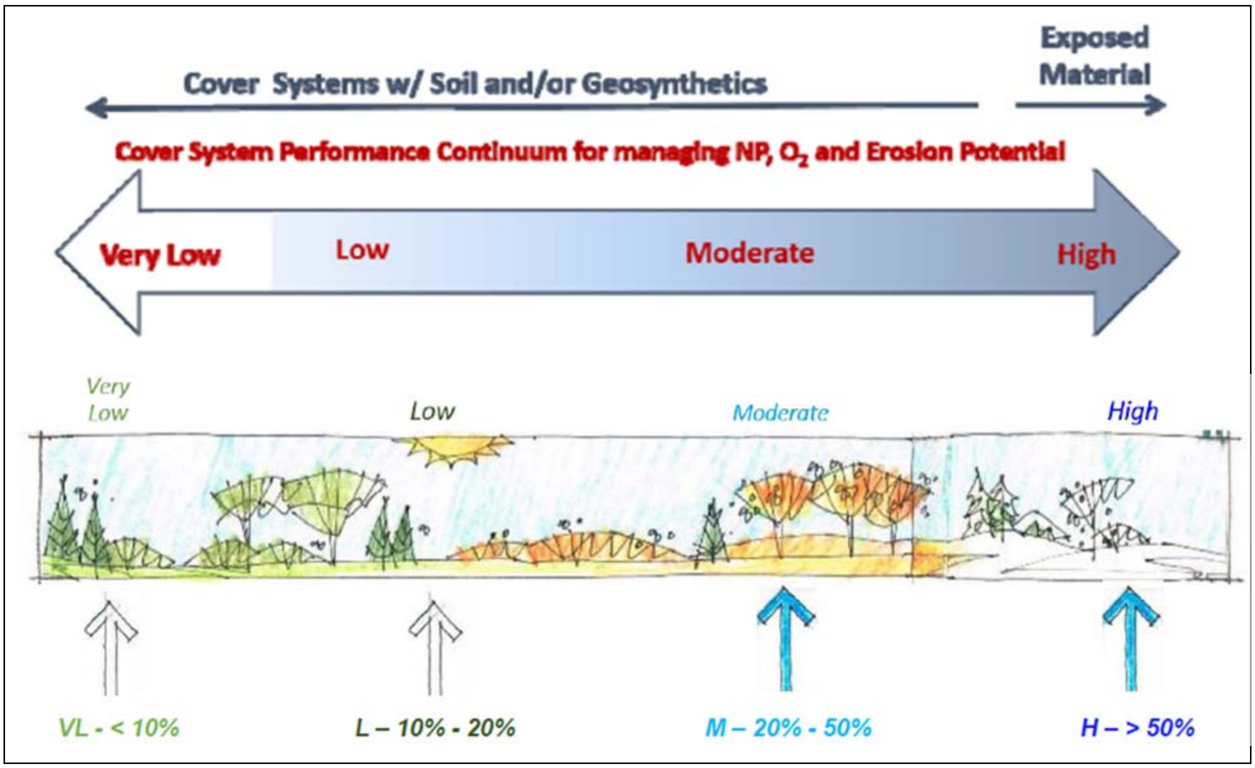


Figure 2-5: Relationship of Net Percolation and Cover Design (O'Kane, 2014 & O'Kane, 2016)

Water Quality modelling of the seepage water quality is discussed in the Kudz Ze Kayah Water Quality Model Report (AEG, 2017b) and in Section 7.6 of the Conceptual Reclamation and Closure Report (AEG, 2017a).

2.6 CLASS A STORAGE FACILITY COVER

The proposed Class A Storage Facility requires the most robust cover system as the material contained in this facility is strongly reactive (PAG and metal leaching). To achieve closure water quality objectives, the KZK Project Water Quality Model Report (AEG, 2017b), indicates that a reduction in net percolation to 2% of the mean annual precipitation (i.e., 98% of mean annual precipitation must be redirected) is required for this facility. To achieve such a low net percolation a very low permeability multi-layer cover is required for this facility. Even with such a significant reduction in net percolation the water quality model indicates that there will be residual loading that would not meet water quality objectives downstream. A constructed wetland treatment system (CWTS) downstream is required to manage residual metal loading (AEG, 2017b). This is discussed further in section 7.6 in the Conceptual Reclamation and Closure Plan (AEG, 2017a).

Industry experience in waste rock closure has shown that some form of multi-layer cover is required to achieve this level of infiltration reduction. This would include a very low permeability layer such as a geosynthetic liner material (e.g., HDPE), a geosynthetic clay liner (GCL), or a highly modified soil layer that will achieve the same reduction in net percolation as the liners. The term "liner" has increasingly been used in the industry to describe the material which, in this case, is used as part of a cover system. As such a multi-layer three-layer cover system is recommended that includes a very low permeability layer.

The specific design that has been evaluated for this conceptual closure plan includes three layers: a very low permeability layer overlain by a minimum of 3.0 m of Class C material waste rock for frost protection, and 0.3 m of growth media to support revegetation. The very low permeability layer may require protection from waste rock and construction traffic depending on the type of layer selected. In the cases of GCL and geosynthetic liners a 0.20 m till layer on either side will provide protection. Additionally, the very low permeability layer will be keyed into the bedding layer beneath the tailings and waste rock. This cover will be installed progressively as the Class A Storage Facility is constructed during operations. A summary of the Class A cover system is provided in Table 2-3.

Table 2-3: Class A Storage Facility Conceptual Cover

Cover Layer	Material Type	Thickness (m)	Approx. Volume (m^3)
Growth media	Top soil/Overburden Blend	0.3	222,600
Frost protection	Class C Waste Rock	3.0	2,487,400
Very low permeability layer	TBD	Dependant on type of layer selected	Dependant on type of layer selected
Bedding layer around liner	Overburden	0.4	313,200

With the addition of a very low permeability layer within the multi-layer cover system on the Class A Storage Facility the short term net percolation is predicted to range from as low as 0.1% to 2%. To maintain a net percolation rate below 2% in the long term, monitoring and maintenance will be required, which has been included in the closure plan design and costing.

Figure 2-6 provides the mean annual water balance for the Class A Storage Facility cover design once the facility is completely constructed, which is based on the following water balance distribution:

$$Q_P = Q_{ET} + Q_{RO} + Q_{In}$$

$$100\% = 30\% + 68\% + 2\%$$

Where:

Q_P is the precipitation flux;

Q_{ET} is the evapotranspiration and sublimation flux;

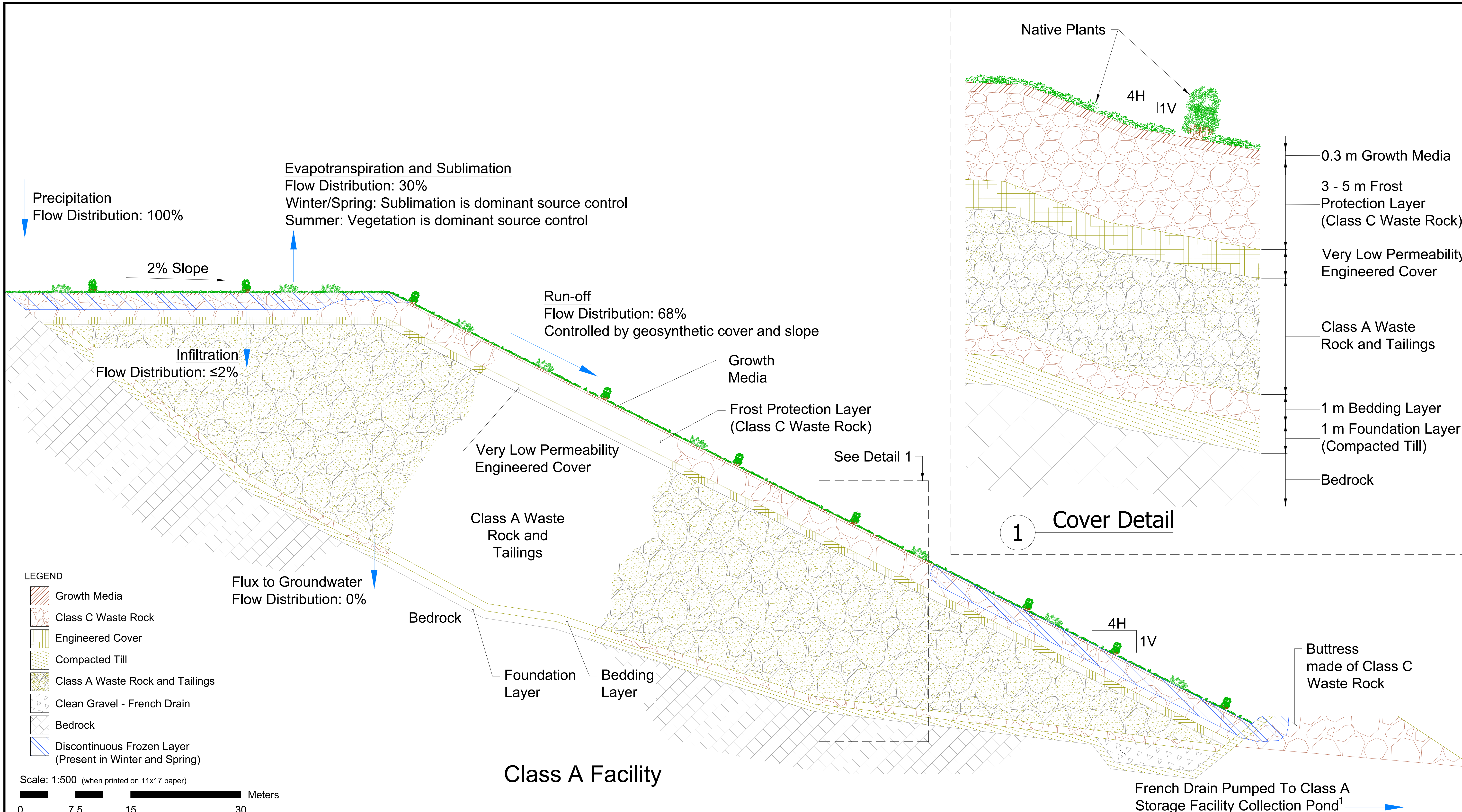
Q_{RO} is the run-off flux; and

Q_{In} is the infiltration flux.

In this water balance, the run-off value includes the natural ground run-off, as well as the run-off produced by the very low permeability multi-layer cover system. The result is at least a 98% reduction of the mean annual precipitation amount, due to the combination of natural processes and the very low permeability cover layer, such that 2% or less infiltrates through the cover and into the waste rock and filtered reactive tailings. The resulting mean annual flow of contact water is estimated to be 2,400 m^3/yr, during closure (AEG, 2017b). The three main constituents of potential interest (COPIs) for the Class A Storage Facility, as indicated by the KZK Project Water Quality Model Report (AEG, 2017b), are cadmium, selenium, and zinc. Figure 2-7 provides the Class A Conceptual Cover Design Schematic with expected flow rates and metal loading values. The estimated mean annual loads predicted out of the toe of the Class A Storage Facility into the collection pond are as follows:

- Cadmium = 0.4 kg/yr,
- Selenium = 5.6 kg/yr, and
- Zinc = 24 kg/yr.

It is worth noting, these loads will be reduced by the Constructed Wetland Treatment System (CWTS) prior to reaching the receiving environment.



Slopes shown do not reflect actual topography and are for illustration purposes.

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Notes:
Based on design information from 2016 Prefeasibility Design Report

[1]During operations and active closure only. Discharge to the environment upon acceptable closure monitoring results.

