KENO HILL SILVER DISTRICT MINING OPERATIONS

ADAPTIVE MANAGEMENT PLAN

October 2021

Prepared for:

ALEXCO KENO HILL MINING CORP.

Prepared by:

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

1. INTRODUCTION

This version of the Adaptive Management Plan has been prepared by Alexco Keno Hill Mining Corp ("Alexco" or the "Company") to include the Bermingham Mine in addition to meeting the requirements under QML-0009 and Water Licence (WL) QZ18-044 for the previously outlined project activities. WL QZ18-044 currently specifies the following Licence Clauses:

#58. Within 90 days of the effective date of this Licence, the Licensee must submit to the Board and implement an update to exhibit 1.11.1, Adaptive Management Plan: Keno Hill Silver District Mining Operations (AMP). Updates to the AMP must include:

a) an update of AMP Event 1 to include an update to all mass load models with annual validation data collected;
b) an update of AMP Event 12 to include:
    i. the integration of WQOs at KV-111 between May and September; and,
    ii. insight into the establishment of an adaptive WQO at KV-21 which captures projected changes to the water quality within the No Cash Catchment;
c) the development of a site specific WQO for arsenic with the following conditions:
    i. update the AMP to reflect the new WQO for arsenic as per exhibit 1.15.1, Giant Mine Remediation Project: Effluent Quality Criteria Report, Appendix F, Site-Specific Water Quality Objectives; and
    ii. validate the 2019 Giant Mine arsenic WQO with site specific data over the four years from the issuance of this Licence. If validation suggests that a more conservative WQO should be implemented, the Licensee must develop, implement and submit an updated AMP which reflects the new site-specific arsenic WQO by December 31, 2024;
d) the incorporation of kinetic and static testing results from the monitoring outlined in the WRMP; and
e) the addition of ammonia, zinc, cadmium, selenium and uranium to the parameters being used to establish thresholds and monitor trends for changes in water quality.

The updates to Exhibit 1.11.1 addressed in this AMP are outlined in Table 1-1.

Table 1-1: Clause 58 Updates to Exhibit 1.11.1 of QZ18-044

Clause 58 Item	Description
a) an update of AMP Event 1 to include an update to all mass load models with annual validation data collected	The requirement to update the Christal Creek, Lightning Creek, and No Cash Creek mass load models annually has been added to AMP Event 1 (Section 4.1.1.3).
b) an update of AMP Event 12 to include: i) the integration of WQOs at KV-111 between May and September; and, ii) insight into the establishment of an adaptive WQO at KV-21 which captures projected changes to the water quality within the No Cash Catchment	i) WQOs for station KV-111 are now included in Table 4-9. ii) Section 4.12.4 includes text indicating that Alexco will hold a workshop with representatives of the three governments to develop a mechanism to update the WQO at KV-21 once treatment of the historical No Cash 500 adit has been implemented. A candidate approach to updating the KV-21 WQO is also presented.
c) the development of a site specific WQO for arsenic with the following conditions: i) update the AMP to reflect the new WQO for arsenic as per exhibit 1.15.1, Giant Mine Remediation Project: Effluent Quality Criteria Report, Appendix F, Site-Specific Water Quality Objectives; and ii) validate the 2019 Giant Mine arsenic WQO with site specific data over the four years from the issuance of this Licence. If validation suggests that a more conservative WQO should be implemented, the Licensee must develop, implement and submit an updated AMP which reflects the new site-specific arsenic WQO by December 31, 2024	i) The arsenic WQO for KV-21 has been updated accordingly (0.025 mg/L) ii) Work to validate the arsenic WQO will be conducted between 2020 and 2024. Should that research indicate that a more sensitive arsenic WQO be appropriate, it will be incorporated into the AMP by December 31, 2024.
d) the incorporation of kinetic and static testing results from the monitoring outlined in the WRMP	AMP Event 2 includes review of waste rock geochemical testing data, particularly kinetic testing, as part of the monitoring requirements and specific thresholds.
e) the addition of ammonia, zinc, cadmium, selenium and uranium to the parameters being used to establish thresholds and monitor trends for changes in water quality	These parameters are included for both the surface water and groundwater AMP Events 12 and 13, respectively.

In addition, it should be noted that this AMP will be reviewed and updated as required to incorporate any modifications to the designs of the new facilities that have not been constructed as of this date. Annual reviews and updates of the AMP will also occur to incorporate new monitoring data collected in the previous year and evaluation of monitoring locations, triggers and thresholds be completed.

2. ALEXCO ACTIVITIES IN THE KHSD

2.1 ACTIVITIES

Alexco and its subsidiary companies are undertaking care and maintenance, exploration and development, active mining and mill processing activities, and closure studies in the Keno Hill Silver District which includes various activities:

Principal activities - Bermingham, Flame & Moth, and Bellekeno Deposits Production and District Mill:

- Mining ore and waste rock from Bermingham, Flame & Moth, and Bellekeno deposits;
- Placement of potentially acid metal leaching (P-AML) rock within engineered waste rock storage facilities;
- Placement of non-acid metal leaching (N-AML) rock in waste rock disposal areas;
- Construction of earthworks and erosion control protection;
- Crushing, grinding, flotation, thickening, filtration, and production of a lead concentrate, zinc concentrate, and tailings streams related to the lead flotation circuit and the zinc flotation circuit;
- Placement of tailings in the engineered Dry Stack Tailings Facility;
- Placement of tailings and P-AML rock in a cemented rock backfill within the former vein areas;
- Water treatment of water from Bermingham, Bellekeno and Flame & Moth Mines, and potentially from the District Mill;
- Use of water for camp purposes and quartz mining undertakings;
- Use of water and wastewater for lime mixing operations;
- Use of water for milling operations; and
- Environmental monitoring, including dust, noise, surface water, groundwater and treated mine water prior to discharge.

Principal activities - Exploration, Development, Care and Maintenance and Closure:

- Surface drilling and advanced underground exploration with view to mine development;
- Direct use of water for camp purposes and quartz mining undertakings;
- Direct use of water and wastewater for lime and reagent mixing operations;
- Deposit of waste into water and receiving environment;
- Waste rock storage;
- Construction and upgrades to access roads;
- Operation and maintenance of four existing wastewater treatment facilities and associated settling ponds using lime treatment (Onek 400, Silver King 100, Galkeno 900, and Galkeno 300 and the Valley Tailings Area);
- Deposit of waste as lime treatment sludge;
- Construction of earthworks and erosion control protection;
- Storage of wastewater in the treatment settling ponds and Valley Tailings Area; and

- Maintenance of existing diversion channels (Porcupine Creek) and ditches.

Ancillary activities:

- Maintenance and operation of site infrastructure related to water treatment systems and access roads;
- Site security and maintenance of site facilities and structures for public health and safety;
- Transport of milk of lime solutions to treatment sites;
- Periodic desludging of treatment settling ponds and transportation or pumping to sludge storage areas which are periodically decanted;
- Mine dewatering for care and maintenance purposes and to advance underground exploration or development;
- Water sampling (effluent and receiving waters);
- Waste rock analysis and classification;
- Environmental monitoring, inspections and sample programs, including monitoring and inspection of physical structures;
- Removal of blockages that have formed naturally or cofferdams that have been constructed as temporary structures to avoid uncontrolled discharge of mine pool water;
- Removal and clean up of infrastructure related to adits, adit structures and facilities;
- Wastewater treatment studies and test programs related to potential closure design options; and
- Operation, inspection, and maintenance of the Valley Tailings Area.

2.2 PLANS IN PLACE

Alexco recognizes that the activities associated with the Bermingham, Flame & Moth, and Bellekeno deposits and the District Mill are being performed in a historic mining district which includes waters and physical workings at the Keno Hill Silver District that could potentially become an environmental risk or hazard that do not yet require immediate attention. The discharge of treated water, the future discharge of water from the District Mill area, and placement of water treatment sludge is being performed in watersheds that are impacted by historic mining operations. The development of a United Keno Hill Mines Reclamation Project is intended to address these water discharges and workings which require further intervention over the long term. As the closure work is implemented, it is expected that changes in the environmental status of the KHSD will be observed.

Several plans are currently in place pursuant to the existing licences and approvals and are referenced throughout this AMP. Table 2-1 lists these plans that have been created or updated as part of Water Licence QZ18-044 and the Quartz Mining License QML-009 to guide the management of activities and monitoring associated with operation of the Bermingham, Flame & Moth, and Bellekeno deposits, and District Mill.

Table 2-1: Plans Under the Existing Mine Licenses to be Updated

QML-009 Plans	WL QZ18-044 Plans
· Emergency Response Plan · Hazardous Materials Management Plan · Heritage Resources Protection Plan · Monitoring, Surveillance and Reporting Plan · Noise Monitoring and Management Plan · Traffic Management Plan · Wildlife Protection Plan · Mine Development and Operation Plan · Mill Development and Operation Plan · Dry Stack Tailings Facility Construction and Operation Plan · Waste Rock Management Plan · Dust Abatement and Monitoring Plan · Reclamation and Closure Plan	· Sludge Management Plan · Groundwater Monitoring Plan · Hydrogeology Monitoring Plan · Water Management Plan · Tailings Characterization Plan · Physical Inspections and Reporting Plan · Monitoring, Surveillance and Reporting Plan · Spill Contingency Plan · Waste Management Plan · Reclamation and Closure Plan · Christal Creek Attenuation Study Plan · No Cash Creek Attenuation Study Plan · Bioreactor Design and Operation Plan · Operations and Maintenance Plan

3. ADAPTIVE MANAGEMENT PLAN OVERVIEW

3.1 ADAPTIVE MANAGEMENT PLAN OBJECTIVES

An adaptive management plan (AMP) is a management tool designed to guide responses to unforeseen or contingency events respecting, for example, water quality and quantity and physical conditions of site workings and infrastructure. The adaptive management approach will provide for assessment of mitigation measures and their effectiveness and guide the orderly implementation of responses. Since it is difficult to predict the specific environmental conditions that may arise and which require a response from management, the AMP does not necessarily provide specific detailed descriptions of responses to every situation. The AMP provides a range of possible responses to use as a guide to respond to specific environmental conditions encountered. Management should use the information provided in the AMP and adapt the appropriate response from this guide, which is the sole purpose of an AMP.

The AMP framework encompassing Company management activities includes:

- routine inspection and environmental monitoring, maintenance and reclamation;
- routine assessment of monitoring and performance data;
- performance thresholds for implementation of appropriate levels of responses for planned contingency measures; and
- reporting of monitoring results and actions.

Results of the monitoring programs (Section 2.2 – Plans in Place) will be assessed on an ongoing basis to determine if any negative trends in water quality, quantity or other parameters are occurring. If the results indicate that there are no negative environmental impacts, then the frequency and length of monitoring and maintenance would continue as usual. Adaptive management will be implemented to respond to negative trends observed through the monitoring programs.