[2]Assumes no storage within waste rock

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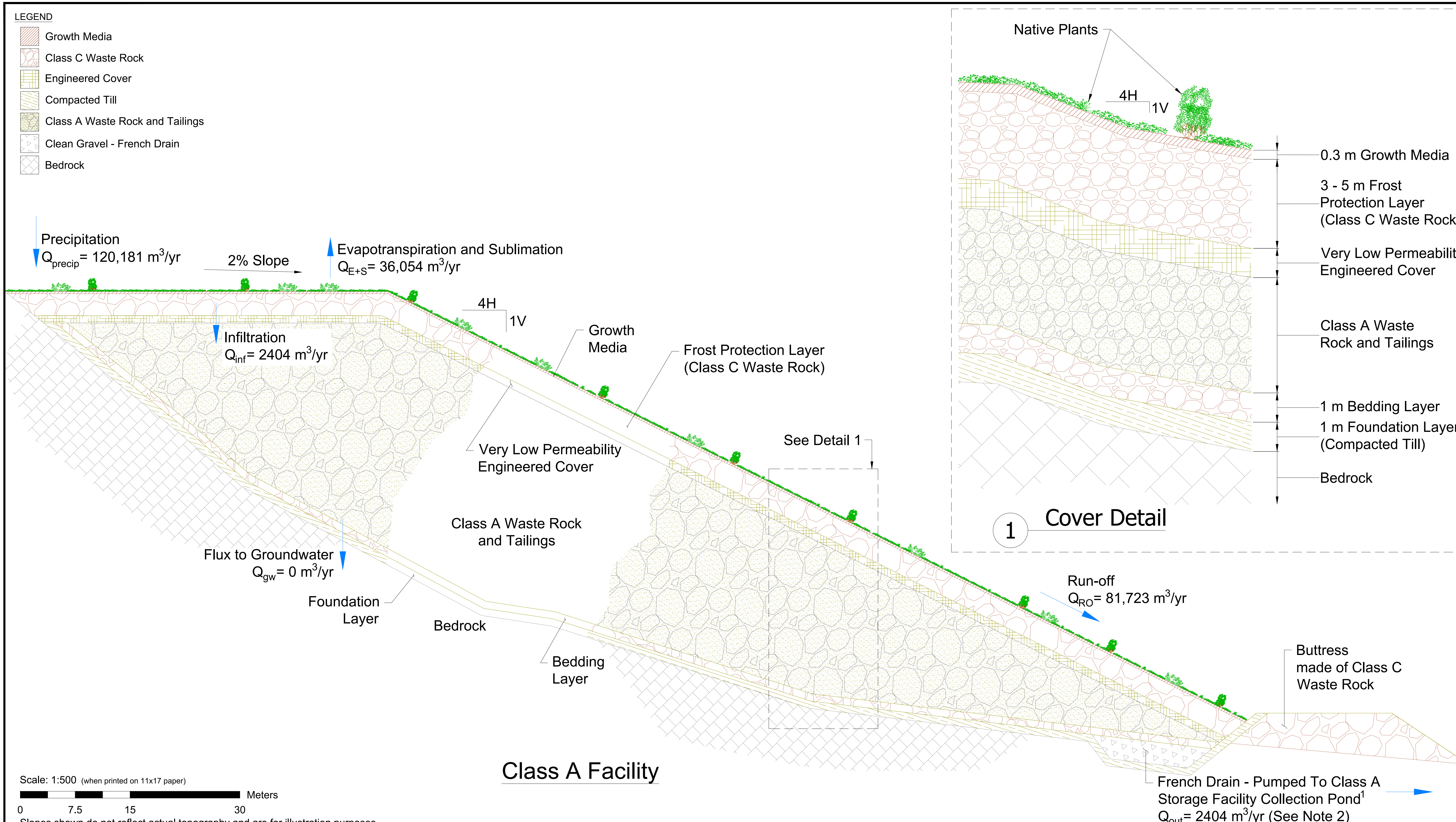
Conceptual Reclamation and Closure Plan
Drawing No: BMC-15-02-B-1003

Figure 2-6

Class A Conceptual Cover
Water Balance

REVISION: A	2016-12-08	PROJECT No.: BMC-15-02
DRAWN BY: KB	DESIGNED BY: CR	REVIEWED BY: LB



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Note:
Based on design information from 2016 Prefeasibility Design Report

Flow rates to be determined once water balance and loading model are finalized.

[1]During operations and active closure only. Discharge to the environment upon acceptable closure monitoring results.

[2] Cd load = 0.4 kg/yr
Se Load = 5.6 kg/yr
Zn Load = 24 kg/yr

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Conceptual Reclamation and Closure Plan
Drawing No: BMC-15-02-B-1001

Figure 2-7

Class A Storage Facility
Cover Schematic

REVISION: A	2016-12-08	PROJECT No.: BMC-15-02
DRAWN BY: KB	DESIGNED BY: CR	REVIEWED BY: LB

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2.7 CLASS B STORAGE FACILITY COVER

The proposed Class B Storage Facility requires a low permeability cover that can reduce net percolation by 75% of mean annual precipitation to achieve closure water quality objectives, as per the KZK Project Water Quality Model Report (AEG, 2017b). A three-layer "enhanced store-and-release type cover" system (MEND, 2012) has been designed to achieve the required reduction in net percolation. This cover system takes advantage of a non-compacted store-and-release layer to reduce the net percolation as well as an underlying compacted till layer to further reduce net percolation during seasonal (particularly freshet) events, when the store-and-release capacity is exceeded (MEND, 2012). The compacted low permeability layer will delay further infiltration so that the excess water is either stored or diverted away as run-off. It is expected an enhanced store-and-release cover system can achieve the performance requirements for the Class B Storage Facility using locally available materials on site.

For the Class B Storage Facility cover the low permeability layer will be 1.0 m compacted till overlain by a minimum of 3.0 m of Class C material waste rock to act as the store-and-release cover, as well as frost protection for the compacted low permeability layer. The store-and-release waste rock layer may be amended with non-compacted till if the Class C waste rock grain size is insufficient to adequately store-and-release infiltrating water. A 0.3 m of growth media will be applied over the entire cover to support revegetation. This cover will be installed progressively as the Class B Storage Facility is constructed. A summary of the Class B cover system is provided in Table 2-4.

Table 2-4: Class B Storage Facility Conceptual Cover

Cover Layer	Material Type	Thickness (m)	Approx. Volume (m^3)
Growth Medium	Top soil/overburden Blend	0.3	210,200
Frost Protection	Class C Waste Rock	3.0	2,348,700
Compacted Till Layer	Overburden	1.0	778,300

Figure 2-8 provides the mean annual water balance for the Class B Storage Facility cover design once the cover is constructed, which is based on the following water balance distribution (terms defined in Section 2.6):

$$Q_P = Q_{ET} + Q_{RO} + Q_{In}$$

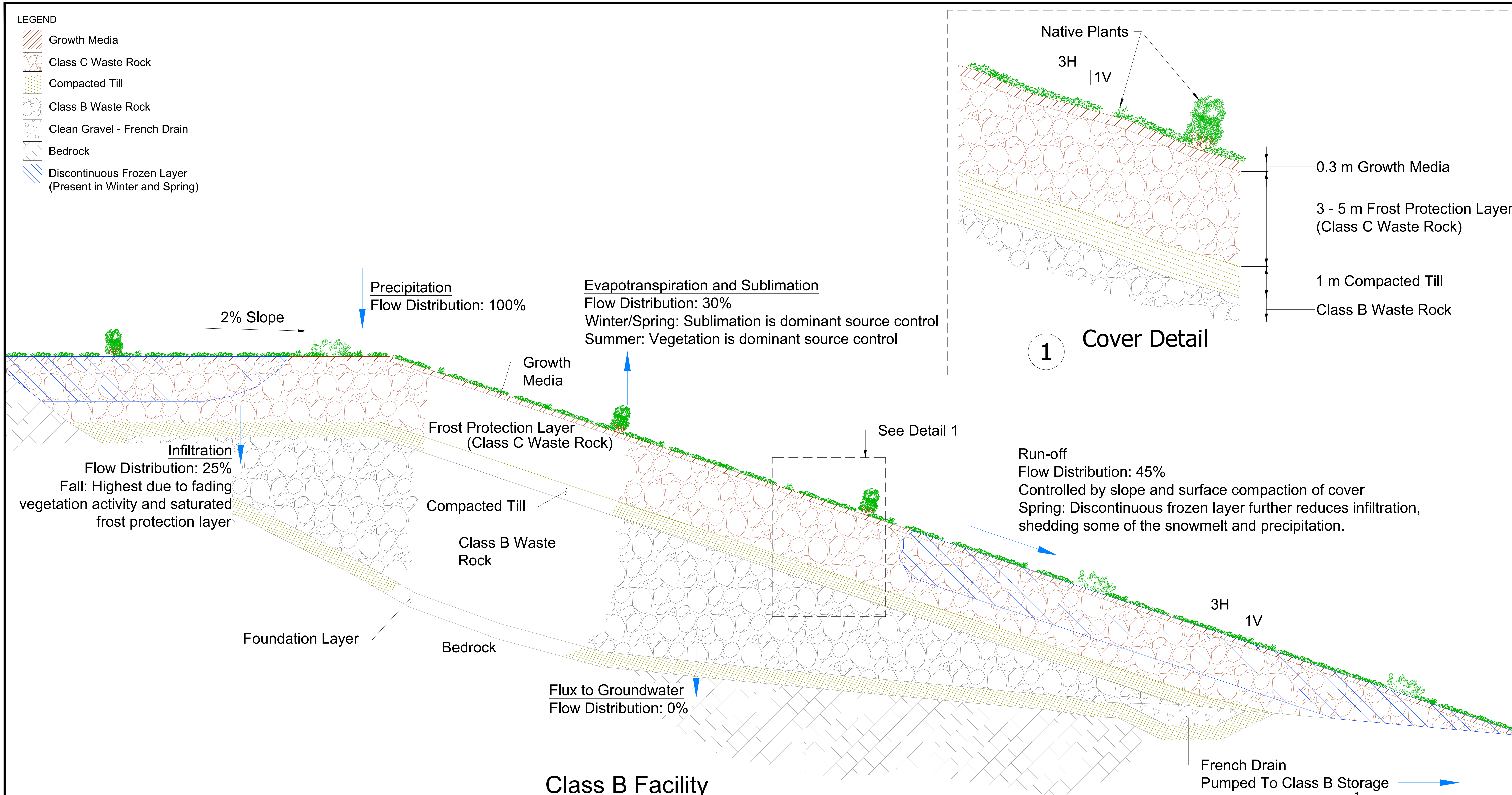
$$100\% = 30\% + 45\% + 25\%$$

In this water balance, the run-off value includes the natural ground run-off, as well as the run-off produced by the enhanced store-and-release type cover. The result is a 75% reduction of the mean annual precipitation amount, due to a combination of natural processes and the 3-layer cover system, such that a maximum of 25% infiltrates through the cover and into the waste rock. The resulting mean annual flow of contact water, once the cover is complete, is estimated to be 28,400 m^3/year. The two main COPIs for the Class B Storage Facility, as indicated by the KZK Project Water Quality Model (AEG, 2017b), are arsenic and antimony. Figure 2-9 provides the Class B Conceptual Cover Design Schematic with expected flow rates and metal loading values.

The estimated mean annual loads predicted out of the toe of the Class B Storage Facility into the collection pond are as follows:

- Arsenic = 8.9 kg/yr; and
- Antimony = 7.3 kg/yr.

It is worth noting, these loads will be reduced by the CWTS prior to reaching a compliance point. Monitoring and maintenance of the cover will be required over the long-term if the performance is expected to sustain a 75% or better reduction in net infiltration.



Scale: 1:250 (when printed on 11x17 paper)

0 3.75 7.5 15 Meters

Slopes shown do not reflect actual topography and are for illustration purposes.

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Notes:
Based on design information from 2016 Prefeasibility Design Report

[1]During operations and active closure only. Discharge to the environment upon acceptable closure monitoring results.

[2]Assumes no storage within waste rock

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BMC MINERALS

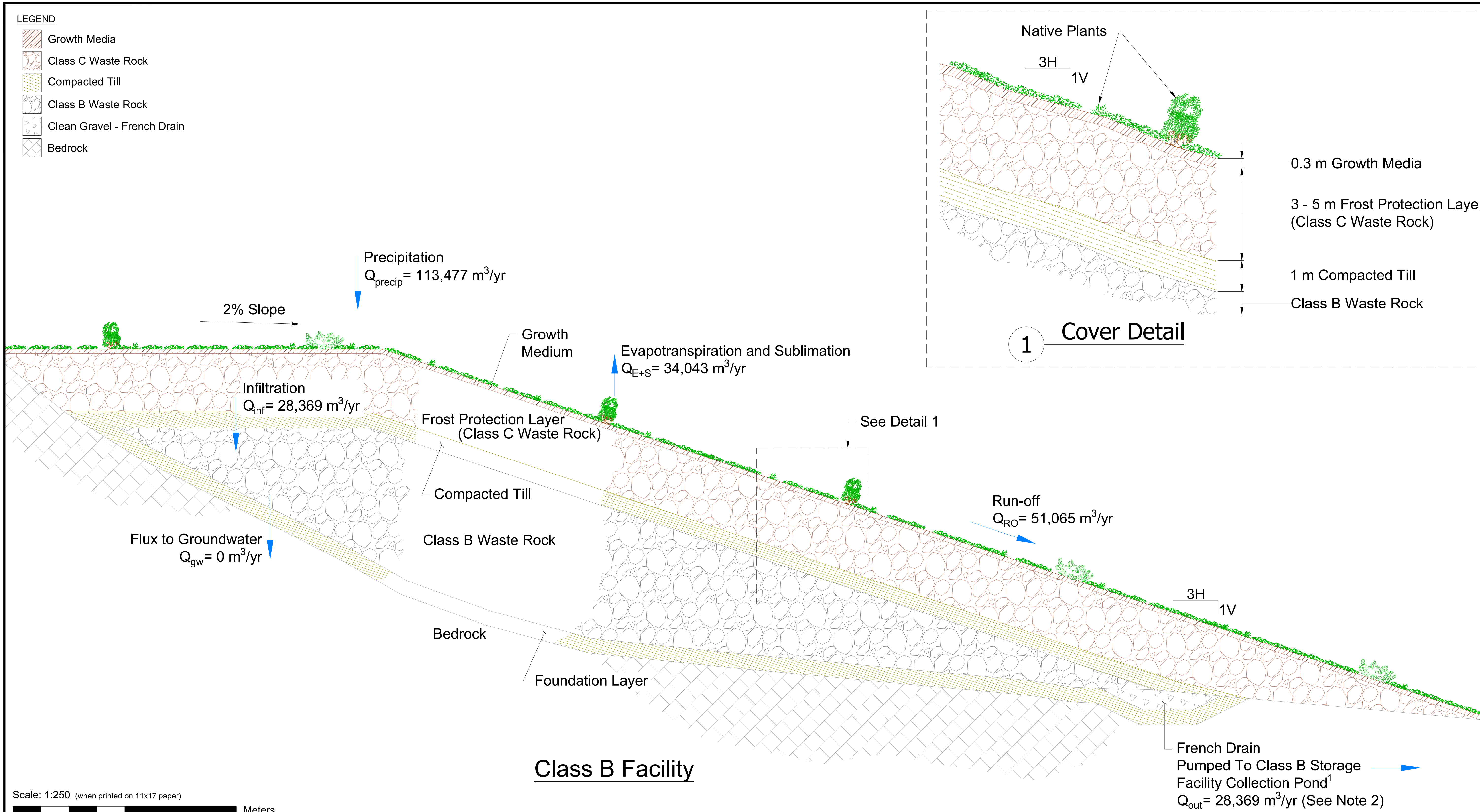
Kudz Ze Kayah
Conceptual Reclamation and Closure Plan
Drawing No: BMC-15-02-B-1002

Figure 2-8

Class B Conceptual Cover
Water Balance

REVISION: A	2016-12-07	PROJECT No.: BMC-15-02
DRAWN BY: KB	DESIGNED BY: CR	REVIEWED BY: LB

E:\Users\Kenneth\Projects\Kudz Ze Kayah\Production Drawings\1000-Geotech\BMC-15-02-B-1002-SeasonalBCover.dwg (last edited by: kboldt; 2017/02/06 - 11:00 AM



Scale: 1:250 (when printed on 11x17 paper)

0 3.75 7.5 15 Meters

Slopes shown do not reflect actual topography and are for illustration purposes.

DATE	ISSUE/REVISION	REV No.	DRW.	APP.
2016-12-08	Draft for review	A	KAB	--

Note:
Based on design information from 2016 Prefeasibility Design Report

Flow rates to be determined once water balance and loading model are finalized.

[1] During operations and active closure only. Discharge to the environment upon acceptable closure monitoring results.

[2] As Load = 8.9 kg/yr
Sb Load = 7.3 kg/yr

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Kudz Ze Kayah
Conceptual Reclamation and Closure Plan
Drawing No: BMC-15-02-B-1000

Figure 2-9

Class B Storage Facility
Cover Schematic

REVISION: A	2016-12-07	PROJECT No.: BMC-15-02
DRAWN BY: KB	DESIGNED BY: CR	REVIEWED BY: LB

E:\Users\Kenneth\Projects\Kudz Ze Kayah\Production Drawings\1000-Geotech\BMC-15-02-B-1000-BCover.dwg (last edited by: kboldt; 2017/02/06 - 10:58 AM

2.8 CLASS C STORAGE FACILITY COVER

The Class C Storage Facility will contain waste rock that is non-PAG and has a low potential for metal leaching, as discussed in Section 3.2. The KZK Project Water Quality Model Report (AEG, 2017b) indicates that this facility is not a significant load source that would impact downstream water quality objectives, and as such there is no need to significantly reduce net percolation through this storage facility. For the purposes of returning the area to as close as possible to existing conditions a growth media layer of 0.3 m will be applied progressively as the facility is constructed to support revegetation. A summary of the Class C cover system is provided in Table 2-5

Table 2-5: Class C Storage Facility Conceptual Cover

Cover Layer	Material Type	Thickness (m)	Approx. Volume (m^3)
Growth Media	Top soil/Overburden Blend	0.3	376,500

3 BORROW ESTIMATES

A preliminary investigation into the amount of borrow required to construct the covers was conducted. The estimated available amounts of Class C waste rock, till, and topsoil were provided by KP and BMC. Calculations were conducted, based on surface areas and thickness of conceptual cover designs, to estimate volumes of material required to construct the cover. Table 3-1 summarizes the estimated results of the available borrow material compared to the required volume.

Table 3-1: Estimated Borrow Volume Requirements

Material Type	Source	Approximate Volume Required (m^3)	Approximate Volume Available (m^3)
Class C Waste Rock Frost Protection	Class C Waste Rock	4,759,700	32,000,000
Compactable Till	ABM Overburden	778,310	9,000,000
Growth Media for Vegetation	Top soil from facility prep.	809,200	954,240
Bedding Layer Till	Class A & B Overburden	313,200	697,600

The estimated topsoil volume available for reclamation is assumed to contain till due to the difficulties of stripping thin layers of topsoil, and as such the blend is referred to as “growth media.” This material will be readily available for closure as it will be excavated and stored next to the facilities from where it was stripped. The Class C material required is currently estimated based on a 3.0 m frost protection layer; however, if further field studies determine the thickness needs to increase there is currently sufficient volumes available.

The volume of till required to compact a low permeability layer on the Class B waste will be a selection of the best available material between the overburden in the proposed footprints of the open pit and the Class B Storage Facility. The volume is currently calculated solely from the ABM open pit footprint for simplicity as there is currently insufficient detail to delineate exact volume between the open pits and the Class B material that meet the criteria. This level of detailed delineation will be established for the next level of design.

The estimated available volume of material is assessed to meet all of the requirements for the conceptual cover design; however, this does not account for competing needs for the material during construction. Priorities will need to be identified during construction on use of the material, and alternatives may need to be found if the material required for covers is used elsewhere.

4 CONCLUSIONS

The materials locally available for covers on-site were evaluated for their suitability in terms of geotechnical characteristics. For the till on site, the PSDs were evaluated on a soil texture ternary diagram for erodibility, which indicates that the majority of till material on-site is suitable for moderate slopes in terms of erodibility. In terms of hydraulic conductivities, the lowest permeabilities estimated for the till on site range between $3x10^{-9}$ and $9x10^{-6}$ m/s, with an average of $2.1x10^{-6}$ m/s, which is insufficient to reduce the necessary precipitation to achieve a very low permeability cover; however, it is sufficient to achieve a low permeability layer combined with store-and-release. Only estimated ranges of and particle size of the Class C waste rock are available. The estimated coarse limit of the Class C waste rock is 60 mm to greater than 800 mm (cobble and boulder) and the fine limit is 0.50 mm to 100 mm (primarily gravel with coarse sand) (KP, 2016b), which is sufficient for a frost protection layer, but site specific information is required to confirm estimated particle sizes.

The geochemical characteristics of the potential cover materials were also evaluated. For the available till, all samples returned neutral to slightly alkaline paste pH (7.3 to 8.6) and contained negligible sulphur (typically below detection <0.01 wt.%). The NP was also generally low, but measurable, with the majority of samples in the 4.0 to 13 kg $CaCO_3$/t range, suggesting that acid generation is considered unlikely. Overall, the till is considered non-PAG and was suitable for use for appropriate cover and construction applications. For the Class C waste rock, ABA testing indicates that the material will have a weighted average of 0.5 wt.% sulphur, 85 kg $CaCO_3$/t NP, and a resulting NP/AP of 5.4. As such, all the Class C material is expected to be non-acid generating. Drainage from the Class C Storage Facility is expected to remain circumneutral to mildly alkaline during operations and post-closure and therefore, specific acid rock drainage (ARD) mitigation measures are not required. As such, the Class C waste rock is suitable for use in cover construction.

Conceptual covers were designed for the Class A and B Storage Facilities. A three-layer cover system is recommended for the Class A Storage Facility that includes a very low permeability layer, such as a geosynthetic liner material, a GCL, or a highly modified soil layer that achieve the same reduction in net percolation as a liner. This three-layer cover system includes a minimum of 3.0 m of Class C material waste rock for frost protection overlying the very low permeability layer, as well as 0.3 m of growth media to support revegetation. For the Class B Storage Facility an “enhanced store-and-release” type cover system is recommended to achieve a 75% reduction in net percolation. A low permeability layer (1.0 m compacted till) will be overlain by a minimum of a 3.0 m store-and-release layer, constructed with Class C waste rock and with non-compacted till. A layer of growth media (0.3 m) will be applied over the entire cover to support revegetation. The Class C Storage Facility will contain waste rock that is non-PAG and has a low potential for metal leaching, as such there is no need to reduce net-percolation through this storage facility. For aesthetic purposes, a growth media layer of 0.3 m will be applied progressively as the facility is constructed, to support revegetation.

A preliminary investigation into the amount of borrow required to construct the covers was conducted. The volume of till required to compact a low permeability layer on the Class B Storage Facility is estimated to be 0.8 Mm^3, and will be borrowed from the ABM open pit and Class B Storage Facility construction footprint. The stripping of just the ABM open pit footprint during constructions is expected to produce approximately 9 Mm^3 of materiaL, significantly more than required. The Class C material required (4.8 Mm^3) is estimated based on a 3.0 m frost protection layer; however, if further field studies determine the thickness needs to increase there is currently sufficient volume of suitable material available onsite (32 Mm^3). Overall, the estimated available material is assumed to meet all of the requirements for the conceptual cover designs.

5 RECOMMENDATIONS

To further develop the conceptual cover designs presented in this memo additional characterization work is required at the KZK site. The following is a list of work that should be conducted:

- Cover material characterization including more detailed field confirmation of material quantities and properties to achieve the design cover performance of the compacted till layer. This program will be coordinated with the field work to confirm the design of the compacted till foundation layers for the Class A and Class B Storage Facilities;
- Hydraulic and geotechnical material characterization, including;
  - Particle Size Distribution curves and rock composition of Class C Materials.
  - Borrow material hydraulic properties testing, such as Atterberg Limits, saturated hydraulic conductivities, and soil water characteristic curves (SWCC) for material to be used in cover systems.
- Program to determine frost penetration depth line at the waste storage facilities. This would include installing temperature (thermistor) and moisture (conductivity) sensors to create a profile in to the top six meters below ground surface to determine depth and seasonal freeze/thaw pattern;
- Predictive modelling of cover performance during detailed design including site climate, storage facility slopes and aspect, and site specific borrow materials to determine realistic short term and long term performance of Class B cover systems; and
- Evaluation of options for performance monitoring such as equipment to measure water ingress through the cover material and the temperature profile of the frost protection cover during progressive reclamation, to monitor and assess the covers during operations, closure, and post-closure.

Following further data collection modelling site climate and base case cover systems to get more site specific net percolation rates would increase certainty.

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APPENDIX B

CONCEPTUAL WETLAND DESIGN MEMO

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Contango Strategies Ltd.
Forward looking. Lateral thinking.

Technical Memo

To: Kelli Bergh, BMC Minerals (No.1) Ltd.

From: Monique Haakensen, Contango Strategies Ltd.

Date: January 20, 2017

Project: Kudz Ze Kayah

Subject: Conceptual Wetland Design based on Water Quality Objectives and Predicted Outflow Concentrations

Document #: 028_0117_02A

1. Purpose

Contango Strategies Ltd (Contango) was retained by Alexco Environmental Group (Alexco) to assess proposed passive water treatment systems for the Kudz Ze Kayah Project (Project) in the Yukon Territory. Contango has prepared this technical memorandum to describe the conceptual wetland design, and subsequent analyses undertaken to obtain acceptable concentrations of the constituents of potential interest (COPIs) for the constructed wetland treatment systems (CWTS, also referred to as treatment wetlands). This is part of a phased approach being taken for the development of closure water treatment options for the Project. Future work is outlined to develop and implement the CWTS such that they will perform in a robust, predictable, and sustainable manner and will consistently achieve downstream water quality objectives. The iterative approach used to develop the closure water treatment plan is also discussed.

2. Background on Treatment Wetlands

The Yukon Government states that "reliance on long term active treatment is not considered acceptable for reclamation and closure planning" (Yukon Energy, Mines and Resources 2006). BMC recognizes that reliance on long term "active care", such as long-term active water treatment is not acceptable. As such, the Project is designed for a long-term closure scenario of minimal monitoring and maintenance in the long term.

Passive and semi-passive treatment has been successfully used for removal of metals and metalloids, and neutralization of acidic waters for many decades. There are many examples globally of copper, cadmium, and selenium treatment by constructed wetlands and other passive and semi-passive treatment technologies from which scientific principals can be sourced for application in new systems, along with more recent advances in technology and application (Ness et al., 2014). Regardless of the type of wetland treatment system or geographic location, fundamentals such as thermodynamic laws, Stokes' laws (settling), stoichiometry, and concepts of coupled biogeochemical reactions are globally applicable, crossing geographical and climatic boundaries. Moreover, there are standard calculations, such as Arrhenius' equation, that can be applied as necessary to adjust for temperature in chemical reactions.

Successful treatment of mine-influenced water in the north and/or cold climates has been achieved by integrating an understanding of the impacts of a cold climate in the system design phases. In cold climates, passive treatment systems are able to effectively treat mine impacted water with no impact of temperature fluctuation on treatment capacity during months when water is free flowing (Contango, March 2016).

Preliminary scoping and closure planning suggests that waste source control (Section 7.4, Appendix B) and pit water treatment (Section 7.2.1 of the Reclamation and Closure Plan) will provide substantial primary contaminant load reduction during the closure phases at the Project. CWTSs have been identified as a feasible secondary (polishing) passive water treatment technology for the Kudz Ze Kayah Project. This is due largely to the existence of wetland systems in the existing ecological condition in the immediate project vicinity (Geona Creek), and the construction of water management ponds which can be converted to CWTS following the cessation of mining without disturbing additional areas.

Benefits of CWTSs can include a decrease of total suspended solids (TSS), treatment of total and dissolved metals, and neutralization of acidic waters. CWTSs can be designed for seasonal or year-round water treatment, requiring varying degrees of maintenance ranging from passive care to semi-active management. CWTSs can also be incorporated into a treatment train with other passive, semi-passive, or active technologies to achieve objectives and/or lower overall operational water treatment costs. These options must consider the water chemistry and flows, but also the overall site objectives and goals for water treatment and therefore, the CWTS.