3.2 AMP EVENTS SUMMARY

The district-wide closure AMP identified a number of “events” which represent potential environmental conditions that would require a management response, if they were to occur; these are the first five “events” listed below. The Bellekeno WL clause 91 added nine additional “events” which are in addition to the ones previously identified in the District-wide closure AMP, identified as “events” 6 through 14 listed below. Four additional “events” were identified in WL QZ09-092, amendment 1, which included two events associated with the Onek and Lucky Queen deposits. Events 15 and 16 were developed for Flame & Moth and events 17 and 18. Additionally, the proposed Bermingham mine has been incorporated into the existing AMP events as part of WL QZ18-044, and reference to Onek and Lucky Queen has been removed since neither deposit is licenced under QZ18-044.

1) Change in Water Quality or Quantity:

- Including, the identification and assessment of trends in water quality in discharges from the Keno Hill Silver District Mill or the Bermingham, Bellekeno, or Flame & Moth Mine sites for parameters with and without effluent discharge standards. Assessment of trends and changes in water quantity from the Keno Hill Silver District Mill or the Bermingham, Bellekeno, or Flame & Moth Mine sites.

2) N-AML Waste Rock Disposal Area(s) Seepage Exhibits AML:
    - Waste rock disposal area(s) (including where used for road and general construction) runoff trending to AML conditions;
    - Identification of water quality changes from N-AML Waste Rock, including results from kinetic testing; and
    - Waste rock screening criteria or segregation protocols are ineffective.
3) Sludge Storage Area Effectiveness Compromised:
    - Seepage observed near sludge storage area; and
    - Sludge storage area approaching capacity.
4) Physical Instabilities:
    - Area of significant subsidence is observed;
    - Rock fall or landslide occurs within a monitored area; and
    - Structure failure or portal collapse.
5) Site Security Compromised:
    - Gate, Fence or Sign Damaged.
6) Development of High Pore Pressures Underneath the DSTF;
7) Development of Significant Erosion of Exposed DSTF Surfaces;
8) Development of Erosion at the District Mill Site and Flame & Moth Discharge Areas;
9) Transport of Sediment from the District Mill Site and Flame & Moth Discharge Areas;
10) Development of Large Differential Settlements at the DSTF or Approved Waste Rock Storage Facilities;
11) Development of Large Differential Settlements Along the Conveyance Flume from the DSTF to the District Mill Site collection and sediment pond;
12) Exceedance of Water Quality Objectives in the Receiving Environment Occurring Irrespective of Compliance with Effluent Discharge Standards;
13) Identification of Groundwater Quality Impacts at the Bermingham Flame & Moth, and Bellekeno Mines or the District Mill Site and Dry Stack Tailings Facility;
14) Fugitive Dust Generated from the DSTF Results in the Exceedance of Yukon Ambient Air Quality Standards or TSP Metal Guidelines; and
15) Attenuation of the Flame & Moth Discharge to Christal Creek or Bermingham Discharge to No Cash Creek Does Not Perform as Predicted.

The AMP response for each of these events is described individually in subsequent sections. Table 3-1 at the end of this section provides a summary of the approach to AMP events. The table summarizes the narrative triggers, indicators and response thresholds, monitoring locations and parameters.

3.3 AMP APPROACH

For each AMP event a methodical approach is provided:

1) Description of the event and possible environmental consequences - Addresses issues or information that trigger the AMP;
2) Location of possible event occurrence – Identifies specific working site locations if applicable to event;
3) Monitoring requirements – Identifies the parameters to be monitored, frequency and means for monitoring each parameter;
4) Specific indicators and thresholds - Defines the conditions when management actions should be taken. There may be a series of indicators and staged thresholds for an individual event; and
5) Approach to responses – Description of the approach to responses including a simplified flow chart to guide the implementation process if any specific thresholds have been crossed.

Table 3-1: AMP Summary

Event	Narrative Trigger	Indicators	Thresholds	Monitoring Locations	Monitoring Parameters
1. CHANGE IN WATER QUALITY OR QUANTITY					
a. Significant change in water quality of Bellekeno water treatment plant discharge, District Mill decant pond, Bermingham water treatment pond decant or Flame & Moth water treatment pond decant	Decline in discharge pH noted or effluent quality trending towards possible exceedance of standards or exceeds licenced standards.	All effluent quality standard parameters	Bellekeno and Mill discharge: Treated effluent: TSS>20 mg/L for three consecutive days; OR pH < 7.0 for three consecutive days; OR total zinc > 0.40 mg/L and pH < 7.0 for three consecutive days; OR total cadmium > 0.0075 mg/L and pH < 7.0 for three consecutive days; OR total arsenic > 0.075 mg/L and pH < 7.0 for three consecutive days; OR ammonia > 4.0 mg/L and pH > 9.0 for three consecutive days; OR weekly samples exceeds Effluent quality standards (EQS). Flame& Moth or Bermingham Discharge: Treated effluent: pH < 7.0 for three consecutive days; OR zinc or ammonia trending towards exceedance of EQS; OR three consecutive samples exceed 80% of the EQS; OR weekly sample exceeds EQS.	Bellekeno Water Treatment Facilities (KV-43), Mill Decant pond (KV-83), Flame & Moth settling pond decant (KV-104), Bermingham settling pond decant (KV-114)	Routine in-situ including ammonia and on-site total zinc, external multi-element ICP, hardness, pH, conductivity, TSS, ammonia
b. Significant change in water quality of adit discharge	Significant decline in field pH or increase in conductivity, zinc, cadmium or ammonia from mine adit discharge to treatment plant	Field pH and conductivity, zinc, cadmium, ammonia	Adit discharge field pH more than 1 pH standard unit lower than historical average or increasing trend towards historical maximum for ammonia, conductivity, cadmium, and zinc	Bellekeno adit (KV-42), Flame & Moth adit (KV-105), Bermingham adit (KV-110)	Same as indicators
c. Bellekeno adit discharge quantity significantly increases	Observed or measured flows display a sustained and statistically significant increase over historical flow conditions	Flow	Increase of flow to within 10% of the licenced maximum discharge rate (864 m^3/day) for seven consecutive days	Bellekeno Water Treatment Facilities (KV-43)	Same as indicators

Event	Narrative Trigger	Indicators	Thresholds	Monitoring Locations	Monitoring Parameters
d. Flame & Moth or Bermingham underground workings inflow rate significantly greater than expected resulting in greater discharge than predicted	Observed or measured flows display a sustained and statistically significant increase over predicted monthly inflow conditions	Flow	Increase of flow rate to within 10% of 3,024 m^3/day for seven consecutive days for Flame & Moth or increase of flow rate to within 10% of 1,200 m^3/day for seven consecutive days for Bermingham	Flame & Moth adit (KV-105) and Bermingham adit (KV-110)	Same as indicators
e. Identification and assessment of trends in water quality in discharges from the District Mill or the Bermingham, Bellekeno or Flame & Moth Mine sites for parameters without effluent discharge standards	Effluent quality trending towards decreased water quality	Parameters without effluent discharge standards (i.e., nitrate, nitrite, selenium, uranium, sulphate)	Increasing trend resulting in exceedance of water quality objectives in receiving environment	Bellekeno Water Treatment Facilities (KV-43), Mill Decant pond (KV-83), Flame & Moth pond decant (KV-104L/C), Bermingham pond decant (KV-114)	Same as indicators
2. WASTE ROCK SEEPAGE EXHIBITS AML					
a. Waste rock seepage or runoff trending to AML conditions	Seepages from waste rock disposal areas or from works constructed or upgraded with N-AML material show significant decline in pH or alkalinity and/or an increase in conductivity, sulphate, zinc or cadmium OR approaching licenced effluent quality standards	pH, conductivity, zinc, cadmium, sulphate, alkalinity	Significant decline in pH between measurements or pH <7.0 and/or conductivity, zinc, cadmium, or sulphate or showing a significant increasing trend or alkalinity shows a significant decreasing trend; OR indicators approaching licenced effluent quality standards	Bellekeno 625 seep and WRDA, Bermingham WRDA and works or features constructed from N-AML material including Bellekeno Haul road, Mill area	pH, conductivity, alkalinity, sulphate, routine multi-element ICP
b. Identification of water quality changes from N-AML Waste Rock or tailings, including results from kinetic testing	Kinetic testing of N-AML waste rock or tailings shows significant decline in pH or alkalinity and/or an increase in conductivity, sulphate, zinc or cadmium	pH, conductivity, zinc, cadmium, sulphate, alkalinity	Significant decline in pH between measurements or pH <6.0 and/ or conductivity, zinc, cadmium or sulphate showing a significant increasing trend or decreasing trend in alkalinity; OR indicators approaching licenced effluent quality standards	Field bins or humidity cells with N-AML waste rock or tailings, DSTF and waste rock disposal areas	pH, conductivity, alkalinity, sulphate, routine multi-element ICP
3. SLUDGE STORAGE AREA EFFECTIVENESS COMPROMISED					

Event	Narrative Trigger	Indicators	Thresholds	Monitoring Locations	Monitoring Parameters
a. Seepage observed near sludge storage areas	Routine inspection of sludge storage area shows seepage	Total zinc, cadmium, pH	pH <7.5, total zinc > 0.5 mg/L, total cadmium > 0.01 mg/L	DSTF, Valley Tailings, and Bermingham SW pit sludge storage areas	Same as indicator
b. Sludge storage area approaching capacity	Sludge storage area approaching minimum freeboard of 1.0 metre below the decant point	Visual observation of freeboard	Freeboard is at 1.5 metre below decant point	DSTF, Bermingham SW pit and Valley Tailings sludge storage cell	Same as indicator
4. PHYSICAL INSTABILITIES					
a. Area of significant surface subsidence has occurred	An observed subsidence has exposed an opening to surface or resulted in slope failure	Visible slope failure, ground subsidence or opening on surface	Opening to underground workings or area of subsidence effects public safety or down gradient environment	Keno Hill Silver District Mining Operations	Same as indicators
b. Rock fall or landslide is observed that affects road right-of-way or intrudes into stream	An observed rock fall or landslide effects a road right-of-way, infrastructure or intrudes into stream	Mine source material movement	Source material affects road or stream	Keno Hill Silver District Mining Operations	Same as indicators
5. SITE SECURITY COMPROMISED					
a. Security gate, fence, sign damaged	Public health and wildlife safety measure damaged or removed	Sign, fence, gates, locks	Security feature damaged, removed, or compromised	Keno Hill Silver District Mining Operations	Same as indicators
6. DEVELOPMENT OF HIGH PORE PRESSURES UNDERNEATH OR WITHIN THE DSTF					
a. High porewater pressure within groundwater monitoring wells in the DSTF	Porewater pressure is observed in groundwater monitoring wells in the DSTF	Porewater pressure	Tip @1.0m or 1.7m depth – Porewater pressure parameter (Ru) exceeds 0.15	Groundwater monitoring wells in the DSTF	Same as indicators
7. DEVELOPMENT OF SIGNIFICANT EROSION OF EXPOSED DSTF SURFACES					
a. Area of significant erosion on exposed DSTF surface	An observed movement of tailings caused by erosion on surface	Visual inspection of tailings surface	Geotechnical engineer or operator inspection identifies adverse operating condition	DSTF	Same as indicators