3. Phased Approach

For CWTSs to be efficient and effective, they must be designed, tested, optimized, implemented, and maintained in a site-specific manner (Table 1) (Haakensen et al., 2015). This can be achieved using a phased approach, which allows for adjustments to be made and operational boundaries to be identified on a small scale (possibly off site) prior to full-scale implementation. Following a phased approach, the full-scale system can be built with an optimized design along with a refined operational decision tree and adaptive management plan. This type of phased approach has been developed in academic programs and applied to full-scale applications that have now operated for decades (Hawkins et al., 1997; Huddleston et al., 2008; Murray-Gulde et al., 2008; Rodgers and Castle, 2008), and is now being applied through Canadian and Northern climates (Fortune Minerals, 2014; Nordin et al., 2010; Ness et al., 2014; Contango Strategies, February 2014, July 2014, & March 2016).

On a case by case basis, and as appropriate for each site and project, the phases of testing for a CWTS may include:

- Phase 1a: Information gathering and site assessment;
- Phase 1b: Conceptual design and sizing;
- Phase 2: Off site bench-scale testing and optimization;
- Phase 3: Off site pilot-scale testing and optimization;
- Phase 4: On site demonstration-scale implementation and monitoring; and
- Phase 5: Full-scale implementation.

Table 1 – Stages of CWTS Testing and Optimization.

Objectives and Goals	*Phase 1: Site Evaluation*	*Phase 2: Bench (lab)*	*Phase 3: Pilot (off site)*	*Phase 4: Demo (on site)*	*Phase 5: Full-scale*
Gather site-specific considerations	+				
Identify plant and substrate borrow sources	+				
Evaluate technology feasibility	+				
Identify latent treatment potential at site	+				
Formulate and test simulated waters		+			
Evaluate substrates		+	+		
Develop flow rates and water depths			+		
Develop rate coefficients and kinetics			+		
Test vegetation characteristics			+		
Acquire proof-of-concept			+		
Environmental parameter control			+		
Intensive monitoring			+		
Determine parameters for proper sizing			+		
Assess possible removal extent			+	+	
Test potential failure and recovery mechanisms			+	+	
On site optimization				+	
Confirm removal rates/extents				+	+

The objectives and deliverables of the discrete phases include:

Phase 1a: Information gathering and site assessment

- Results of consultation with design team members to determine and identify:
    - specific project objectives and goals,
    - timelines,
    - site-specific restrictions,
    - information gaps,
    - development of initial plans,
- Potential plant species for use based on site-specific information,
- Baseline quantification of water samples in the context of CWTS remediation,
- Baseline quantification of hydrosoils and plants in the context of CWTS remediation,

- Assessment of latent remediation potential of site (microbiological, geochemical, biogeochemical).

Phase 1b: Conceptual design and sizing (one or more designs may be tested in Phase 2 and 3)

- Identification of water quality parameters and concentrations that will be used for pilot-scale tests

Phase 2: Off site Bench-scale Testing and Optimization

- Design of simulated water(s)
- Preliminary testing (e.g., titrations)
- Evaluate substrates and carbon sources

Phase 3: Off site Pilot-scale Testing and Optimization

- Assembly of pilot-scale CWTS off site in controlled facility
- Performance monitoring and stress testing using simulated influent

It should be noted that for Phase 3, sufficient size, volume, and time is required of the pilot-scale testing for results to be meaningful and scalable. Moreover, the simulated influent must adequately reflect the entire water chemistry in order to be representative of actual treatability. That is, to consider the constituents that could facilitate or impair treatment and not just be comprised of the key elements of concern for treatment. Once information is gathered through Phases 1-3, additional phases will be outlined in future proposals and may include the following (as appropriate for the project):

Phase 4: On site demonstration-scale design and monitoring

- Design of on site demonstration scale CWTS;
- Construction of demonstration scale CWTS at site; and
- Performance monitoring.

This will be constructed near the processing plant and water treatment plant (WTP). It will be 'fed' by a sub-stream of contact water being pumped to the WTP. Results from the monitoring of this facility will inform the design in Phase 5.

Phase 5: Full-scale implementation

- Design of full scale CWTS;
- Construction bids, permit and initiation;
- Construction and post-construction monitoring;
- Planting and/or maturation;
- Acclimation and initial monitoring; and

- Ongoing operation and periodic monitoring of CWTS.

4. Summary of Findings from Site Investigation

As part of the phased approach being taken for development, a CWTS feasibility site assessment was conducted on August 25 – 28th, 2015 for the Project. The objectives were to characterize the conditions of natural wetlands in the project area, evaluate the natural treatment capacity of any natural wetlands in the project area, evaluate the feasibility of the use of CWTS at the site, and determine design parameters necessary for the conceptual design of potential wetland areas and eventual costing of their implementation.

The results from the site assessment are reported in Document #028_1215_01E (Contango, October 2016) and briefly summarized here:

- Passive and/or semi-passive water treatment is theoretically feasible at the Project.

- Native plants and beneficial microbial communities were identified at multiple locations at the Project that are capable of contributing to desirable water treatment activities.

- Wetland plant species *C. aquatilis* (water sedge) and aquatic mosses are abundant at the Project, host natural beneficial microbes, and promote conditions conducive to water treatment.

- Wetland plant *Schoenoplectus* (bulrush) is abundant in the nearby area as a secondary option if necessary.

- Natural beneficial microbes were found in abundance in wetlands, seeps, and creeks at the Project. These microbes are capable of water treatment processes such as reduction of nitrate, nitrite, selenium, and sulphate.

- Further characterization and determination of final water chemistry and usage objectives must be clearly defined in order to appropriately and accurately suggest a CWTS design.

- Deterrence of local wildlife should be incorporated into the CWTS design given the evidence of both beaver and moose at the Project wetland and creek areas.

- Willows and alders may need to be considered in a long-term management plan as they alter wetland hydrology by promoting channeling of water and could also encourage beaver activity.

5. Project Design and Constituents of Concern

The Project is a proposed open pit and underground metal sulphide deposit mine, containing copper, lead, zinc, gold and silver in Yukon Territory. The Project includes an open pit mine of the ABM and Krakatoa zones, three waste rock storage facilities, a paste fill plant, a warehouse and administration complex, fuel storage and distribution, an overburden stockpile, a process mill for copper, lead and zinc concentrates, a water treatment plant, accommodation facilities, and a power plant. Following the cessation of milling and mining activities, the tailings and waste rock will be covered and the open pit will fill with groundwater and discharge from Fault Creek, which will receive in-pit treatment. Water quality modelling estimates that water from the ABM Lake outflow will contain concentrations of antimony, arsenic, cadmium, fluoride, nitrite, selenium, uranium, and zinc that are in exceedance of the preliminary Water Quality Objectives (Alexco, 2016, 2017) (pWQOs, Table 2), and are herein collectively referred to as COPIs. Other than fluoride, these COPIs can be treated by passive means, such as in pit treatment and CWTS. These COPIs are predicted to be present at relatively low concentrations. These conditions favour the use of passive treatment technologies such as CWTSs. Due to the concentrations of COPIs theoretically predicted to be in the ABM pit water and the waste rock runoff in post-closure, a passive treatment train was designed to improve water quality to meet the pWQOs. The treatment train was developed through an iterative design process (Section 6.3), which comprised *in situ* treatment in ABM Lake followed by two CWTS being the South Wetland and North Wetland.

Table 2 - Proposed Water Quality Objectives for COPIs in Geona Creek.

Antimony	Arsenic	Cadmium	Uranium	Selenium[1]	
				Min	Max
0.009	0.005	0.00029	0.015	0.00212	0.00535

[1]The site specific water quality objective (SSWQO) for Se is variable and is determined using equation:
Se SSWQO (mg/L) = 0.002 mg/L at sulphate ≤60 mg/L;
Se SSWQO (mg/L) = $(0.1736*(\text{sulphate})^{0.597})/1000$ at sulphate >60 mg/L.

6. CWTS Design Selection

For the modelling exercise described and discussed in this technical memorandum, the most passive design possible was considered for the Project. The goal of final mine site closure is to ensure long-term physical and geochemical stability and to minimize reliance on long-term active treatment. To meet the requirements for water treatment with minimal intervention, the selected passive treatment wetland design is one where there is no operational management necessary, and only minimal periodic maintenance is required, which could be performed by manpower (i.e., without machinery).

Based on these guiding objectives, the selected configuration at the Project is a horizontal surface flow treatment wetland. A conceptual horizontal flow treatment wetland is presented below in figure 1. Dotted arrows show flow path through wetland and into substrate and root zone. Vegetation in this example includes both emergent macrophytes (e.g., *Carex aquatilis*, aquatic sedge), and bryophytes (aquatic mosses), which have been found at the Kudz Ze Kayah site (Contango, October 2016). Because naturally psychrophilic (cold loving) sulphide-producing and selenium-reducing bacteria have been confirmed to exist at the Kudz Ze Kayah site (Contango, October 2016), lower temperatures are not expected to result in a decreased performance rate.

This type of CWTS can be designed to generate either oxidizing or reducing conditions (as may be needed for treatment of various COPIs), by modifying substrate, water depth, flow rates, vegetation types, and addition of organic amendments. It is acknowledged that there are other designs (e.g., subsurface flow, vertical flow) that could potentially achieve treatment in a smaller footprint, but these would be associated with greater operations and maintenance requirements.

An anaerobic (reducing) horizontal surface flow CWTS design was selected for the conceptual modelling of treatment for the Project. Reducing conditions will treat antimony, cadmium, and zinc through production of insoluble sulphide minerals, and directly treat selenium and uranium through dissimilatory reduction and mineralization of these latter two elements. It is recognized that an aerobic (oxidizing) system would traditionally be selected for treatment of arsenic. However, anaerobic CWTS also have the ability to remove arsenic from water, although with slower treatment rates than would be possible with an aerobic CWTS design. Owing to the low concentrations of arsenic needing to be treated at the Project, it is believed that it can be treated within the same wetland design as the other constituents. For nitrite, this constituent can either be removed in anaerobic CWTS, or will convert to nitrate under oxidizing conditions which is discussed further in Section 7.4.

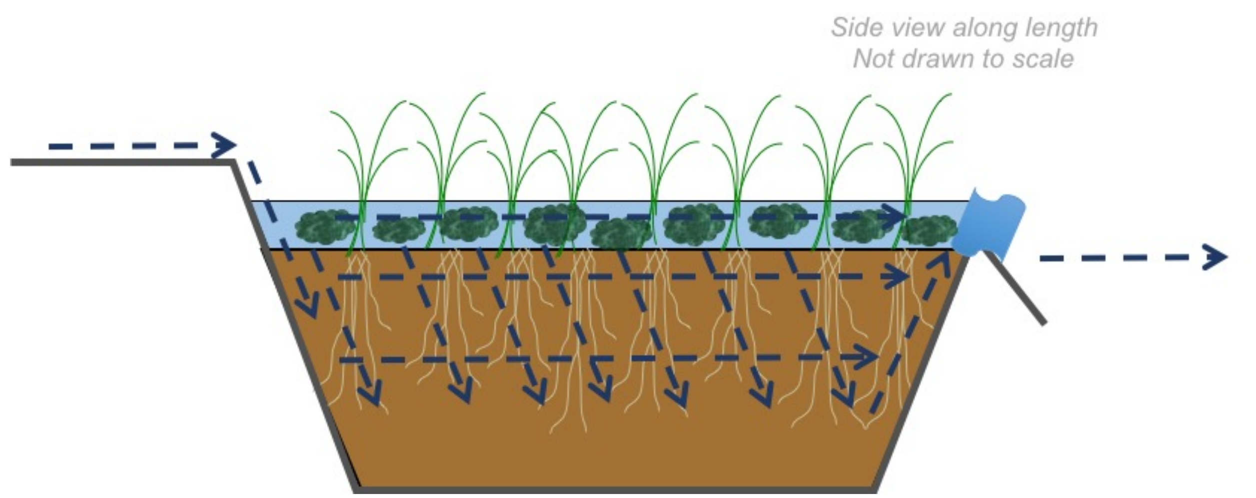


Figure 1 — Conceptual diagram of horizontal surface flow wetland.
Dotted arrows show flow path through wetland and into substrate and root zone. Vegetation in this example includes both emergent macrophytes (e.g., *Carex aquatilis*, aquatic sedge), and bryophytes (aquatic mosses), which have been found at the Project.

6.1. Conceptual CWTS Design

As an example layout, each CWTS will be built with multiple small cells connected together in a treatment series. The series will be replicated in parallel. This design element serves several purposes as described below:

- Water in wetlands can channel over time, causing a faster water flow through the system. By dividing a water flow into multiple cells separated by spillways, the water can only ever channel through a single cell at once, thereby maintaining the overall hydraulic retention time and treatment effectiveness; and

- Having replicates of the series allows for any alterations needed during demonstration and acclimation phases, as one series can be taken off line and adjusted while the others will continue to treat water.

A typical conceptual CWTS schematic has been included in figure 2 and figure 3. Assumptions specific to the conceptual design of the CWTSs include the following:

- Multiple series of flat bottom cells will operate in parallel;
- Anaerobic cells have an operating water depth of approximately 0.30 m (using *Carex aquatilis* as the vegetation species, however this could be deeper if *Schoenoplectus* are used);
- Cells are divided by berms with rip rap armouring along the slopes and at the inlets;
- Perimeter berms will be constructed with a crest width sufficient to accommodate maintenance vehicles or foot traffic, as appropriate;
- The soil to be placed at the bottom of the cells will be sourced on site, analyzed and amended as needed to achieve the appropriate conditions to treat water and promote plant and microbial growth. The soil will be mixed with amendments such as biochar, slow release fertilizer, wood chips and crushed oyster shells in order to provide enhanced surface area, nutrients, organic carbon, and buffering capacity, respectively, in order to initiate natural biological cycles for water treatment within the CWTS;
- The CWTS will be densely planted (i.e., approximately 2 to 5 plants per cubic meter) by hand with emergent aquatic vegetation obtained from, at, or near the site. These plants are typically dug with a backhoe and then the rhizomes (thick roots that the plants use to spread) are cut into smaller pieces for planting; and
- After planting, the cells can be brought on line. During this maturation period, good-quality water will initially be used (i.e., not seepage) so that the plants can have a chance to develop, multiply and mature. This water can be partially recycled through the wetland using a pump.

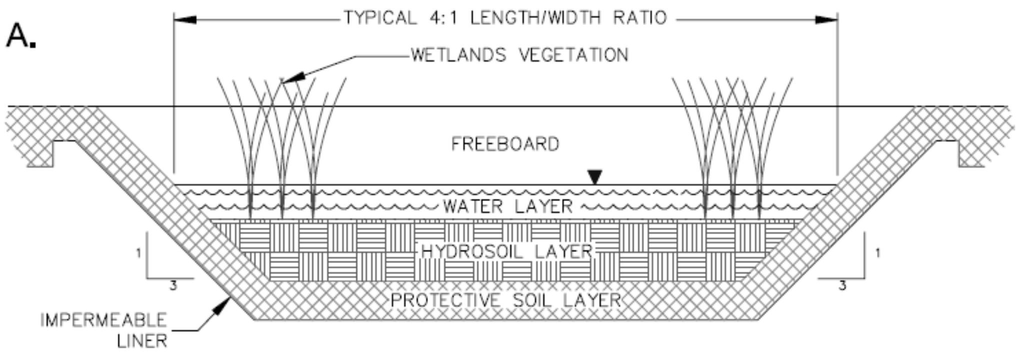


Figure 2 – Profile of a Typical Surface Flow CWTS (Rodgers and Castle, 2008).

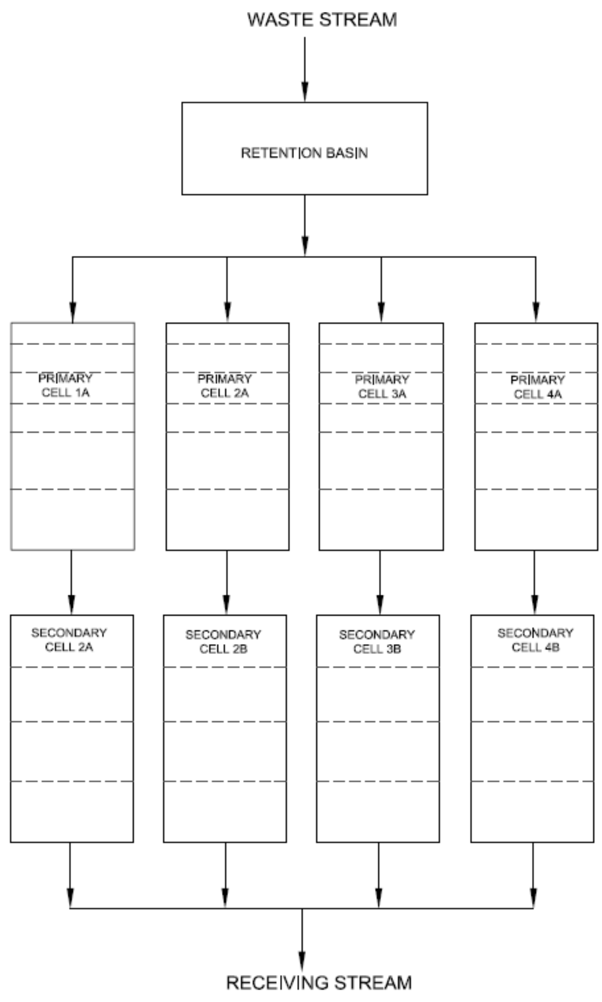


Figure 3 – Schematic Flow Diagram of a Typical Horizontal Flow CWTS Layout, Showing Built in Redundancy (Murray-Gulde et al., 2008).

Flows will be allowed to follow seasonal variation, with some equilibration of flows and concentrations of constituents provided by sedimentation ponds upstream of each CWTS.

The treatment wetland is conceptually designed to incorporate features that make it less prone to temperature fluctuations. These include beneficial cold-loving (psychrophilic) bacteria and the incorporation of aquatic bryophytes (mosses) into the planted area such that there will be an annual balance between sorption (cold months) and remineralization and sedimentation of the sorbed elements via microbial sulphate reduction in warmer months.

6.2. Maintenance and operation in cold temperatures

Minimal ongoing maintenance will be required during operation of the CWTS. Specific maintenance activities and frequencies will be refined through the phase development of the system, however, general maintenance normally includes: regular inspections to remove debris, examine berms and spillways, and adjust rocks or sandbags at the spillways to even flow paths. Routine water quality sampling will begin during maturation to confirm that the quantifiable conditions of the CWTS environment, otherwise known as explanatory parameters, are within desired ranges, and to monitor their stability. These parameters include alkalinity, conductivity, dissolved oxygen, pH, redox, ion balance, available electrons, flow, and temperature. If they are out of range, it is possible to adjust using additional amendments such as those that were originally added to the soil. Access to the CWTS to allow for this limited maintenance and monitoring will be required.

Due to the accretion of sediments and detritus mass within the CWTS, it may be necessary to raise the operating water level within the cells during their operation. Inter-cell flow structures will be constructed to allow for the placement of stop logs (or rocks, sandbags) to raise the water levels and accommodate this build-up of mass.

In the winter, the wetlands will freeze through to the ground and the water will stop flowing until the spring thaw. There are microbes (called psychrophiles or "cold loving" bacteria) that live best at temperatures between +10 and -20°C. If there is liquid water, these bacteria will be actively treating the water, and there will also be sorption sites available for temperature-independent treatment. Additionally, reducing wetlands are designed to produce excess sulphides, which can bind with iron to form amorphous iron sulphides (known as acid volatile sulphides, AVS, due to the testing method). The AVS generated in a reducing CWTS serves as an exchange mechanism that can be used for treatment during cold temperatures, where the iron is swapped for metals that are more desired such as Cd and Sb. The CWTS will be designed and optimized to produce excess AVS during summer months when temperatures are warm and microbes are more active, to ensure treatment rates remain constant during colder temperatures.

In spring thaw, water that flows over the surface of the wetland will be diluted by snow melt and ice melt. When wetlands begin to melt, they melt from the edges in, and also melt starting from each plant stem outwards, forming liquid tubes in the ice surrounding the dead plant stem from the previous year(s). This allows water exchange to the sediment to begin very early in the thawing process, and the decaying plant stems themselves are a very active spot for microbial activity (Haakensen et al., 2013).

7. Methodology for CWTS Outflow Water Quality Prediction

7.1. Assumptions

The following assumptions were incorporated into the CWTS modelling:

- The water is near neutral pH and net alkaline.
- The water balance model assumed no freezing in winter, which in Northern environments is an exceptionally conservative estimate given the location and climate of the Project.
- The treatment wetlands are conceptually designed to incorporate features that make it less prone to performance effects by temperature fluctuations. These include the incorporation of aquatic bryophytes (mosses) into the planted area such that there will be an annual balance between sorption (cold months) and remineralization and sedimentation of the sorbed elements via microbial sulphate reduction in warmer months.
- The wetland sizes were provided by Alexco and were based on the topography at the Project in the South Wetland and North Wetland areas. The conceptual size of the South Wetland is 17,000 m^2 (1.7 ha) and the conceptual size of the North Wetland is 16,500 m^2 (1.65 ha).

7.2. Removal Rate Coefficients and Calculations

An important factor for wetland design is the rate of treatment, also known as the treatment rate coefficient (k). The treatment rate coefficient is based on the treatability of a specific constituent and the hydraulic retention time of the system, both of which are site-specific based on water chemistry, wetland designs, and characteristics of the system. Because site-specific treatment rate coefficients (k) have not yet been developed for the Project, proxies were applied from other projects with as similar of chemistry and conditions as possible in order to conceptually assess the CWTSs outflow concentrations given the pre-determined size of each wetland for the Project (table 2).

The treatment rate coefficients applied here are intended to be a conservative estimate for theoretical outflow concentration purposes, and will need to be refined through pilot-scale (off site), and demonstration-scale (on site) testing, as removal rate coefficients are highly site-specific and must be developed in a site-specific manner, for each element of interest. While they may sometimes be applied in a conceptual manner to other situations/sites (as was done here), caution should be taken in applying a removal rate coefficient developed for one design and water chemistry to a very different chemistry or design basis. It is also often the case that *k* must be calculated and applied for different ranges of certain constituents, which can be further refined with pilot-scale and demonstration-scale testing.

Based on experience from treatment wetlands being used and developed in Yukon and Northwest Territories, the treatment rate coefficient (*k*) applied for As and Se follow a zero-order reaction kinetic, while the rate coefficients for Cd and U follow first-order kinetics. The treatment rate coefficients for As and U were derived from pilot-scale testing that has been conducted for a mine in the Northwest Territories, while the coefficients for Cd and Se were derived from demonstration-scale testing that is ongoing at a mine in Yukon (Contango, January 2017). There was no rate coefficient available specific to Sb, and so the rate coefficient from As was used as a proxy.

In Equation 1-4, *Cf* is final concentration, *Ci* is initial concentration, *V* is volume of water in the system, and *Q* is flow rate. Using the removal rate coefficients (*k*) in Table 3 and equations 1-4, parameters can be rearranged to solve for those of interest. The volume of water in each CWTS is calculated using the conceptual wetland size multiplied by the calculated water depth of the conceptual design. For this analysis, a conceptual water depth of 80 cm was used, which is calculated from the assumptions of a horizontal surface flow wetland with 30 cm of free water at the surface and 1.5 meters of substrate with an expected 33% pore space filled with the water. Using the conceptual volumes and predicted flow rates and initial concentrations, Equations 1 and 2 can be rearranged to calculate the theoretical outflow concentration (*Cf*) of each constituent for each CWTS. For conservativism, *Cf* values that are below the Geona Creek pWQO are set to equal that concentration.

Table 3 — Elements considered in treatment wetland models, with respective treatment rate coefficient (*k*) values.

Element	*k*[1]
Zero order reaction kinetic	
As	0.01032
Se	0.000384
Sb	0.01032
First order reaction kinetic	
Cd	0.19272
U	0.192

$$k = \frac{-\ln\left(\frac{Cf}{Ci}\right)}{V}\, x\, Q$$

Equation 1 — Equation for calculation of first-order removal rate coefficient.

$$Cf = Ci \times e^{-k\, x\, \frac{V}{Q}}$$

Equation 2 — Equation for calculation of first-order removal rate coefficient, rearranged to solve for outflow concentration.

$$k = \frac{(Ci - Cf)}{V}\, x\, Q$$

Equation 3 — Equation for calculation of zero-order removal rate coefficient.

$$Cf = Ci - k\, x\, \frac{V}{Q}$$

Equation 4 — Equation for calculation of zero-order removal rate coefficient, rearranged to solve for outflow concentration.