Event	Narrative Trigger	Indicators	Thresholds	Monitoring Locations	Monitoring Parameters
8. DEVELOPMENT OF EROSION AT THE DISTRICT MILL OR FLAME & MOTH SITE DISCHARGE AREAS					
a. Erosion at the District Mill or Flame & Moth site discharge areas	Erosion and ground degradation is observed in area downgradient of the discharge locations	Visual inspection of area downgradient of discharge location	Geotechnical engineer or operator inspection identifies adverse operating condition	Visual inspection of area downgradient of discharge locations	Same as indicators
9. TRANSPORT OF SEDIMENT FROM THE DISTRICT MILL SITE, BERMINGHAM, OR FLAME & MOTH DISCHARGE AREAS INTO CHRISTAL CREEK					
a. Transport of sediment from the Mill site or Flame & Moth discharge areas to Christal Creek	An observation of significant erosion is observed in area downgradient of the discharge location resulting in high TSS discharge	TSS in discharge after final control point and visual inspection of area downgradient of discharge locations	TSS of 20 mg/L in daylighted discharge. TSS of 15 mg/L greater than monthly seasonal average calculated from existing conditions concentration at KV-50 and KV-21. TSS at KV-81 in Lightning Creek is 25 mg/L higher than upstream of Flame & Moth discharge area on Lightning Creek.	Area downgradient of Mill pond discharge (KV-83), Flame & Moth pond decant (KV-104), and Bermingham pond decant (KV-110)	TSS
10. DEVELOPMENT OF LARGE DIFFERENTIAL SETTLEMENTS AT THE DSTF					
a. Significant differential settlements are observed in the DSTF	An observation of significant differential settlements is observed at the DSTF	Displacement of survey monitors and slope indicators	Displacements greater than 25 mm in any direction	Survey monuments and slope inclinometers	Same as indicators
11. DEVELOPMENT OF LARGE DIFFERENTIAL SETTLEMENTS ALONG THE CONVEYANCE FLUME FROM THE DSTF TO DISTRICT MILL SITE COLLECTION AND SEDIMENT POND					
a. Significant differential settlements are observed along the conveyance flume	An observation of significant differential settlements is observed in the conveyance flume	Displacement of survey monuments	Displacements greater than 25 mm in any direction	Survey monuments	Same as indicators
12. EXCEEDANCE OF WATER QUALITY OBJECTIVES IN THE RECEIVING ENVIRONMENT OCCURRING IRRESPECTIVE OF COMPLIANCE WITH EFFLUENT QUALITY STANDARDS					
a. A significant increasing trend is observed in receiving environment even though authorized licenced discharges	Receiving environment water quality are trending towards exceeding the WQOs or exceed the WQO.	Arsenic, cadmium, copper, lead, nickel, selenium, silver, uranium, zinc, ammonia, nitrate, nitrite, sulphate	Trending towards or exceedance of water quality objective at a receiving environment monitoring station based on	Receiving environment monitoring stations (Christal Creek at KV-50, KV-6, and KV-7,	Same as indicators

Event	Narrative Trigger	Indicators	Thresholds	Monitoring Locations	Monitoring Parameters
are within effluent quality standards; Exceedance of WQO			seasonal norms compared to preceding 3 years data.	Lightning Creek at KV-81, No Cash Creek at KV-111 and KV-21, and Star Creek at KV-56)	
13. IDENTIFICATION OF GROUNDWATER QUALITY IMPACTS WITHIN THE KENO HILL SILVER DISTRICT MINING OPERATIONS					
a. A significant increasing trend is observed in groundwater near the District Mill (including DSTF) or N-AML Waste Rock Disposal Areas	Constituent concentration exceeds baseline measurements for a given monitoring well or shows statistically significant increasing trend	Sulphate, ammonia, nitrite, nitrate, dissolved arsenic, cadmium, copper, lead, nickel, selenium, silver, uranium, and zinc	Exceedance of the 95th percentile for constituents that have a surface water quality objective OR YCSR standard. Statistically significant increasing trend compared to past three years of data	KV-85 to KV-89, KV-107, KV-108, KV-109, BH-39, KV91 to KV-94, KV-116, RB-MW-1, NC-MW-1, KV-122, KV-123, KV125, KV-127	Same as indicators
b. Water level within groundwater monitoring wells in the DSTF and water quality is approaching KV-83 EQS	Water level is observed in monitoring wells within the DSTF	Water level, ammonia, dissolved arsenic, cadmium, copper, lead, nickel, silver, and zinc	More than 30 cm of water is in well and water quality trending towards KV-83 EQS	Groundwater monitoring wells in the DSTF (BH39, KV-107)	Same as indicators
14. FUGITIVE DUST GENERATED FROM THE DSTF RESULTS IN THE EXCEEDANCE OF YUKON AMBIENT AIR QUALITY STANDARDS					
a. Dust generated from the DSTF exceeds Yukon ambient air quality standards and metal guidelines	An increasing trend in fugitive dust from the DSTF and/or haul roads is observed	TSP, PM10, PM2.5 and metals	An increasing trend in TSP, PM10 or PM2.5 measurements or in metal concentrations towards Yukon Ambient Air Quality Standards or Ontario Ambient Air Quality Criteria for metals; An exceedance of the Yukon Ambient Air Quality Standards for particulate matter or the Ontario Ambient Air Quality Criteria for metals in TSP at AQ3.	AQ1, AQ2 and AQ3	Same as indicators

Event	Narrative Trigger	Indicators	Thresholds	Monitoring Locations	Monitoring Parameters
15. ATTENUATION OF THE FLAME & MOTH OR BERMINGHAM DISCHARGE TO CHRISTAL CREEK AND NO CASH CREEK, RESPECTIVELY, DOES NOT PERFORM AS PREDICTED					
a. Natural attenuation does not remove metals to the degree expected from Flame & Moth or Bermingham Mine discharge and water quality in Christal Creek or No Cash Creek may be degraded and not meet the water quality objectives	The calculated natural attenuation at KV-50 or KV-21 is less than 50% for any of these elements and the WQOs in Table 4-9 are exceeded for KV-50 or KV-21	Cadmium, nickel and zinc for Christal Creek and silver, arsenic, copper, nickel, lead and ammonia For No Cash Creek	Calculated natural attenuation at KV-50 or KV-21 is less than 50% for any of these elements and the WQOs for KV-50 or KV-21 are not met	KV-6, KV-50, KV-104L/C, KV-21, KV-111, KV-114	Same as indicators

4. KENO HILL SILVER DISTRICT MINING OPERATIONS AMP EVENTS

4.1 EVENT 1: CHANGE IN WATER QUALITY OR QUANTITY

Results of water quality and quantity monitoring are assessed on an ongoing basis to determine if significant changes are occurring and if an adaptive management response is required. The following sections describe what constitutes a significant change to water quality or quantity and associated responses that would be implemented.

4.1.1 SIGNIFICANT CHANGE IN WATER QUALITY

4.1.1.1 Descriptions

All data for current water sample stations as required in the WL QZ18-044 are stored in an EQWin database that allows water quality to be tracked at each site such that conditions can be identified at any point in the season. New sampling stations and their respective data collected for the Flame & Moth & Bermingham Mines are also being stored in the same database. In this way parameters can be tracked, and fluctuations from the normal to levels where management is required to respond can be monitored. Set point triggers can be placed in the database so that response parameters are flagged for notification and action.

4.1.1.2 Locations

Water quality is currently monitored from the Bellekeno water treatment facilities and District Mill for potential effects to the receiving environment including loading of down gradient waters. The Flame & Moth pond decant (KV-104L/C) and Bermingham pond decant (KV-114) are also monitored. These sites are listed below and shown in Figure 4-1.

Water Treatment Facilities:

- KV-43 – Bellekeno 625 Treatment Pond Decant;
- KV-83 – District Mill Treatment Decant;
- KV-104L/C – Flame & Moth settling pond decant; and
- KV-114 – Bermingham settling pond decant.

Adits:

- KV-42 – Bellekeno 625 Adit;
- KV-105 – Flame & Moth Adit; and
- KV-110 – Bermingham Adit.

4.1.1.3 Monitoring Requirements

Specific parameters from the monitored areas will be compared to specific thresholds to determine if they have been exceeded. Monitoring requirements will change should one of the AMP thresholds be triggered. This could include more frequent monitoring of grab samples at the station location as well as more frequent monitoring of the receiving environment below the site where the trigger was initiated.

In addition, the Christal Creek, Lightning Creek, and No Cash Creek mass load models will be updated annually to validate the model predictions using measured flow and water quality data.

4.1.1.4 Specific Thresholds

Specific thresholds for the different categories of monitoring stations that will initiate a response are provided in the following sections.

4.1.1.4.1 Water Treatment Facilities/Licenced Effluent Discharges/Parameters with Effluent Quality Standards

Water quality data from treatment facilities and other potential effluent discharge from the Bellekeno 625 decline and District Mill decant pond will be assessed to determine if the following thresholds have been exceeded:

- Daily sampling result for pH less than 7.0 units at a water treatment facility decant for more than 3 consecutive days; or
- Daily sampling result for zinc or ammonia trending toward possible exceedance of effluent quality standard; or
- Total arsenic >0.075 mg/L and pH < 7.0 units for three consecutive days; or
- Total cadmium > 0.0075 mg/L and pH < 7.0 units for three consecutive days; or
- Total zinc > 0.40 mg/L and pH < 7.0 units for three consecutive days; or
- Ammonia > 4.0 mg/L and pH > 9.0 for three consecutive days;
- TSS > 20 mg/L for three consecutive days; and
- Sample result exceeds effluent quality standards (EQS) (Table 4-1 and Table 4-2).

The water quality data from the Flame & Moth pond decant will be assessed to determine if the following thresholds have been exceeded:

- Daily sampling result for pH less than 7.0 units at a water treatment facility decant for more than 3 consecutive days;
- Daily sampling result for zinc or ammonia trending toward possible exceedance of EQS;
- Results from three consecutive events that exceed 80% of the EQS listed in Table 4-3 and Table 4-4; and
- Sample result exceeds EQS (Table 4-3 and Table 4-4).

The water quality data from the Bermingham pond decant will be assessed to determine if the following thresholds have been exceeded:

- Daily sampling result for pH less than 7.0 units at a water treatment facility decant for more than 3 consecutive days;
- Daily sampling result for zinc or ammonia trending toward possible exceedance of EQS;
- Results from three consecutive events that exceed 80% of the EQS (Table 4-5); and
- Sample result exceeds EQS (Table 4-5).

470000 480000 490000

7100000 7090000

DISTRICT MILL AND KENO CITY INSET

BELLEKENO INSET

BERMINGHAM INSET

McQuesten Lake KV-72 Cache Creek Hanson Lakes Ladue Lake South McQuesten River HANSON/MCQUESTEN ROAD Ladue Creek Gambler Lake Germaine Lake Faro Gulch Silver Basin Gulch Keno Ladue River McKay Gulch Sadie Ladue Creek Gambler Gulch Allen Creek Faith Creek

KV-1 KV-8 Christal Creek KV-7 KV-2 No Cash Creek Sandy Creek Star Creek KV-56 KV-21 KV-20 KV-111 NO CASH 500 KV-118 KV-19 BERMINGHAM INSET SILVER TRAIL HIGHWAY CALUMET DRIVE GALKENO 300 VALLEY TAILINGS WEATHER STATION Breriatt Creek CALUMET WEATHER STATION

WERNECKE ROAD SIGN POST ROAD KENO 700 Hope Gulch Charity Gulch McMillan Gulch McNeill Gulch KV-39 KV-40 KV-37 KV-48 Christal Lake BELLEKENO INSET Lightning Creek Thunder Gulch DISTRICT MILL AND KENO CITY INSET

1:7,500

National Topographic Data Base (NTDB) compiled by Natural Resources Canada at a scale of 1:50,000. Cadastral data compiled by Natural Resources Canada. Reproduced underlicense from Her Majesty the Queen in Right of Canada, Department of Natural Resources Canada. All rights reserved.