7.3. Iterative Process for Multi-Step Passive Treatment System Design

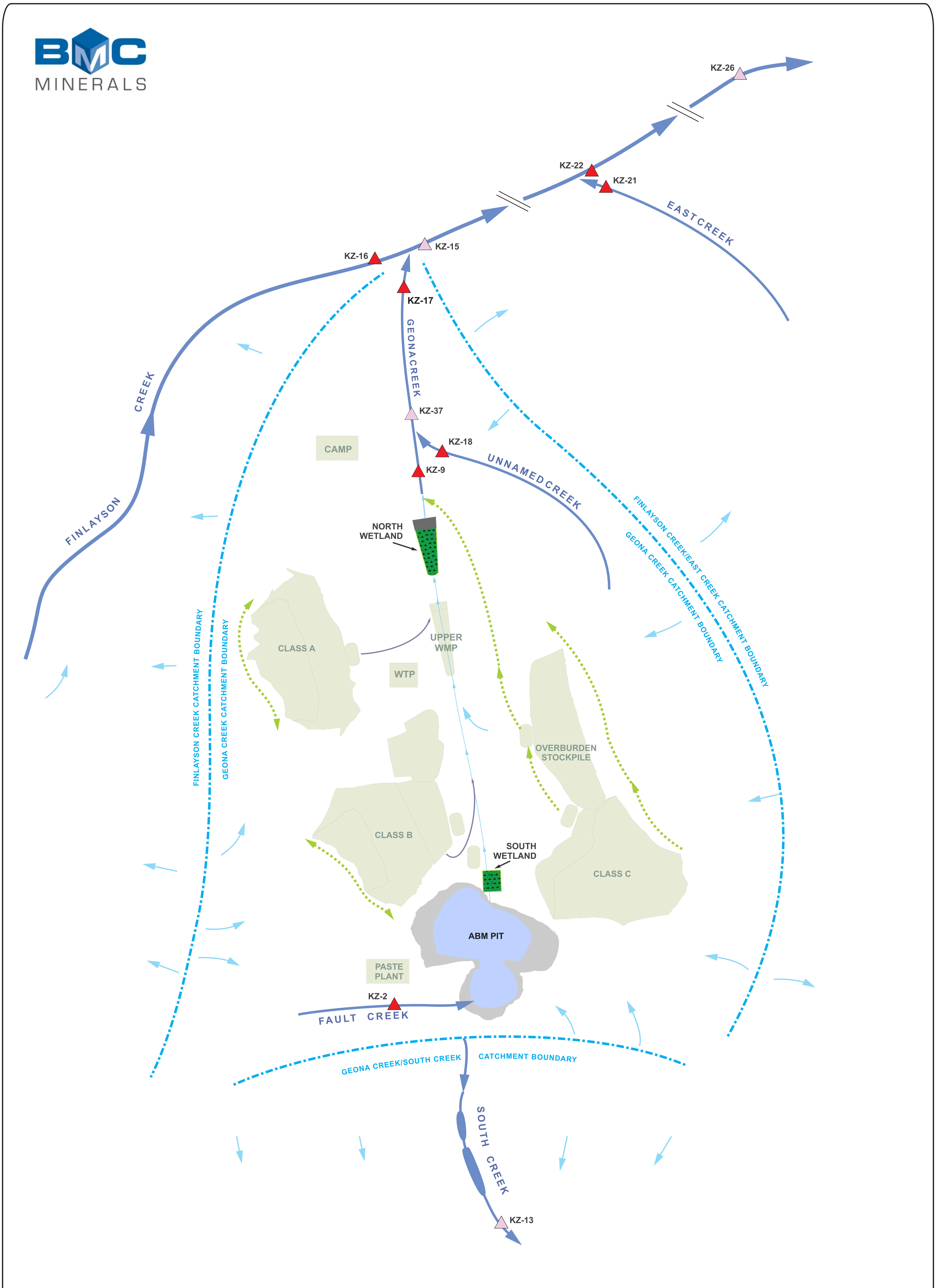
Outflow concentration sensitivity analysis was conducted by testing the theoretical year 27 post mine closure water quality and flows in a model for each of the elements on a month to month basis in wet, dry, and mean scenarios. An iterative process was used to design the passive treatment train to achieve post-closure water quality objectives.

Water quality objectives are being developed for Geona Creek downstream of the North Wetland outflow. As a conservative approach to determining acceptable outflow water quality for the North Wetland (i.e., the final outflow of the multiple step passive treatment system), the outflow concentrations were compared to the pWQO proposed for Geona Creek (Table 2).

In the first iteration, outflow water quality was modelled for a single CWTS footprint (North Wetland). A single CWTS at the North end of the project resulted in predicted improvement of water quality; however, especially in periods of high flow, the decrease in concentrations of COPIs was predicted to be less than would be desired. As such, a second iteration of design was undertaken, with a second CWTS added at the outflow of ABM Lake (South Wetland), with the outflow of the South Wetland feeding the North Wetland along with other site runoff and impacted waters. This second iteration further improved water quality, however, some COPIs were still predicted to be higher than pWQOs in Geona Creek. Therefore, a third iteration of design and modelling was undertaken, with inclusion of *in situ* treatment within ABM Lake to pre-treat water flowing to the South Wetland. In this third and final iteration of the design, the water was modelled to be pre-treated in ABM Lake, which then flows to the South Wetland for continued treatment, and then flows north and mixes with other site impacted waters to receive final treatment in the North Wetland before leaving the site (Figure 4). In this final iteration of the multi-step passive treatment system design, zinc is fully treated within ABM Lake and is below the Geona Creek pWQO through the remainder of the treatment systems and therefore not modelled within the CWTS.

7.3.1. South Wetland

Pre-treated water will flow from ABM Lake to the South Wetland for continued treatment. The conceptual size of the South Wetland is 17,000 m^2 (1.7 ha), containing 8 cells, each cell an area of 2,116 m^2. The conceptual layout of the South Wetland is provided in Figure 5.



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CONCEPTUAL DRAWING AND FOR ILLUSTRATION PURPOSES ONLY; FEATURES ARE NOT TO SCALE

ALEXCO ENVIRONMENTAL GROUP

	Reclaimed and Revegetated Mine Feature Footprint		Constructed Wetland Treatment System
	Mine Feature Footprint		Seepage
	ABM Pit Lake @ 1380 masl		Watercourse
	Surface Water Monitoring Station		Diversion Ditch
	Modelled Location		Catchment
			Surface Flow Direction

WMP - Water Management Pond
WTP - Water Treatment Plant

KUDZ ZE KAYAH PROJECT

FIGURE 4
POST CLOSURE
WATER MANAGEMENT SCHEMATIC

DRAWN BY GIS	JANUARY 2017	VERIFIED BY KW

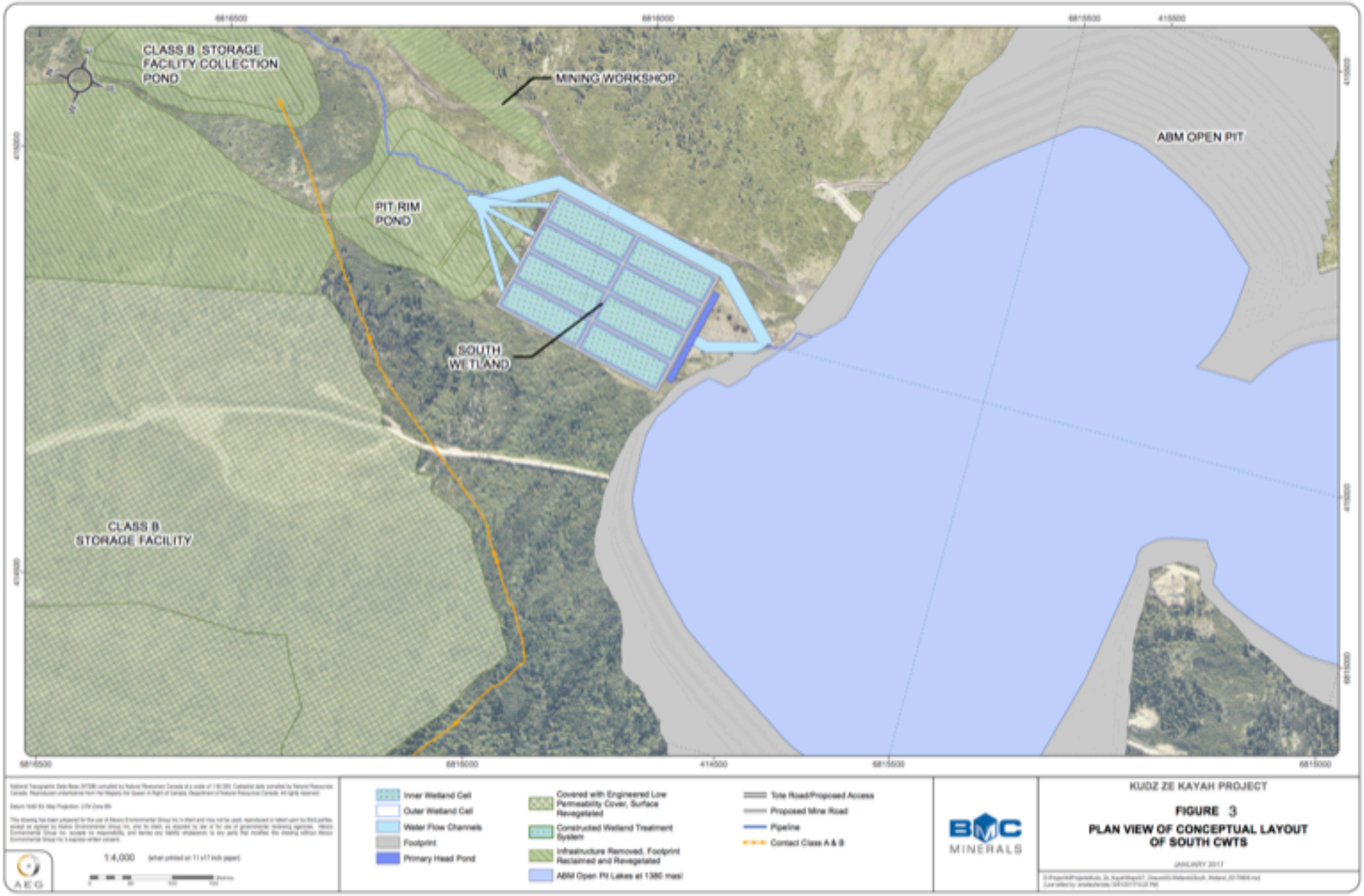

Figure 5 — Conceptual layout of the South Wetland.

7.3.2. North Wetland

The Lower Water Management Pond (LWMP) has been selected as the location for the construction of the North Wetland in the closure period for the following reasons:

- The operational LWMP structure will provide a source of CWTS construction materials (LWMP Dam);
- The footprint of the LWMP will be previously disturbed, and a CWTS in this location would not disturb additional area; and
- This is the location of the final discharge of combined site seepage and runoff, with no substantial project related water quality influences downstream (i.e., final polishing location).

Figure 6 below shows a conceptual rendering of what the LWMP CWTS would look like (looking South) in the post-closure period, and the same conceptual layout is presented in plan view in Figure 7.

Outflow from the South Wetland will flow north, mixing with other site impacted waters, and receive final treatment in the North Wetland before discharging and flowing towards Geona Creek. The conceptual size of the North Wetland is 16,500 m^2 (1.65 ha), containing 16 cells, with varying areas. The conceptual layout of the North Wetland is provided in Figure 7.

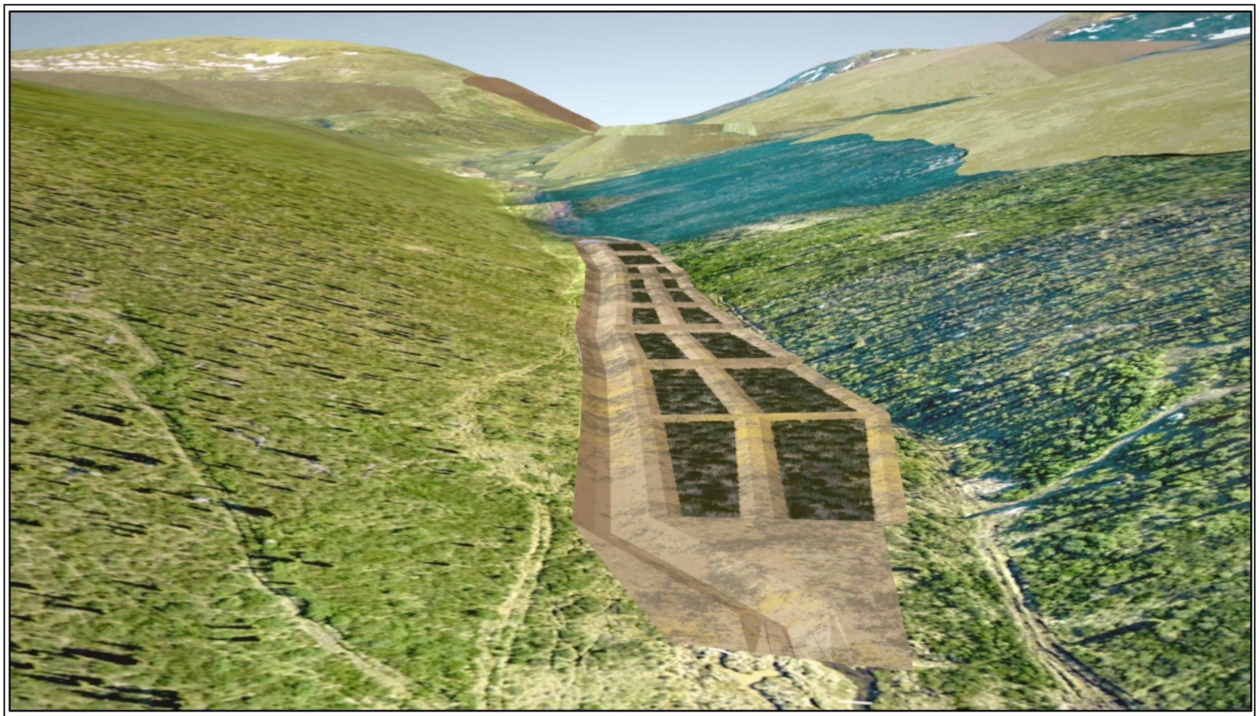

Figure 6 - Conceptual Rendering of LWMP CWTS during Post-Closure Period.

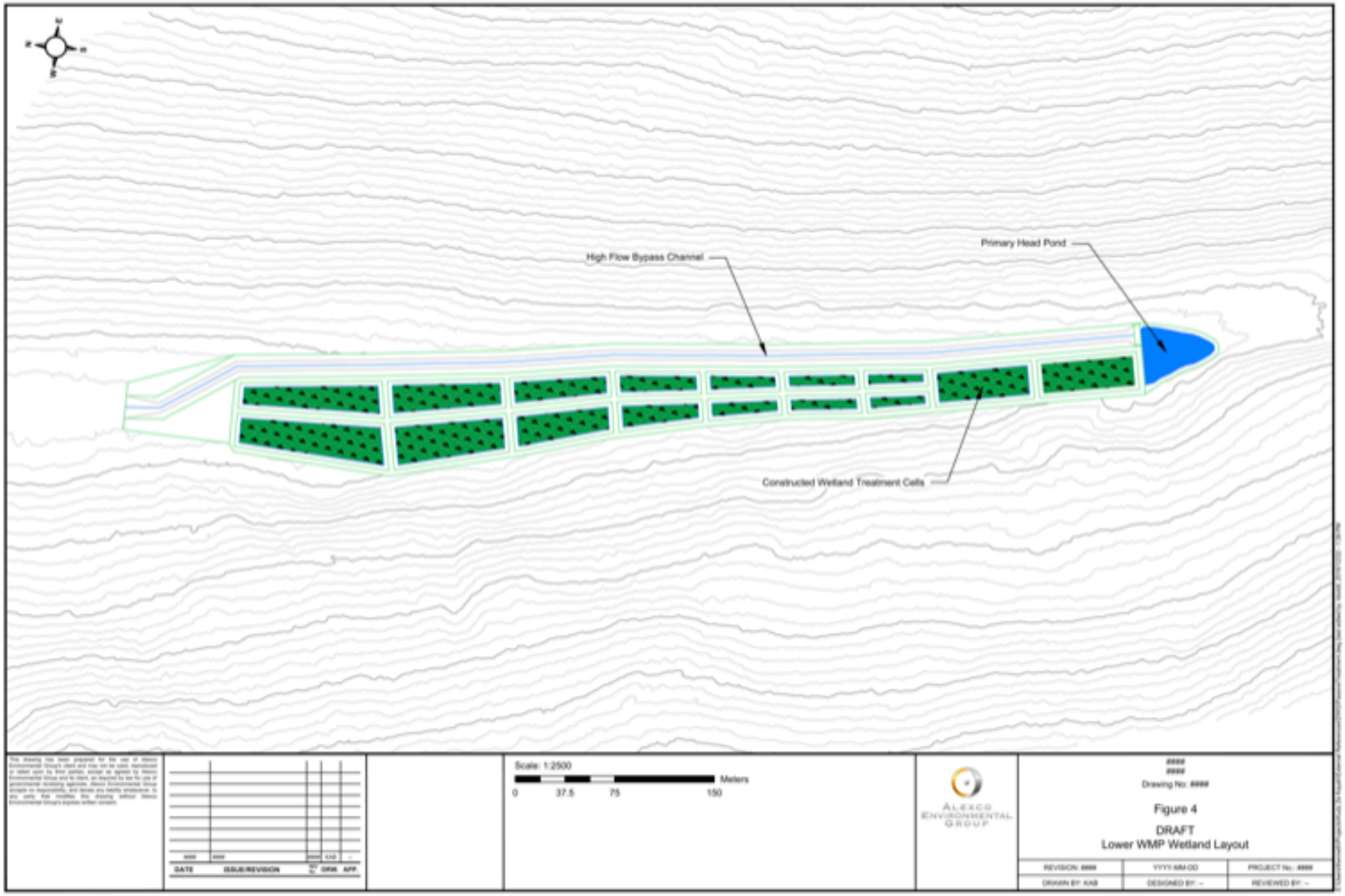

Figure 7 — Conceptual layout of the North Wetland.

7.4. Linear Flow Velocity

The linear flow velocity at the narrowest point in the North Wetland was determined for each month in the mean, wet, and dry scenarios of year 27 to year 50 post-closure to assess the treatment potential or risks associated with flow and COPI concentration variations (Alexco, 2016, 2017). The linear flow velocity is determined using the flow rate and the cross-sectional area of a point in the conceptual CWTS. A linear flow velocity greater than 10 cm/s is not conducive to settling, and therefore, does not allow for effective treatment (Rodgers and Castle, 2008). Furthermore, a linear flow velocity greater than a set value dependent on the grain size of the hydrosoil could result in scouring, and therefore, damage to the wetland. Figure 8 illustrates the Hjulström Curve which is used to predict the flow required to erode sediments of a given grain size. Assuming the CWTS are constructed with a substrate of coarse sand, the velocity required to cause erosion or scouring of the wetland substrates is 35 cm/s (and is a conservative estimate as the vegetation will provide further soil stabilization and prevention of erosion). The highest theoretical linear flow velocity is calculated by using the highest flow period and the narrowest point in the CWTSs (which is in the North Wetland), and results in a maximum linear flow velocity of 11.3 cm/s. A flow velocity of 11.3 cm/s is not expected to scour the North Wetland during high flow events. Although the linear flow velocity exceeds 10 cm/s in the narrowest point of the North Wetland in the June and July wet scenario, the water quality model does not suggest that there are inflow constituents exceeding SSQWO during those months. Therefore, the flow velocity is not expected to adversely affect the treatment potential of the constituents of concern during the high flow periods of the wet scenario.

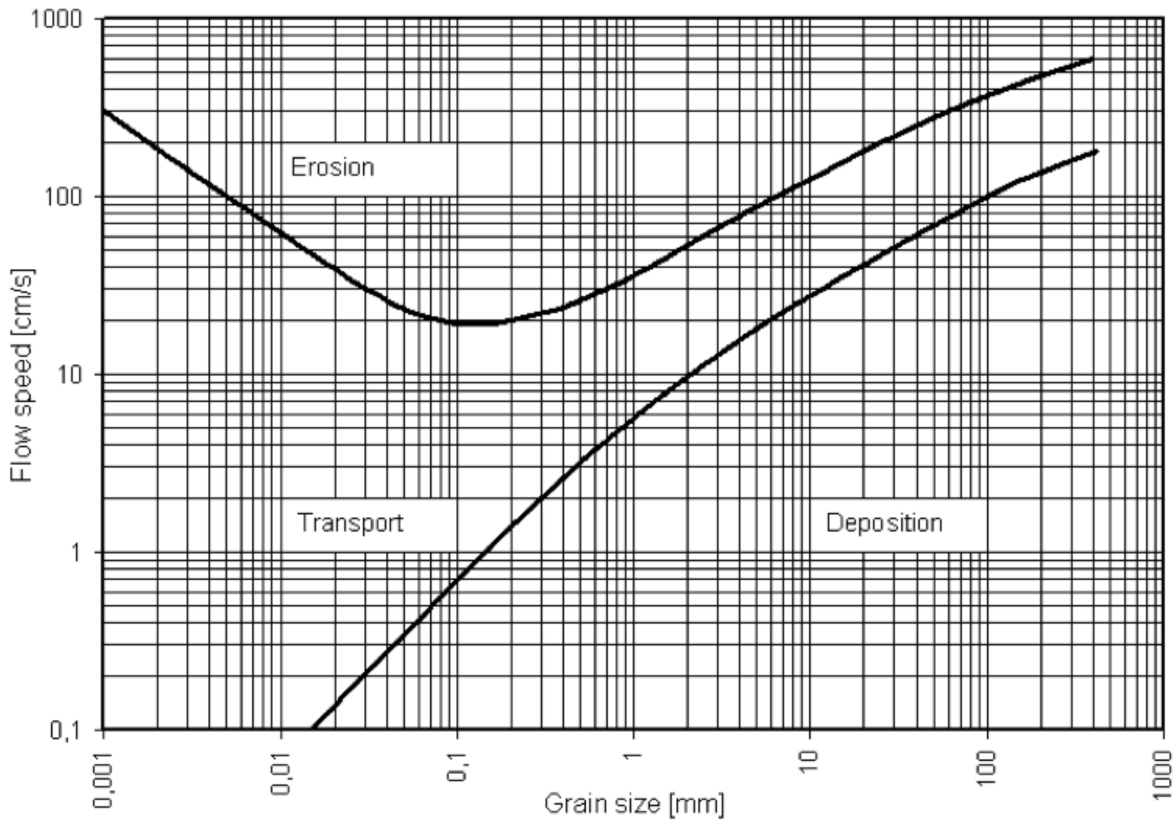

Figure 8 — Hjulström Curve indicates the flow velocity required to erode sediments of a given grain size. In the case of the conceptual CWTS, a minimum grain size of 1 mm is estimated.

8. Results

As a conservative approach to determining acceptable outflow water quality for the North Wetland (i.e., the final outflow of the multiple step passive treatment system), the outflow concentrations were compared to the pWQO developed for Geona Creek. Additionally, as part of the iterative design process, the proposed Geona Creek pWQOs were used to compare the model estimated outflow concentrations of COPIs from ABM Lake and the South Wetland to determine whether additional treatment would likely be needed.

Outflow concentrations based on sensitivity analysis are provided for the COPIs in the South Wetland in Table 4, all COPIs other than selenium were below the pWQO for the North Wetland, and therefore only selenium is provided in Table 5 for the North Wetland. The table includes the removal of the COPIs within the CWTS as the percent removed by comparing inflow and outflow concentrations, and as load removed (g/day). These two measures of treatment are presented here as when flows are higher, the load removed is greater, even though the percent removal may be lower. Therefore, in times of high flow, such as May and June, the load removed will be greater due to the amount going through the CWTS even though the percentage of the COPIs treated will be lower.

8.1. Antimony (Sb)

The conceptual outflow concentrations of Sb from the South Wetland met the pWQO for this element in all scenarios modelled ( ). Moreover, the other water sources contributing from site prior to the North Wetland inflow did not result in an increase of the Sb concentration beyond the pWQO, as such, it was not modelled for treatment in the North Wetland.

8.2. Arsenic (As)

The concentration of As decreased sufficiently through treatment in both the South Wetland and North Wetland to meet proposed Geona Creek pWQO at the outflow of the North Wetland. In almost all cases, the Geona Creek pWQO is met at the outflow of the South Wetland, and only in one modelled case (May, during the wet year scenario) the North Wetland provides final polishing of 0.00013mg/L of arsenic from the water (from 0.00513mg/L to the pWQO of 0.005mg/L)

8.3. Cadmium (Cd) and Uranium (U)

The conceptual outflow concentrations of Cd and U from the South Wetland exceeded the pWQO proposed for Geona Creek. However, the water quality model estimates that after mixing with other site waters, the modelled inflow Cd and U concentrations into the North Wetland are below the targeted pWQO proposed for Geona Creek. Therefore, Cd and U were not modelled for treatment in the North Wetland.

8.4. Nitrite (NO_2)

Nitrite is expected to either rapidly oxidize to nitrate within the CWTS, and result in non-detectable concentrations of nitrite, or be reduced in the anaerobic CWTS. The stoichiometry of the reaction for nitrite oxidizing to nitrate has been calculated, and confirmed that the resulting increase of nitrate concentration is negligible and will not result in any appreciable concentration changes (would be within the method error of the nitrate test analytical method).

8.5. Selenium (Se)

The SSWQO for Se is determined by an equation that is dependent on sulphate concentrations (Alexco, 2016/2017). If this equation is used on the outflow of the South Wetland, the selenium concentration at that point is within acceptable concentrations. However, sulphate concentrations are expected to decrease (with the inflow of additional water sources) prior to the North Wetland, and accordingly, the acceptable calculated selenium concentration also decreases. Therefore, additional treatment is predicted to be needed at the North Wetland.

The inflow (*Ci*) and outflow (*Cf*) concentrations of selenium for the North and South Wetlands were compared with the calculated theoretical acceptable concentration for each outflow (using the sulphate concentration calculation proposed for the SSWQO at Geona Creek). The outflow concentrations of selenium from both the South and North Wetlands are always lower than the theoretical acceptable concentration as calculated using the outflow water sulphate concentrations. However, these concentrations are higher than the proposed calculated SSWQO at Geona Creek because of the lower sulphate concentrations in Geona Creek. Therefore, the maximum allowable outflow concentration of selenium for the North Wetland to Geona Creek was reverse calculated based on the proposed SSWQO in Geona Creek. In all scenarios and months, the outflow concentration (*Cf*) of selenium from the North Wetland is well below the maximum allowable calculated concentration that would be needed to achieve the SSWQO at Geona Creek (Table 4).

8.6. Zinc (Zn)

Zinc is predicted to be fully treated by the *in situ* treatment in ABM Lake and is below the Geona Creek pWQO through the remainder of the treatment systems and therefore not modelled within the CWTSs. The outflow of the North Wetland to Geona Creek is expected to be below the pWQO.

Table 4 — Conceptual outflow concentrations (*Cf*)[1] for 1.7 hectare South Wetland for year 27 post mine closure in the Mean, Wet, and Dry predicted scenarios.