Datum: NAD 83; Map Projection: UTM Zone 8N

1:90,000 (when printed on 11 x17 inch paper)

0 1 2 3 4 5 Kilometers

- Active Surface Water Quality Station
- Pending/Proposed Water Quality Station
- Weather Station
- Adit
- As Built Mine Feature
- Valley Tailings
- Silver Trail Highway
- Other Road
- Watercourse
- Waterbody

AKHM

ALEXCO KENO HILL MINING CORP.

FIGURE 4-1
SURFACE WATER QUALITY STATION LOCATIONS

OCTOBER 2021

D:\Projects\AllProjects\ALEX-05-01\gis\mxd\Overview_Maps\WQ\02-SURFACEWATER\Specific_Topic\Licensee\SWMonitoring_KenoHill_Qz09-092_20210723.mxd
(Last edited by: amafaslishevska; 2021-10-19T5:14 PM)

Table 4-1: Licensed Bellekeno 625 Adit Treated Discharge Effluent Quality Standards

Parameter	Maximum Concentration in a Grab Sample (mg/L)
pH	6.5 to 9.5 pH Units
Total suspended solids	25
Ammonia Nitrogen (as N)	5
Arsenic (Total)	0.1
Cadmium (Total)	0.01
Copper (Total)	0.1
Lead (Total)	0.2
Nickel (Total)	0.5
Radium 226	0.37 Bq/L
Silver (Total)	0.01
Zinc (Total)	0.5
96-hour Rainbow Trout LC50 at 100% concentration	Non-toxic

Table 4-2: District Mill Licensed Effluent Quality Standards

Parameter	Maximum Concentration in a Grab Sample (mg/L)
pH	6.5 to 9.5 pH Units
Total suspended solids	25
Ammonia Nitrogen (as N)	5
Arsenic (Total)	0.1
Cadmium (Total)	0.01
Copper (Total)	0.1
Lead (Total)	0.2
Nickel (Total)	0.5
Radium 226	0.37 Bq/L
Silver (Total)	0.02
Zinc (Total)	0.5
96-hour Rainbow Trout LC50 at 100% concentration	Non-toxic

Table 4-3: Flame & Moth Effluent Quality Standards for Discharge to Christal Creek (KV-104C)

Parameter	Maximum Concentration in a Grab Sample	Maximum Concentration in a Grab Sample	Maximum Concentration in a Grab Sample	Maximum Concentration in a Grab Sample
Discharge rate	Up to 10 L/s	Up to 20 L/s	Up to 30 L/s	Up to 35 L/s
Arsenic (Total)	0.043	0.021	0.017	0.012
Cadmium (Total)	0.01	0.01	0.0094	0.0086
Copper (Total)	0.042	0.026	0.021	0.019
Lead (Total)	0.131	0.081	0.064	0.056
Nickel (Total)	0.5	0.5	0.5	0.5
Silver (Total)	0.00089	0.00064	0.00053	0.00049
Zinc (Total)	0.5	0.5	0.5	0.5
pH	6.5-9.5	6.5-9.5	6.5-9.5	6.5-9.5
Total suspended solids	15	15	15	15
Ammonia Nitrogen as N	6.5	3.7	2.7	2.4
96-hour Rainbow Trout LC50 at 100% concentration	Non-toxic	Non-toxic	Non-toxic	Non-toxic

Table 4-4: Flame & Moth Effluent Quality Standards for Discharge to Lightning Creek (KV-104L)

Parameter	Maximum Concentration in a Grab Sample	Maximum Concentration in a Grab Sample	Maximum Concentration in a Grab Sample	Maximum Concentration in a Grab Sample
Discharge rate	Up to 10 L/s	Up to 20 L/s	Up to 30 L/s	Up to 35 L/s
Arsenic (Dissolved)	0.034	0.020	0.015	0.013
Cadmium (Dissolved)	0.0012	0.0007	0.00052	0.00048
Copper (Dissolved)	0.042	0.023	0.016	0.015
Lead (Dissolved)	0.035	0.019	0.014	0.012
Nickel (Dissolved)	0.42	0.42	0.43	0.40
Silver (Dissolved)	0.0029	0.0016	0.0011	0.0010
Zinc (Dissolved)	0.23	0.13	0.09	0.08
pH	6.5-9.5	6.5-9.5	6.5-9.5	6.5-9.5
Total suspended solids	15	15	15	15
Ammonia Nitrogen as N	10	10	9.0	8.1
96-hour Rainbow Trout LC50 at 100% concentration	Non-toxic	Non-toxic	Non-toxic	Non-toxic

Table 4-5: Bermingham Effluent Quality Standards for Discharge to No Cash Creek Catchment (KV-114)

Parameter	Maximum Concentration in a Grab Sample (mg/L)
pH	6.5 to 9.5 pH Units
Total suspended solids	25
Ammonia Nitrogen (as N)	5
Arsenic (Dissolved)	0.061
Cadmium (Dissolved)	0.01
Copper (Dissolved)	0.024
Lead (Dissolved)	0.048
Nickel (Total)	0.37
Radium 226	0.37 Bq/L
Silver (Dissolved)	0.00062
Zinc (Dissolved)	0.5
96-hour Rainbow Trout LC50 at 100% concentration	Non-toxic

The thresholds for the Bermingham adit, Bellekeno 625 adit, and Flame & Moth adit discharges that would be applied in order to determine if mine water source quality had been significantly altered:

- A monitoring pH concentration trend, 1.0 standard pH unit below historic average. A trend would be established comparing the prior month average to the historic average.
- An increasing trend towards historical maximum in comparison to the previous 24 months of data for ammonia, cadmium, conductivity and zinc.
- Specific metals trends will be evaluated if a pH, conductivity, ammonia, zinc or cadmium trend has been triggered. Due to the nature of mining activities high concentration of suspended solids and metals found in the suspended solids are periodically expected as sumps are cleaned out or during dewatering changes; consequently, metals concentrations will not be a primary trigger.

The thresholds for the identification and assessment of trends in water quality in discharges from the District Mill, or the Bermingham, Bellekeno, or Flame & Moth mine sites for parameters without effluent discharge standards (i.e., nitrate, nitrite, selenium, uranium, sulphate):

- An increasing trend whereby the water quality objectives in the receiving environment maybe be exceeded.

4.1.1.5 Responses to Changes in Water Quality

Responses to changes in water quality from treatment plants and changes in adits will be different to account for the level of control over the results of water quality, where treatment plants are actively managed, while a mine's water quality is dependent on the native groundwater associated with veins, host rock, recharge, and other factors not directly under the control of the mine operator.

4.1.1.6 Responses to Changes in Treatment Plants

If an adaptive management trigger associated with the treatment plants is identified as being triggered, the following steps will be performed:

- Investigation of the root cause of the exceedance.
- If a root cause of exceedance can be readily identified and remedied, the remedy will be implemented in a timely manner, and the inspector notified of the remedy implementation in a timely manner according to permit requirements.
- If a root cause cannot be readily identified, a study plan will be outlined and communicated to involve qualified professionals to assist in the identification of the root cause.
- Water will be stored in underground sumps or the mill sediment pond to the extent practical to limit discharge until root causes have been identified and a solution implemented.

4.1.1.7 Responses to Changes in Mine Adit Chemistry

Monthly averages of pH, conductivity, ammonia, cadmium and zinc are considered good surrogate parameters to identify water quality changes that may affect the effectiveness, cost and feasibility of water treatment associated with the mine adit drainage. If the trend analysis identifies specific changes then the following steps will be performed:

- Investigation of the root cause of the exceedance:
- Due to the nature of underground mine workings, inflows to different areas of the mine may be different than other areas. A screening level water quality study will be implemented using field pH and conductivity equipment to identify mine areas that may be contributing to the change in water quality.
- A review of recent mining practices and a study of specific rock lithologies in the area of recent mining activity will be performed to assess if the change is associated with specific rock types or if a mining practice could be associated with the change.
- If a root cause can be identified, plans will be implemented to manage the water quality, which may include modification of the water treatment plant design or operating approach.

4.1.2 SIGNIFICANT CHANGES IN WATER QUANTITY

4.1.2.1 Significant Changes Water Quantity for Bellekeno Mine

The Bellekeno Water Management Plan provides for a monitoring approach to identify water quantity and to determine if water quantity from the Bellekeno mine is showing long term trends that indicate sustained changes in water quantity. However, if sustained changes in water quantity are encountered from the development and mining activities show that the increase of water is within 10% of the licenced maximum discharge rate (864 m^3/day) for seven consecutive days flow discharge criteria exceeded, an adaptive management response is required.

4.1.2.2 Change in Predicted Water Quantity for Bermingham and Flame & Moth Mines

Short term temporary spikes in water quantity are to be expected as new mine areas with water transmissive features such as veins or fractures are encountered. However, if encountered, experience from the advanced development and initial mining activities show that the amount of water associated with these initial drainage episodes is not significant, and in a short timeframe the water drains from the vein or fracture and the net contribution compared to the ongoing flow is minimal. The trigger is a sustained increase of flow rate. The trigger for Flame & Moth is increasing of flow rate within 10% of 3,024 m^3/day for 7 consecutive days. The trigger for Bermingham Mine is increasing of flow rate within 10% of 1,200 m^3/day for 7 consecutive days.

4.1.2.3 Monitoring Requirements and Specific Thresholds

4.1.1.4.2 Monitoring Requirements for Significant Change in Water Quantity for Bellekeno Mine

The relevant flowmeter and totalizer that measures water quantity data from KV-42, the Bellekeno adit, is located just upstream of the rapid mix tank. The data from the flowmeter and totalizer will be downloaded on a frequent basis and analyzed monthly. The average daily totalized flow for each month will be compared with the trailing 24 months of water flow to establish trends and also to determine significant deviation from the trends.

The threshold for determining significantly increased water flow are:

- If the water discharge from KV-43, the water treatment plant discharge, is within 10% of 864 m^3/day for seven consecutive days, which is the licence Clause in WL QZ18-044. KV-43 shows the net adit outflow and will not be affected by changes in water recycle usage.

4.1.1.4.3 Monitoring Requirements for Change in Predicted Water quantity for Bermingham and Flame & Moth Mines

The Flame & Moth adit will be monitored continuously via a totalizer flow meter. The data from the flowmeter and totalizer will be downloaded on a frequent basis and analyzed monthly.