Scenario		Flow (m^3/day)	Antimony				Arsenic				Cadmium				Uranium			
			mg/L		Removal		mg/L		Removal		mg/L		Removal		mg/L		Removal	
			C_i	C_f	%	Load (g/day)	C_i	C_f	%	Load (g/day)	C_i	C_f	%	Load (g/day)	C_i	C_f	%	Load (g/day)
Mean	Jan	2,492	0.013	0.009	30.8	10.0	0.020	0.005	74.9	37.2	0.0008	0.0003	57.9	1.2	0.023	0.015	34.8	19.9
	Feb	2,198	0.013	0.009	30.8	8.8	0.020	0.005	75.0	33.0	0.0008	0.0003	57.9	1.0	0.023	0.015	34.8	17.6
	Mar	1,846	0.013	0.009	30.8	7.4	0.020	0.005	75.1	27.8	0.0008	0.0003	57.9	0.9	0.023	0.015	34.8	14.8
	Apr	4,508	0.013	0.009	30.8	18.0	0.020	0.005	75.1	68.1	0.0008	*0.0004*	44.1	1.6	0.023	0.015	34.8	36.1
	May	12,683	0.013	0.009	30.8	50.7	0.020	*0.009*	40.5	140.4	0.0008	*0.0007*	18.7	1.9	0.023	*0.019*	18.6	54.3
	Jun	14,047	0.013	0.009	30.8	56.2	0.020	*0.010*	48.3	140.4	0.0008	*0.0007*	17.0	1.9	0.023	*0.019*	17.0	54.8
	Jul	8,236	0.013	0.009	30.8	32.9	0.020	0.005	74.6	121.0	0.0008	*0.0006*	27.3	1.8	0.023	*0.017*	27.2	51.5
	Aug	7,479	0.013	0.009	30.8	29.9	0.020	0.005	74.8	110.7	0.0008	*0.0006*	29.6	1.8	0.023	*0.016*	29.5	50.7
	Sep	7,914	0.013	0.009	30.8	31.7	0.020	0.005	74.8	117.3	0.0008	*0.0006*	28.2	1.8	0.023	*0.017*	28.1	51.2
	Oct	5,090	0.013	0.009	30.8	20.4	0.020	0.005	7.8	75.5	0.0008	*0.0005*	40.2	1.6	0.023	0.015	34.8	40.7
	Nov	3,898	0.013	0.009	30.8	15.6	0.020	0.005	74.9	58.2	0.0008	*0.0004*	49.0	1.5	0.023	0.015	34.8	31.2
	Dec	3,035	0.013	0.009	30.8	12.1	0.020	0.005	75.0	45.4	0.0008	0.0003	57.8	1.4	0.023	0.015	34.8	24.3
Wet	Jan	2,611	0.013	0.009	30.8	10.4	0.020	0.005	74.9	39.0	0.0008	0.0003	57.9	1.2	0.023	0.015	34.8	20.9
	Feb	2,289	0.013	0.009	30.8	9.2	0.020	0.005	75.0	34.3	0.0008	0.0003	57.9	1.1	0.023	0.015	34.8	18.3
	Mar	1,904	0.013	0.009	30.8	7.6	0.020	0.005	75.1	28.6	0.0008	0.0003	57.9	0.9	0.023	0.015	34.8	15.2
	Apr	5,852	0.013	0.009	30.8	23.4	0.020	0.005	75.1	88.4	0.0008	*0.0005*	36.1	1.7	0.023	0.015	34.8	46.8
	May	18,240	0.013	0.009	30.8	73.0	0.020	*0.012*	38.4	140.4	0.0008	*0.0007*	13.4	2.0	0.023	*0.020*	13.3	56.0
	Jun	23,381	0.013	0.009	30.8	93.5	0.020	*0.014*	30.4	140.4	0.0008	*0.0007*	10.6	2.0	0.023	*0.021*	10.6	56.8
	Jul	20,021	0.013	0.009	30.8	80.1	0.020	*0.013*	35.6	140.4	0.0008	*0.0007*	12.3	2.0	0.023	*0.020*	12.2	56.3
	Aug	10,539	0.013	0.009	30.8	42.2	0.020	*0.006*	67.2	140.4	0.0008	*0.0006*	22.0	1.9	0.023	*0.018*	21.9	53.2
	Sep	13,008	0.013	0.009	30.8	52.0	0.020	*0.009*	54.4	140.4	0.0008	*0.0007*	18.2	1.9	0.023	*0.019*	18.2	54.4
	Oct	5,507	0.013	0.009	30.8	22.0	0.020	0.005	74.8	81.7	0.0008	*0.0005*	37.9	1.7	0.023	0.015	34.8	44.1
	Nov	4,147	0.013	0.009	30.8	16.6	0.020	0.005	74.9	61.9	0.0008	*0.0004*	46.8	1.6	0.023	0.015	34.8	33.2
	Dec	3,205	0.013	0.009	30.8	12.8	0.020	0.005	75.0	48.0	0.0008	*0.0004*	55.9	1.4	0.023	0.015	34.8	25.6

Dry	Jan	2,099	0.013	0.009	30.8	8.4	0.020	0.005	74.9	31.4	0.0008	0.0003	57.9	1.0	0.023	0.015	34.8	16.8
	Feb	1,896	0.013	0.009	30.8	7.6	0.020	0.005	75.0	28.4	0.0008	0.0003	57.9	0.9	0.023	0.015	34.8	15.2
	Mar	1,653	0.013	0.009	30.8	6.6	0.020	0.005	75.1	24.9	0.0008	0.0003	57.9	0.8	0.023	0.015	34.8	13.2
	Apr	3,749	0.013	0.009	30.8	15.0	0.020	0.005	75.1	56.7	0.0008	*0.0004*	50.3	1.5	0.023	0.015	34.8	30.0
	May	10,037	0.013	0.009	30.8	40.1	0.020	*0.006*	69.7	140.4	0.0008	*0.0006*	23.0	1.8	0.023	*0.018*	22.9	52.9
	Jun	10,751	0.013	0.009	30.8	43.0	0.020	*0.007*	66.2	140.4	0.0008	*0.0006*	21.6	1.9	0.023	*0.018*	21.6	53.3
	Jul	5,513	0.013	0.009	30.8	22.1	0.020	0.005	74.6	81.0	0.0008	*0.0005*	37.8	1.7	0.023	0.015	34.8	44.1
	Aug	5,428	0.013	0.009	30.8	21.7	0.020	0.005	74.8	80.4	0.0008	*0.0005*	38.3	1.7	0.023	0.015	34.8	43.4
	Sep	5,763	0.013	0.009	30.8	23.1	0.020	0.005	74.8	85.4	0.0008	*0.0005*	36.5	1.7	0.023	0.015	34.8	46.1
	Oct	3,910	0.013	0.009	30.8	15.6	0.020	0.005	74.8	58.0	0.0008	*0.0004*	48.8	1.5	0.023	0.015	34.8	31.3
	Nov	3,069	0.013	0.009	30.8	12.3	0.020	0.005	74.9	45.8	0.0008	0.0003	57.4	1.4	0.023	0.015	34.8	24.5
	Dec	2,474	0.013	0.009	30.8	9.9	0.020	0.005	75.0	37.0	0.0008	0.0003	57.9	1.1	0.023	0.015	34.8	19.8

[1]For conservativism, *Cf* values that are below the Geona Creek pWQO are set to equal that concentration. Where the *Ci* or *Cf* concentration is greater than Geona Creek SSWQO, the value is indicated with italic font.
Ci – Initial Concentration (Inflow); *Cf* – Final Concentration (Outflow).

Table 5 — Selenium inflow and outflow concentrations (*Cf*)[1] of the South and North Wetlands compared to the theoretical allowable concentrations based on sulphate-related pWQO calculations and Geona Creek pWQO.

Scenario		South Wetland			North Wetland				Geona Creek
		C_i	C_f	Allowable *Cf* calculated from sulphate concentration	C_i	C_f	Allowable *Cf* calculated from sulphate concentration	Maximum *Cf* allowed to achieve Geona Creek pWQO	pWQO
Mean	Jan	*0.0050*	*0.00290*	0.00531	0.00122	0.00280	0.00280	-	0.00280
	Feb	*0.0050*	0.00294	0.00532	0.00119	0.00294	0.00294	-	0.00294
	Mar	*0.0050*	0.00323	0.00533	0.00114	0.00323	0.00323	-	0.00323
	Apr	*0.0050*	*0.00384*	0.00534	0.00165	0.00265	0.00265	0.0092	0.00265
	May	*0.0050*	*0.00459*	0.00534	*0.00254*	0.00252	0.00252	0.0062	0.00252
	Jun	*0.0050*	*0.00463*	0.00529	0.00217	0.00228	0.00228	0.0067	0.00228
	Jul	*0.0050*	*0.00437*	0.00529	*0.00250*	0.00235	0.00235	0.0071	0.00235
	Aug	*0.0050*	*0.00430*	0.00531	*0.00260*	0.00249	0.00249	0.0075	0.00249
	Sep	*0.0050*	*0.00434*	0.00532	*0.00267*	0.00254	0.00254	0.0069	0.00254
	Oct	*0.0050*	*0.00397*	0.00532	0.00232	0.00257	0.00257	0.012	0.00257
	Nov	*0.0050*	*0.00366*	0.00534	0.00128	0.00250	0.00250	-	0.00250
	Dec	*0.0050*	*0.00328*	0.00535	0.00125	0.00264	0.00264	-	0.00264
Wet	Jan	*0.0050*	*0.00300*	0.00531	0.00123	0.00276	0.00276	-	0.00276
	Feb	*0.0050*	0.00290	0.00532	0.00120	0.00290	0.00290	-	0.00290
	Mar	*0.0050*	0.00318	0.00533	0.00115	0.00318	0.00318	-	0.00318
	Apr	*0.0050*	*0.00411*	0.00534	0.00161	0.00257	0.00257	0.0092	0.00257
	May	*0.0050*	*0.00471*	0.00534	0.00226	0.00248	0.00248	0.0062	0.00248
	Jun	*0.0050*	*0.00478*	0.00529	0.00191	0.00232	0.00232	0.0067	0.00232
	Jul	*0.0050*	*0.00474*	0.00529	0.00181	0.00212	0.00212	0.0071	0.00212
	Aug	*0.0050*	*0.00450*	0.00531	0.00230	0.00251	0.00251	0.0075	0.00251
	Sep	*0.0050*	*0.00460*	0.00532	0.00216	0.00239	0.00239	0.0069	0.00239
	Oct	*0.0050*	*0.00405*	0.00532	0.00226	0.00255	0.00255	0.012	0.00255
	Nov	*0.0050*	*0.00374*	0.00534	0.00129	0.00248	0.00248	-	0.00248

	Dec	*0.0050*	*0.00337*	0.00535	0.00126	0.00261	0.00261	-	0.00261
Dry	Jan	*0.0050*	0.00301	0.00531	0.00119	0.00301	0.00301	-	0.00301
	Feb	*0.0050*	0.00318	0.00532	0.00115	0.00318	0.00318	-	0.00318
	Mar	*0.0050*	0.00350	0.00533	0.00109	0.00350	0.00350	-	0.00350
	Apr	*0.0050*	*0.00361*	0.00534	0.00170	0.00274	0.00274	0.0092	0.00274
	May	*0.0050*	*0.00448*	0.00534	***0.00279***	*0.00263*	0.00255	0.0062	0.00255
	Jun	*0.0050*	*0.00451*	0.00529	*0.00235*	0.00230	0.00230	0.0067	0.00230
	Jul	*0.0050*	*0.00405*	0.00529	***0.00297***	*0.00268*	0.00249	0.0071	0.00249
	Aug	*0.0050*	*0.00404*	0.00531	***0.00308***	*0.00278*	0.00255	0.0075	0.00255
	Sep	*0.0050*	*0.00409*	0.00532	***0.00319***	*0.00289*	0.00266	0.0069	0.00266
	Oct	*0.0050*	*0.00366*	0.00532	0.00272	0.00272	0.00272	0.012	0.00272
	Nov	*0.0050*	*0.00330*	0.00534	0.00127	0.00263	0.00263	-	0.00263
	Dec	*0.0050*	*0.00289*	0.00535	0.00123	0.00281	0.00281	-	0.00281

[1]For conservativism, *Cf* values that are below the Geona Creek pWQO are set to equal that concentration.Where the *Ci* or *Cf* concentration is greater than: Geona Creek SSWQO, indicated with italic font; Allowable Cf calculated from sulphate concentration, indicated with bold italic font (4 cases, *Ci* only); Maximum *Cf* allowed to achieve Geona Creek SSWQO, not indicated as there are no exceedances.
Ci – Initial Concentration (Inflow); *Cf* – Final Concentration (Outflow).

8.7. Sulphate

In general terms, sulphide (reduced form of sulphate) is necessary for metals treatment, but in turn, metals (cations) are required to remove sulphide from solution. Based on stoichiometry, the ratio of sulphide mineral forming metals and metalloids in the water (i.e., Sb, Cd, Fe, etc.) to sulphide suggests that there is a molar ratio of several orders of magnitude excess sulphate compared to cationic metals. The predicted closure water chemistry at the Project therefore suggests that removal of metals and metalloids from the water should be consistently accomplished with little impacts of seasonal variation; however, it also implies that only very minimal sulphate treatment will be achieved passively for these waters.

That is to say, the reason that sulphate concentrations are not expected to decrease greatly in the treatment wetlands is because there are low concentrations of metals to be treated in general. While this is not ideal for sulphate treatment, this does mean that there are sufficient concentrations of sulphate in the water to safeguard against fluctuations of influent metal concentrations.

9. Recommendations and Next Phases of Work

The rates and extents of treatment within this memo are currently at a conceptual level. The size, location, and design of the CWTSs and passive treatment train will continue to be refined and optimized through a phased program throughout the Project design and during construction and operations, and as representative water quality becomes available. This phased program is further outlined in Section 2.1.

The next steps for recommended work are:

1) Refine predictions and sizing through development of site-specific treatment rate coefficients through off-site pilot-scale testing and optimization.
2) On-site demonstration-scale confirmation and optimization.
3) Full-scale implementation.

10. Closure

We trust the information herein satisfies your present requirements. Should you have any questions, please contact the persons listed below. We appreciate the opportunity to provide the services detailed in this report, and look forward to discussing any comments you may have.

Regards,

Contango Strategies Ltd.

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