Thresholds for determining significantly increased water flow are:

- If the water discharge at Flame & Moth adit (KV-105) is within 10% of the licensed maximum discharge rate of 3,024 m^3/day for seven consecutive days. KV-105 shows the net adit outflow and will not be affected by changes in water recycle usage.
- If the water discharge from the Flame & Moth adit (KV-105) increases from 0-10L/s to greater than 20 L/s in a period of less than two weeks.
- If the water discharge at the Bermingham adit (KV-110) is within 10% of the licensed maximum discharge rate of 1,200 m^3/day for seven consecutive days. KV-110 shows the net adit outflow and will not be affected by changes in water recycle usage.
- If the average daily water discharge at the Bermingham adit (KV-110), calculated each month, shows an increasing trend which is extrapolated to exceed the daily discharge rate of 1,200 m^3/day within six months.

4.1.2.4 Responses to Changes in Water Quantity

If a significant increase in water quantity is determined by the statistical test or if 90% of the WL water quantity discharge is observed, the following response actions will be taken:

- Investigation of the root cause of the exceedance;
    - Due to the nature of underground mine workings, inflows to different areas of the mine may be different than other areas. A screening level water quantity study will be implemented using portable flow meter equipment such as portable flumes or a standard time to fill the bucket test to identify mine areas that may be contributing to the change in water quantity.
- If a root cause can be identified, plans will be implemented to manage the change in water quantity, which may include modification of the water treatment plant design or changing the mine operating approach such as increasing water recycle usage.
- Investigation into limiting mine inflows into Bermingham and Flame & Moth including establishing additional surface water diversions or diversions around the vent raises.

4.2 EVENT 2: N-AML WASTE ROCK SEEPAGE OR TAILINGS EXHIBITS AML

As mentioned previously in Section 2.2(Plans in Place) a number of plans are in currently in place with respect to waste rock management and monitoring. The efficacy of these plans has been demonstrated through advanced exploration, development and production at the Bellekeno Mine. Although Alexco has a high level of confidence in the ability of these plans to accurately predict drainage chemistry and accurately designate waste rock appropriately, the following sections pertain to the possibility for acidic or metal leachate (AML) to occur as a result of seepage or runoff though waste rock disposal areas or areas where waste rock designated as N-AML has been used as a construction material. In addition, seeps from historic (unsegregated) waste rock piles, and tailings are also considered.

4.2.1 DESCRIPTION

DSTF and N-AML waste rock seeps/runoff will be monitored to determine if water quality is trending to AML conditions and waste rock screening criteria or management is not adequately working resulting in an adaptive management response being required. Kinetic testing results will also be reviewed to determine if changes in water quality could be expected from N-AML waste rock or tailings.

4.2.2 LOCATIONS

- An observed seep has historically been monitored below Bellekeno 625 (KV-44);
- Any seepage from works constructed or upgraded with N-AML material, which currently includes Bellekeno East and Bellekeno powerline roads. Other Bellekeno East waste rock management areas as defined in the Waste Rock Management Plan are also monitored for drainage or seeps;
- Any seepage from works constructed or upgraded with N-AML material proposed at Bermingham and Flame & Moth which includes: the extension of the advanced exploration waste rock disposal area (WRDA) at Bermingham, placement of the WRDA on the proposed rock dump at Bellekeno, placement of waste rock in a WRDA adjacent to the Flame & Moth site with the District Mill area, and the Keno City Bypass Road;

- Any other roads, facilities or structures built from N-AML material to be constructed under existing licenses;
- The DSTF; and
- Field bins or humidity cells with N-AML waste rock or tailings.

4.2.3 MONITORING REQUIREMENTS

Specific monitoring requirements for the Bellekeno 625 seep (KV-44) are outlined in QZ18-044. Similar monitoring requirements are outlined for the Bermingham and Flame & Moth N-AML waste rock. Monthly field measurements of flow, pH, temperature, conductivity and zinc, will be taken between May and October at KV-44. Seep monitoring stations will be established at the proposed Lucky Queen and Bermingham WRDA's, and the Keno City Bypass Road. These proposed N-AML constructed features will be monitored following the same frequency and parameters as mentioned above.

Kinetic testing of N-AML waste rock and tailings are being conducted using field bins and/or humidity cells. Field bins are typically monitored on a monthly basis during open water season, while humidity cells are conducted in a lab environment over a minimum 40-week period with testing weekly to bi-weekly thereafter, depending on parameters.

As per the Waste Rock Management Plan, any waste rock drainage or seeps observed between May and October will be monitored for estimated flow volume and basic field parameters of pH and conductivity. Evidence of sulphide oxidation such as snow melt areas or the presence of sulphide oxidations products will also be noted.

4.2.4 SPECIFIC THRESHOLDS

Field measurements of pH, conductivity and zinc, and lab measurements of zinc and cadmium will be monitored to determine if the following specific thresholds have been breached due to AML:

- pH significantly declining between measurements or dropping below 7.0;
- Sulphate showing an increasing trend;
- Alkalinity showing an decreasing trend;
- Conductivity, zinc or cadmium showing a significant increasing trend;
- Sample results approaching licenced effluent quality standards; and
- Kinetic testing of N-AML waste rock shows a significant decline in pH/alkalinity, or increase in sulphate, conductivity, zinc, or cadmium.

4.2.5 APPROACH TO RESPONSES

Initial responses to an observed waste rock seep or runoff trending to AML conditions can include further inspection and testing of the waste rock source material to ensure that the rock types used for construction are acceptable and mitigative measures such as ditching, berming, or pumping water, rock removal or whatever alternative is required to prevent degradation to the quality of the receiving environment. A full suite of water quality analysis will be performed by an external laboratory to verify the accuracy of field measurements. The location of seepage or runoff will be documented with photos and GPS.

Downstream or down gradient locations will be monitored to ensure that AML runoff does not eventually reach fish bearing waters. If water quality analyses indicate runoff does deposit metal loading into a fish bearing stream or creek, the initial response of ditching, berming, pumping or selective waste rock removal to prevent this would be implemented. Once the seepage/runoff is diverted or removed, measures would be taken to prevent the AML from occurring. This may include removing the material responsible for producing the AML runoff and transporting it to a P-AML Waste Rock Storage Facility, or installing a cover or water diversion system.

Weekly monitoring at the location trending to AML conditions would be implemented until seepage/runoff stops for two consecutive weeks or thresholds are not triggered for two consecutive months.

4.3 EVENT 3: SLUDGE STORAGE AREA EFFECTIVENESS COMPROMISED

As mentioned previously in Section 2.2 (Plans in Place) a Sludge Management Plan is currently in place. The following sections pertain to the potential for the effectiveness of the Valley Tailings sludge storage area (the specific sludge storage area dedicated to Bellekeno-related sludge) to become compromised. Sludge storage in the DSTF will be evaluated by DSTF monitoring programs. Sludge storage at the Bermingham Southwest (SW) will also be evaluated.

4.3.1 SEEPAGE OBSERVED NEAR SLUDGE STORAGE AREA

4.3.1.1 Description

Any seepage observed in the vicinity of the sludge storage areas will be monitored to determine if it is resulting from sludge deposition.

4.3.1.2 Locations

The DSTF, Valley Tailings and Bermingham SW sludge storage areas will be routinely monitored for seepage.

4.3.1.3 Monitoring Requirements

Visual inspections will be conducted at the DSTF, Bermingham SW pit and Valley Tailings Sludge Storage Cell when these facilities are in use. Any seepage will be documented and water quality assessed for alkalinity pH, sulphate, total zinc and cadmium.

4.3.1.4 Specific Thresholds

Any new identified seeps will be monitored and analyzed for the pH, alkalinity, sulphate, zinc, and cadmium thresholds:

- pH < 7.5, zinc > 0.5 mg/L, cadmium > 0.01 mg/L.

4.3.1.5 Approach to Responses

Seepage observed in the vicinity of the sludge storage areas will be documented with photos and monitored for flow, field pH, zinc and cadmium. A full suite of water quality analysis will be performed by an external laboratory to verify the accuracy of field measurements. The flow path will be documented and an assessment

of the down gradient environment conducted to determine if flow is reaching surface waters and whether or not they are fish bearing. If seepage is depositing a load into a fish bearing stream or creek, ditching, berming or pumping may be implemented to prevent this. An alternative sludge storage area would be assessed and use of the current one would cease. The Sludge Management Plan would be revised to incorporate any new sludge storage areas and implemented.

4.3.2 SLUDGE STORAGE AREA APPROACHING CAPACITY

4.3.2.1 Description

Sludge storage areas will be monitored daily during use to ensure sufficient capacity.

4.3.2.2 Locations

The DSTF, Bermingham SW pit and Valley Tailings Area Sludge Storage Cell.

4.3.2.3 Monitoring Requirements

Visual inspection of freeboard in Bermingham SW and Valley Tailings Sludge Storage Cell will be conducted when this facility is in use.

4.3.2.4 Specific Thresholds

Freeboard is approaching capacity: 1.5 m. A minimum freeboard of 1.0 m below the decant point will be maintained.

4.3.2.5 Approach to Responses

- Determine if there is seepage from the sludge storage area as per the visual inspection.
- An investigation would be conducted of the ability to increase the facility capacity by increasing berm height for example.
- Alternative sludge storage area would be assessed and use of the current one would cease.
- The Sludge Management Plan would be revised to incorporate any new sludge storage areas and implemented.

4.4 EVENT 4: PHYSICAL INSTABILITIES

The following sections pertain to potential physical instabilities that may be encountered in the Keno Hill Silver District Mining Operations, though specific DSTF triggers will be discussed separately.

4.4.1 AREA OF SIGNIFICANT SUBSIDENCE IS OBSERVED

Subsidence can be observed as a result of slope failure or erosion, which could potentially affect the down gradient environment, particularly surface water. Slope failure could eventually result in a rock fall or landslide

or lead to structure failure or portal collapse. Additionally, areas where permafrost is encountered unexpectedly during construction activities for new mine facilities are also considered.

4.4.1.1 Locations

Throughout the Keno Hill Silver District Mining Operations based on routine inspection throughout the property and as outlined in the Physical Inspection and Reporting Plan. The Physical Inspection and Reporting Plan has been updated to include Bermingham, and Flame & Moth Mines.

4.4.1.2 Monitoring Requirements

Maintenance personnel will routinely observe subsidence, slope failure, or erosion in the course of their daily site activities. Routine inspections will be performed in accordance with the Physical Inspection and Reporting Plan.

4.4.1.3 Specific Thresholds

The specific thresholds that will initiate an adaptive management response include:

- A depression with defined edges is noted in the ground with the potential to create a public safety concern;
- A cave-in has occurred allowing access to the underground workings of a mine site;
- Unexpected encounter of permafrost for construction of new mine facilities; and
- Break in soil/ slope creep/ sediment transport observed from physical structure with perceived potential to effect nearby structures or down gradient surface water.

4.4.1.4 Approaches to Responses

As per the general approach to the adaptive management plan, a staged response to an observed area of subsidence, slope failure or erosion will be implemented if the threshold is triggered.

The initial response to observing an area of subsidence, slope failure or erosion will be to prevent a hazard to public health and safety and minimize sediment transport to surface waters. This could include installation of barriers such as dykes or silt fencing or construction of diversion ditches or berms.

If necessary, physical removal or physical repair of the structure will be performed to remediate it to a safe status. Access to the area would be limited using fencing, barricades, or signage to alert the public and other maintenance personnel to the danger that may exist.

If there are no underground workings in the area, then it is possible that the subsidence, slope failure or erosion would be due to liquefaction of soil near the surface and may not be a cause for concern. The break or depression will be filled in with soil and monitored to see if the subsidence, slope failure or erosion continues. If the subsidence, slope failure or erosion continues to appear after repair, then further investigation by a mining engineer may be warranted, particularly if there is a risk to the stability of a nearby structure. Any physical repairs to slopes or embankments would involve an assessment in consultation with a mining engineer before implementation.

The final stage will be to implement the repair at the area of the subsidence, slope failure or erosion and to monitor the area to watch for signs of continued subsidence, slope failure or erosion at or around the previously identified area.

If permafrost is encountered unexpectedly during the construction of new mine facilities the design engineer will be notified to review the design and perform any modifications if required.

4.4.2 ROCK FALL OR LANDSLIDE OCCURS WITHIN MONITORED AREA

4.4.2.1 Description

The deposition of waste rock in the Keno Hill Silver District Mining Operations is being done in areas where engineering assessments were performed for suitability. However, it is possible that waste rock piles can possibly shift due to changes in foundation conditions. Even though it is remote or unlikely, a significant amount of material can potentially block access to a site.

4.4.2.2 Locations

Monitoring locations are throughout the area of the Keno Hill Silver District Mining Operations in accordance with the Physical Inspection and Reporting Plan.

4.4.2.3 Monitoring Requirements

At a minimum, the locations identified in the Physical Inspection and Reporting Plan, and other areas as observed by site operators. Maintenance personnel will routinely observe soil or earth movement during their daily site activities.

4.4.2.4 Specific Thresholds

The specific thresholds that will initiate an adaptive management response include:

- A rock fall or landslide has blocked access to a previously monitored site;
- A rock fall or landslide has blocked access to a roadway previously used by the public;
- A rock fall or landslide has blocked or re-directed the flow of water of a documented stream or watercourse; and
- Liquefaction of a waste rock pile foundation has caused waste rock to migrate closer to a watercourse.

4.4.2.5 Approaches to Responses

As per the general approach to the adaptive management plan, a staged response to the presence of a rock fall or a landslide will be implemented if a threshold is triggered.

The initial response to observing a rock fall or a landslide will be to determine if it impedes on a right-of-way or a water flow path. If the debris impedes on a right of way, access to the area will be limited using fencing, barricades, or signage to alert the public and other maintenance personnel to the debris' presence.

The next stage of the response will be to examine the area to assess the possibility of further erosion of the originating slope. This task may require the services of a registered engineer. If warranted, a plan will be developed to prevent future erosion in the area.

The final step in the response to debris from a rock fall or a landslide impeding on a right-of-way will be to remove the debris, likely with heavy machinery, and transport it to an isolated waste pile where the debris will not affect any watercourse or physical stability.

If the rock fall or landslide debris enters a watercourse, then water quality testing will be implemented. This will be done to determine if the presence of the rock in the water is contributing any metal loading to the water. If the loading in the water is found to be affected by the source material, then a mitigation plan will be developed and implemented in consultation with technical experts and regulatory agencies until such time as the debris can be removed from the watercourse, and water levels return to their historical norm.

If the metal loading is determined to be not affected by the source material, then no mitigation treatment plan will be necessary, and the debris can be removed from the watercourse. The final stage will be to continue monitoring water quality at that location for a period of time until it is determined that the rock fall or landslide had no lingering effects on the water quality.

4.5 EVENT 5: SITE SECURITY COMPROMISED

4.5.1 GATE, FENCE OR SIGN DAMAGED

In the Keno Hill Silver District Mining Operations hazards to public safety exist. In order to alleviate these hazards, depending on the type of hazard and its accessibility, structures, gates, fences, or signs have been erected to prevent the public from entering these areas or draw their attention to the hazard.

Over the course of time, some of these deterrents may suffer damage or may degrade which impedes on their ability to perform as a safety deterrent. The most likely scenario is for the item to have fallen down, however, the item's performance may have been degraded by weather erosion or possibly at the hands of vandals.

4.5.2 LOCATIONS

This applies throughout the Keno Hill Silver District Mining Operations.

4.5.3 MONITORING REQUIREMENTS

Since it is almost impossible to predict when or where a gate, fence, or sign will be damaged, there can be no specific monitoring requirements to observe these circumstances prior to their existence. The monitoring information required is observations of damage to any of these safety features throughout the Keno Hill Silver District Mining Operations. Maintenance personnel will be familiar with the placement of gates, signs, and fences around the property and thus, during their routine site activities will be able to observe when one of these features requires attention.

4.5.4 SPECIFIC THRESHOLDS

The specific thresholds that will initiate the action plan will be as follows:

- A gate is found open outside of a scheduled visit by authorised site personnel;
- A gate post is found to be damaged such that the gate is sufficiently disabled to prevent access to the site by authorized site personnel;
- A gate post is found to be damaged such that the gate no longer prevents unauthorised access to a site of concern;
- A fence or structure is found to be damaged such that it no longer prevents unauthorised access to a site of concern;
- The placard of a sign has been damaged either by environmental conditions or by vandalism such that the sign is no longer effective in relaying the information intended; and
- A signpost has been damaged to an extent where the sign is in a position which renders it ineffective in relaying the information intended.

4.5.5 APPROACHES TO RESPONSES

As per the general approach to the adaptive management plan, a staged response to any one of the above circumstances will be implemented if the threshold is triggered.

The initial response to a gate being found open or a fence being damaged and allowing access to the site will first trigger an examination of the area in question in order to ascertain whether trespassers are in the vicinity and may have initiated the condition of the gate or fence. If trespassers are found and do not appear to impose a risk to the site personnel, they will be cordially escorted off the property and the gate will be locked. If site personnel feel that there may be a risk in confronting the trespassers, then the appropriate authorities will be contacted immediately and requested to attend to the situation. If the lock on the gate has been damaged or tampered with, it will be replaced in a timely fashion.

If the gate is found to be damaged such that in no longer prevents unauthorised personnel from accessing a site, then the same measures above will be implemented. Once the trespassers have been escorted off site or the area is deemed to not contain any trespassers, the gate will be repaired or replaced in a timely fashion to ensure it will prevent access to the site by unauthorized personnel.

If the placard of a sign has been damaged either by environmental conditions or by vandalism, or the sign post is broken such that the sign is no longer effective in relaying the information intended, then maintenance personnel should note this at the time of observation and this information should be passed on to the project manager.

4.6 EVENT 6: HIGH PORE PRESSURE UNDERNEATH DSTF

Tetra Tech Inc. (formerly EBA Engineering Consultants (EBA)) designed the Dry Stack Tailings Facility for Alexco. In September 2010, EBA developed the Operation, Maintenance, and Surveillance Manual (OMSM) (EBA, 2010) for the Dry Stack Tailings Facility at the direction of Alexco for the Keno Hill District Mill. This manual will be referenced in response to some triggers.

Located beneath the DSTF is a Drainage Blanket. This feature provides drainage beneath the facility and will allow excess water, whether in the stack or freed from thawing permafrost, to drain away and not allow porewater pressures to build underneath and/or within the tailings.

According to the DSTF design, the drainage blanket was constructed with gravel material obtained from excavation near the toe of the DSTF. The drainage blanket was then covered with a properly bedded geosynthetic clay liner to act as a collection layer for any seepage leaving the tailings stack. This material will help prevent tailings and tailings porewater from infiltrating the coarser gravel material of the drainage blanket.

The OMSM contains an adaptive management plan which can be triggered if the tailings handling and disposition is not meeting critical performance objectives according to specific conditions. Close monitoring of the DSTF is critical in determining if and when action is required. Section 9.0 of the OMSM contains a surveillance plan that provides for adequate monitoring to determine if and when adaptive management is required.

Specific to the development of high pore pressures identified underneath the DSTF, the OMSM presents the includes triggers as well as response actions (Table 4-6):

Table 4-6: High Pore Pressure Event

Taken from Table 14 of EBA's OMSM

Provision	Monitored Item	Triggers / Threshold	Action
EBA Design Report	Groundwater Monitoring Wells	Tip @ 1.0 m or 1.7 m depth – Porewater pressure parameter (Ru) exceeds 0.15	Facility designer will review well data. Monitoring and review will be increased to semi-weekly until determined unnecessary.
		Tip @ 1.0 or 1.7 depth – Porewater pressure parameter (Ru) exceeds 0.25	Facility designer will review existing well data Facility designer will conduct a site visit and determine if tailings placement and /or construction plan requires modification. Monitoring and review will be increased to daily until determined unnecessary. Facility designer will determine if additional instrumentation is required. Facility designer will complete analysis of mitigative measures should exceedance continue.

In the event that the above triggers occur, the Alexco staff will perform one or all of the listed actions to address the identified issue.

4.7 EVENT 7: SIGNIFICANT EROSION OF EXPOSED DSTF SURFACES

The OMSM presents a management plan to ensure that the DSTF is managed to create compacted tailings, to limit run-on of surface water that could cause erosion, and also a plan to operate the DSTF in adverse conditions. The OMSM plan (pp. 22-23) states:

Potentially adverse conditions must be accounted for in the operation of the DSTF. These conditions, along with mitigative measures of dealing with them, are as follows.

- High Rainfall;
- Erosion control – grade control and compaction of tailings stack during construction to seal lifts and prevent pooling of water;
- High snow accumulation;
- Removal prior to lift placements;
- Snow dumps will be sited to minimize any erosional impacts during thaw conditions;
- Freezing temperatures;
- Location of placement – east portion of placement area away from the ultimate tailings slope as compaction prior to freezing problematic;

- Compaction – must be completed prior to the tailings freezing;
- Tailings Characteristics (higher moisture);
- Location of placement – south portion of placement area away from the ultimate tailings slope; and
- Compaction – may require drying out material prior to achieving compaction. At the discretion of the Geotechnical Engineer, material requiring additional compactive effort will be moved to less critical areas of the DSTF; i.e., south portion of the placement area away from the ultimate tailings slope, if required.

The OMSM surveillance plan includes key parameters to determine if failure modes are occurring. A visual observation list includes (Section 9.3, pages 27-28)

- Surface—cracking, bulging, depression, sinkholes;
- Seepage—new seepage areas, changes in seepage areas;
- Turbid water in the natural drainages around or downstream the facility;
- Water or tailings flowing down the stack indicating improper grading; and
- A failure or breach of a component of the facility.

Other routine monitoring required by the OMSM plan includes:

- Checking for settlement or holes in embankment crest or benches;
- Checking for holes on the surface of the tailings indicating possible piping of material to outside;
- Checking for dust;
- Measuring water levels in monitoring wells located in the foundation soils during operation;
- Measuring ground temperatures using cables in the foundation soils during operation;
- Surveying DSTF components—displacement of survey monuments;
- Measuring slope inclinometers located in the foundation soils;
- Water sampling of Christal Creek; and
- Recording Weather conditions.

Erosion is an adaptive management event which can be triggered if significant erosion of exposed DSTF surfaces occurs. Close monitoring of the DSTF is critical in determining if and when action is required.

Specific to these conditions, Table 4-7 developed by EBA lists triggers as well as response actions.

Table 4-7: Significant Erosion

Taken from Table 13 of EBA's OMSM

Provision	Monitored Item	Triggers / Threshold	Action
Water Licence QZ18-044	Tailings Runoff	Visible turbidity in runoff and/or excessive erosion evidence	Address runoff at source; report to Water Board within 60 days Apply appropriate runoff, erosion or sediment control measures

In the event that the above triggers occur, the Alexco staff will perform one or all of the listed actions to address the identified issue.

4.8 EVENT 8: EROSION AT THE DISTRICT MILL OR FLAME & MOTH DISCHARGE SITES

4.8.1 DESCRIPTION

The Mill Pond will periodically discharge to ground and only occurred to date seasonally to date in 2015 and 2016. The Flame & Moth pond decant will discharge to Lightning Creek and to ground toward Christal Creek. However, the development of erosion or permafrost degradation at the discharge to ground locations may compromise and affect the down gradient environment, particularly soils including permafrost.

4.8.2 LOCATIONS

The discharge to ground areas at Mill Pond (KV-83) to Christal Creek, and the discharge areas in Christal Creek and Lightning Creek from the Flame & Moth pond decant (KV-104).

4.8.3 MONITORING REQUIREMENTS

Maintenance personnel will routinely inspect for subsidence, slope failure, or erosion during their daily site activities. Monitoring will aim to identify areas of erosion prior to any significant sediment loading, significant erosion or slope degradation and requirement to relocate the discharge area. Weekly inspections of the discharge to ground locations will be included in and carried out as part of the Physical Inspections and Reporting Plan.

4.8.4 SPECIFIC THRESHOLDS

The specific thresholds that will initiate an adaptive management response include:

- A depression with defined edges is noted at the discharge to ground locations; and
- Break in soil/ slope creep/ sediment transport is observed at the discharge to ground locations with perceived potential to effect discharge or down gradient surface water.

4.8.5 APPROACHES TO RESPONSES

As per the general approach to the adaptive management plan, a staged response to the development of erosion and/or permafrost degradation will be implemented if the threshold is triggered.

The initial response to observing erosion or permafrost degradation at the discharge to ground location will be to prevent further degradation of the area through limiting the transport of waste to surface waters. This could include the installation of barriers such as dykes or berms.

If necessary, physical repair will be performed to ensure longer term stability of the area, such as general armouring of the discharge to ground location. Access to the area would be limited using fencing or signage to alert maintenance personnel to the concern.

The final stage will be to monitor the area to watch for signs of continued erosion or degradation.

4.9 EVENT 9: TRANSPORT OF SEDIMENTS FROM BERMINGHAM DISCHARGE, MILL POND DISCHARGE AREA OR FLAME & MOTH DISCHARGE AREAS

4.9.1 DESCRIPTION

The Mill Pond has periodically discharge to ground and only occurred seasonally in 2015 and 2016. The Flame & Moth pond decant will discharge to Lightening Creek and to ground toward Christal Creek. Additionally, the Bermingham Mine discharge will be to ground, but may develop a surface channel as mine discharge rates increase. However, the development of erosion or permafrost degradation at the discharge to ground locations may compromise and affect the down gradient environment, particularly surface water.

4.9.2 LOCATIONS

The area downgradient of the discharge to ground from the Mill Pond (KV-83) and Bermingham (KV-110), and the discharge area at the Flame & Moth pond decant (KV-104).

4.9.3 MONITORING REQUIREMENTS

Maintenance personnel will routinely inspect for the daylighting of the mill pond discharge and any associated TSS. Weekly inspections of the discharge to ground locations will be included in and carried out as part of the Physical Inspection and Reporting Plan. Additionally, site KV-50 in Christal Creek will be monitored weekly when Flame & Moth is discharging and KV-81 in Lightning Creek. Station KV-21 is monitored monthly when the Bermingham mine is discharging.

4.9.4 SPECIFIC THRESHOLDS

The specific thresholds that will initiate an adaptive management response include:

- TSS of 20 mg/L in daylighted discharge;
- TSS of 15 mg/L greater than monthly seasonal average calculated from the previous three years concentration at KV-50 and KV-21; and

- TSS at KV-81 in Lightning Creek is 25 mg/L higher than upstream of Flame & Moth discharge area on Lightning Creek.

4.9.5 APPROACHES TO RESPONSES

As per the general approach to the adaptive management plan, a staged response to the transport of sediments from discharge locations will be implemented if the threshold is triggered.

The initial response to observing erosion or permafrost degradation at the discharge to ground location will be to prevent the transport of waste to surface waters. This could include the installation of barriers such as dykes or berms with silt fencing.

If necessary, physical repair will be performed to ensure longer term stability of the area, such as general armouring of the discharge to ground location. Access to the area would be limited using fencing or signage to alert maintenance personnel to the concern.

The final stage will be to monitor the area to watch for signs of continued erosion or degradation.

4.10 EVENT 10: LARGE DIFFERENTIAL SETTLEMENTS AT DSTF

Included in EBA's OMSM is an adaptive management plan which can be triggered if differential settlements within the DSTF surfaces occur. Close monitoring of the DSTF as outlined in Section 4.7 will be implemented to determine if and when action is required.

Specific to these conditions, Table 4-8 developed by EBA lists triggers as well as response actions.

Table 4-8: Large Differential Settlements

Taken from Table 14 of EBA's OMSM

Provision	Monitored Item	Triggers / Threshold	Action
EBA Design Report	Survey Monuments and Slope Inclinometers	Displacements greater than 25 mm in any direction	Facility designer will review existing piezometer, temperature, and survey data. Facility designer will conduct a site visit and determine if tailings placement and/or construction plan requires modification. Monitoring and review will be increased to semi-weekly until determined unnecessary. Alexco to complete survey of area of interest to monitor any future displacement, if any. Facility designer will determine if additional instrumentation is required. Facility designer will complete analysis of mitigative measures should exceedance continue.
Water Licence QZ09-092	Toe runoff collection ditches, conveyance channel and water collection pond	Presence of abnormal cracking or failure	Report to general manager, take corrective action as required.

In the event that the above triggers occur, the Alexco staff will perform one or all of the listed actions to address the identified issue.

4.11 EVENT 11: LARGE DIFFERENTIAL SETTLEMENTS FROM DSTF TO STORMWATER COLLECTION POND

The development of large differential settlements along the conveyance flume from the DSTF to the District Mill Site collection and sediment pond will be identified and addressed through the same actions listed in Table 4-7 above.

4.12 EVENT 12: EXCEEDANCE OF WATER QUALITY OBJECTIVES IN RECEIVING ENVIRONMENT

Sitewide monitoring of the entire KHSD, and specific monitoring of the Keno Hill Silver District Mining Operations is being performed in accordance with WL QZ18-044 and the plans referenced in Section 2.1.

In addition to the historical impacts of mining in the KHSD, the Bermingham mine, Bellekeno Mine, District Mill, Flame & Moth Mine, placer mining on Lightning creek, deposition of waste in the Keno City municipal dump facility, and other non-mining activities has the potential to impact the receiving environment.

4.12.1 DESCRIPTION

With respect to the Keno District Mining undertaking, it is imperative to identify the impact of the discharges authorized under this licence with the existing discharges occurring in the KHSD and other human activities in the area. Consequently, site-wide monitoring information must be compared with water quality information collected and compiled for the Keno Hill Silver District Mining Operations to assess the relative impacts of these various activities.

All data for current water sample stations required in WL QZ18-044 are stored in an EQWin database that allows water quality to be tracked at each site such that conditions can be identified at any point in the season. In this way, parameters can be tracked, and fluctuations from the normal to levels where management is required to respond can be monitored. Set point triggers can be placed in the database so that response parameters are flagged for notification and action.

Comparison of all water quality information is routinely done and a variance report is generated on at least a quarterly basis for sitewide information that could identify sitewide trends.

4.12.2 LOCATIONS

Water quality is monitored from the Bellekeno water treatment facilities and District Mill for potential effects to the receiving environment including loading of down gradient waters. In addition, once Bermingham and Flame & Moth are in production, their settling pond decant will also be monitored. These sites are shown in Figure 4-1.

4.12.3 MONITORING REQUIREMENTS

All water quality information in the KHSD and the Keno Hill Silver District Mining Operations is analyzed for exceedances of CCME criteria, as well as variances with the previous 12 months of data at that location, which can assist in the determination of causes of water quality changes over time. All exceedances of water quality for licenced parameters will be compared with historical exceedances. Monitoring of radium will occur in the receiving environment as required per Schedule 5 section 7 of the Metal Mining Effluent Regulations (Canada Gazette, 2017).

4.12.4 SPECIFIC THRESHOLDS

Water quality objectives (WQOs) for No Cash Creek (KV-21, KV-111), Star Creek (KV-56), Christal Creek (KV-50, KV-6, and KV-7), Lightning Creek (KV-81), and the South McQuesten River (KV-2) have been established using generic CCME or BCMoE guidelines or using the background concentration procedure. The background concentration procedure was used to develop WQOs for constituents that frequently exceed the CCME and BCMoE guidelines (i.e., greater than 10% of samples exceed guideline). Short-term maximum and long-term average threshold concentrations were developed from the 95th percentile and upper confidence level (95%) mean of the data set (past ten years, where available), respectively. Thus, 95th percentile WQOs are compared on a per sample basis, whereas the upper confidence level mean WQOs are compared to the rolling annual average. The WQOs for Christal, Lightning, No Cash, and Star Creeks and the South McQuesten River are presented in Table 4-9. Appendix A includes a summary of the updates made to the thresholds in comparison to the previous version of the AMP.

If an increasing trend towards a WQO or a WQO exceedance is detected then further responses will be undertaken. Given that seasonal patterns are inherent to the receiving environment water quality data, the Seasonal Mann-Kendall test is recommended for use. In addition to accounting for seasonality in the data, this statistical test does not require the data to be normally distributed (i.e., it is a non-parametric test) and can accommodate instances of missing data or data below the detection limit. Where a statistically significant increasing trend is identified (i.e., p-value less than 0.05), the AMP is triggered if extrapolation of this trend indicates the WQO will be exceeded within 12 months.

The trend analysis threshold review will incorporate the five previous years of data relative to the WQOs, whereas the comparison against the UCLM will be carried out monthly on a 12 month moving average.

It is recognized that the implementation of the reclamation plan for the historical United Keno Hill Mines site will result in marked improvements to water quality in No Cash Creek. This will result in lower constituent concentrations (primarily cadmium and zinc) at station KV-21 as following treatment of the historical No Cash 500 adit discharge. Alexco has proposed to convene a workshop between Alexco, Yukon Government, Government of Canada, and the First Nation of Na-cho Nyak Dun to develop a mechanism to update the WQOs for KV-21 as water quality in No Cash Creek improves. Such changes would likely focus on those constituents for which the background concentration procedure was used to develop the WQOs (i.e., constituents that often exceed generic water quality guidelines) and for which treatment of the historical No Cash 500 adit discharge may result in lower concentrations at KV-21 (i.e., cadmium and zinc). Although the approach to update the WQOs at KV-21 would be reached via a collaborative effort with the three government stakeholders, a potential method might involve the development of "preliminary" WQOs extracted from a one-year data set of monthly samples collected at KV-21 in the first year since the successful implementation of treatment at the No Cash 500 adit. These WQOs would be updated annually until a three year data set is available from which the "final" WQOs may be derived.

Table 4-9: Water Quality Objectives for Christal Creek, Lightning Creek, No Cash Creek, Star Creek, and South McQuesten River (mg/L)

	KV-50	KV-6	KV-7	KV-81[a]	KV-21[a]	KV-56	KV-111[a]	KV-2
Ammonia-N	CCME	CCME	CCME	CCME	CCME	CCME	CCME	CCME
Nitrate-N	CCME	CCME	CCME	CCME	CCME	CCME	CCME	CCME
Nitrite-N	CCME	CCME	CCME	CCME	CCME	CCME	CCME	CCME
Arsenic	0.0432[b], 0.0277[c]	0.0167[b], 0.0098[c]	0.0102[b], 0.0043[c]	CCME	0.025[f]	CCME	CCME	CCME
Cadmium	0.00602[d], 0.00280[e]	0.0321[d], 0.00115[e]	0.00726[b], 0.00216[c]	0.00148[b], 0.00070[c]	0.00359[d], 0.00193[e]	0.000297[d], 0.000132[e]	0.000541[b], 0.000258[c]	0.000941[b], 0.000647[c]
Copper	0.00602[d], 0.00280[e]	0.0321[d], 0.00115[e]	0.00726[b], 0.00216[c]	0.00148[b], 0.00070[c]	0.00359[d], 0.00193[e]	BCMoE	BCMoE	0.00651[b], 0.00376[c]
Lead	BCMoE	BCMoE	BCMoE	BCMoE	BCMoE	BCMoE	BCMoE	BCMoE
Nickel	CCME	CCME	CCME	CCME	CCME	CCME	CCME	CCME
Silver	CCME	CCME	CCME	CCME	CCME	CCME	CCME	CCME
Uranium	CCME	CCME	CCME	CCME	CCME	CCME	CCME	CCME
Zinc	0.271[b], 0.205[c]	0.367[b], 0.207[c]	0.220[b], 0.120[c]	CCME	4.94[d], 2.28[e]	CCME	0.179[b], 0.0602[c]	0.152[b], 0.103[c]

Sulphate	544[b], 409[c]	BCMoE	BCMoE	BCMoE	539[d], 349[e]	BCMoE	BCMoE	BCMoE
Selenium	BCMoE	BCMoE	BCMoE	BCMoE	BCMoE	BCMoE	BCMoE	BCMoE
Radium	-	0.037 Bq/L	-	0.037 Bq/L	-	-	0.037 Bq/L	-

a) Objectives for KV-81, KV-21, and KV-111 metals are dissolved
b) 95th percentile from July 2011 to August 2021 data set, except for KV-111 which ranges from September 2017 to August 2021
c) Upper confidence level mean from July 2011 to August 2021 data set, except for KV-111 which ranges from September 2017 to August 2021
d) 95th percentile from July 2017 and June 2018 to August 2021 data set for KV-21 and KV-56, respectively
e) Upper confidence level mean from July 2017 and June 2018 to August 2021 data set for KV-21 and KV-56, respectively t
f) Site specific based on Golder (2013) presented in Bermingham Water Quality Model (AEG, 2019)

4.12.5 RESPONSES TO CHANGES IN RECEIVING ENVIRONMENT WATER QUALITY

Potential responses to exceedances include the following:

- Increased sampling frequency may be required around the area of the exceedance and will be implemented to help determine potential causes;
- Investigation of the root cause of the exceedance including utilizing the Goldsim model to understand the loadings of the system of concern. Compare the monitoring results to the Goldsim predicted concentrations;
- If a root cause of exceedance can be readily identified and remedied, the remedy will be implemented in a timely manner, and the inspector notified of the remedy implementation in a timely manner according to permit requirements; and
- If a root cause cannot be readily identified, a study plan will be outlined and communicated to involve qualified professionals to assist in the identification of the root cause.

4.13 EVENT 13: IDENTIFICATION OF GROUNDWATER QUALITY IMPACT WITHIN THE KENO HILL SILVER DISTRICT MINING OPERATION

The Groundwater Monitoring Plan provides data that can be utilized to assess groundwater quality impacts associated with mining and milling activities. The original Groundwater Monitoring Plan identified two areas of the Bellekeno undertaking where groundwater monitoring will be carried out. The updated Groundwater Monitoring Plan includes the Flame & Moth and Bermingham area where additional groundwater monitoring has been proposed.

4.13.1 DESCRIPTION

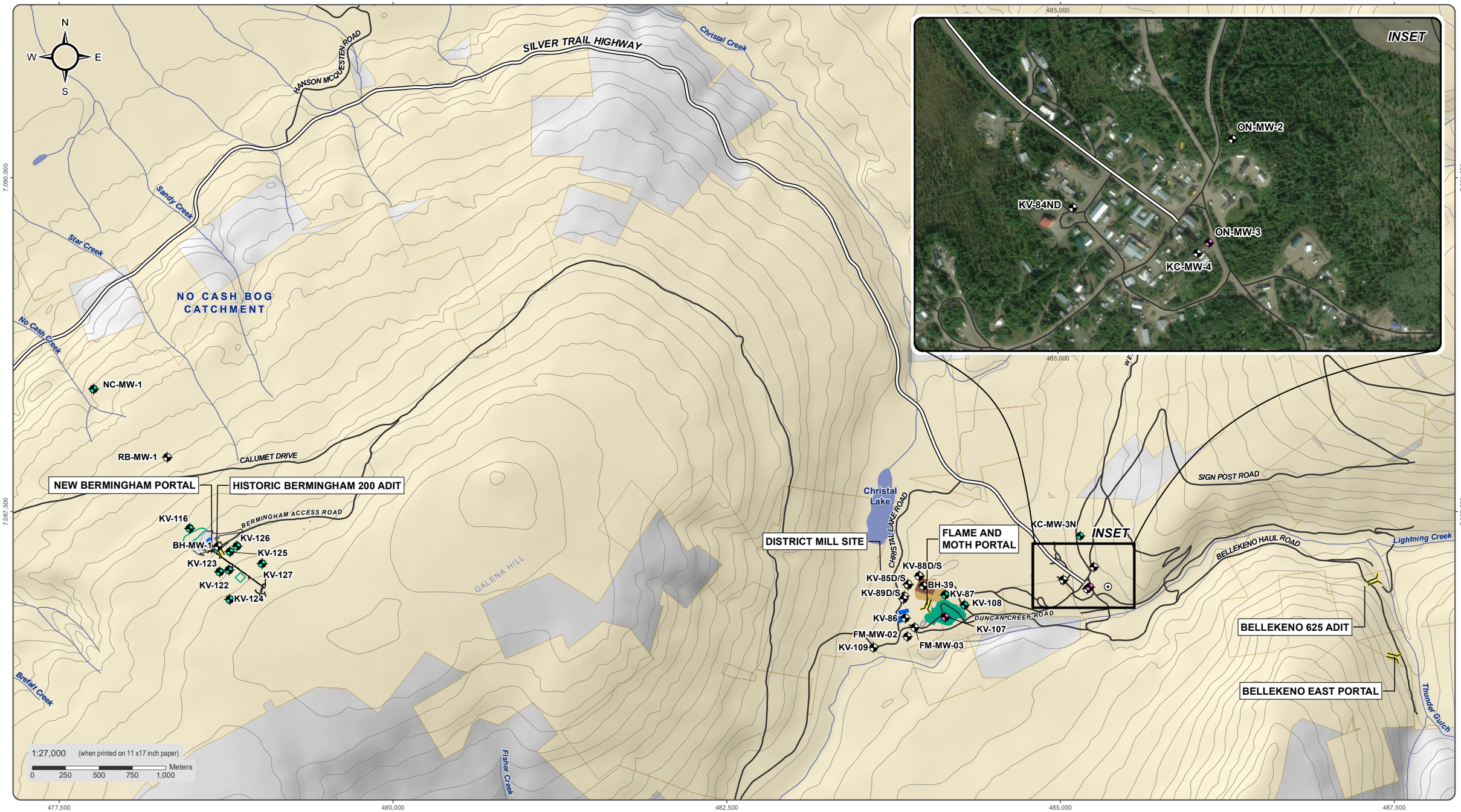
Groundwater in the vicinity of Keno City and the mill site flows in a north-westerly direction towards Christal Creek. A network of shallow and deep groundwater monitoring wells is specified for the District Mill site in order to determine if there are any impacts to groundwater as a result of deposition of waste authorized by the Licence and also to determine if upgradient users may be influencing groundwater which flows toward the site (i.e., the Keno City dump). The District Mill Site (including Flame & Moth) is located upgradient of Christal Creek, so understanding any impacts to groundwater as a result of the undertaking is important to help determine any risk to Christal Creek. Although groundwater flow direction has been demonstrated to flow towards the northwest away from Keno City, KV-84Nd in Keno City is also being monitored (see Section 4.14).

The second groundwater monitoring location specified by the Groundwater Monitoring Plan is downgradient of the N-AML Waste Rock Disposal Area along the north flank of Sourdough Hill to the west of the Bellekeno 625 adit. It is assumed that groundwater flow in this area follows surface topography and flows down slope towards Lightning Creek. Groundwater wells located below the toe of the N-AML Waste Rock Disposal Area will be used to determine if seepage from N-AML waste rock is having any impacts to downgradient groundwater quality, which might in turn, impact water quality in Lightning Creek.

A third location is identified as part of the Bermingham Mine and is on the north side of Galena Hill. This includes areas downgradient of the mine, N-AML WRDA, Bermingham SW pit sludge disposal area and P-AML WRSF and these locations are shown on Figure 4-3.

4.13.2 LOCATIONS OF GROUNDWATER MONITORING WELLS

Existing and proposed groundwater monitoring wells at the District Mill Site (including Flame & Moth) and DSTF area (KV-85 to KV-89, KV-108, KV-109 and BH-39), are shown on Figure 4-2. Additionally, BH-39 is located within phase 1 of the DSTF and KV-107 will be installed in phase 2 of the DSTF. Additional wells (KV-116, KV-122 to KV-127, RB-MW-1 and NC-MW-1) for the Bermingham Mine are shown on Figure 4-3.



Datum: NAD 83; Map Projection: UTM Zone 8N

- Proposed Monitoring Well
- Monitoring Well
- Newly Installed Groundwater Monitoring Well
- Adit
- Infrastructure Footprint
- Pond
- DSTF 322k Tonnes Design
- Current DSTF
- To Be Constructed Mine Features
- Alexco/ERDC Quartz Claims
- Silver Trail Highway
- Other Road

AKHM

ALEXCO KENO HILL MINING CORP.

FIGURE 4-2
KHSD GROUNDWATER MONITORING LOCATIONS

OCTOBER 2021

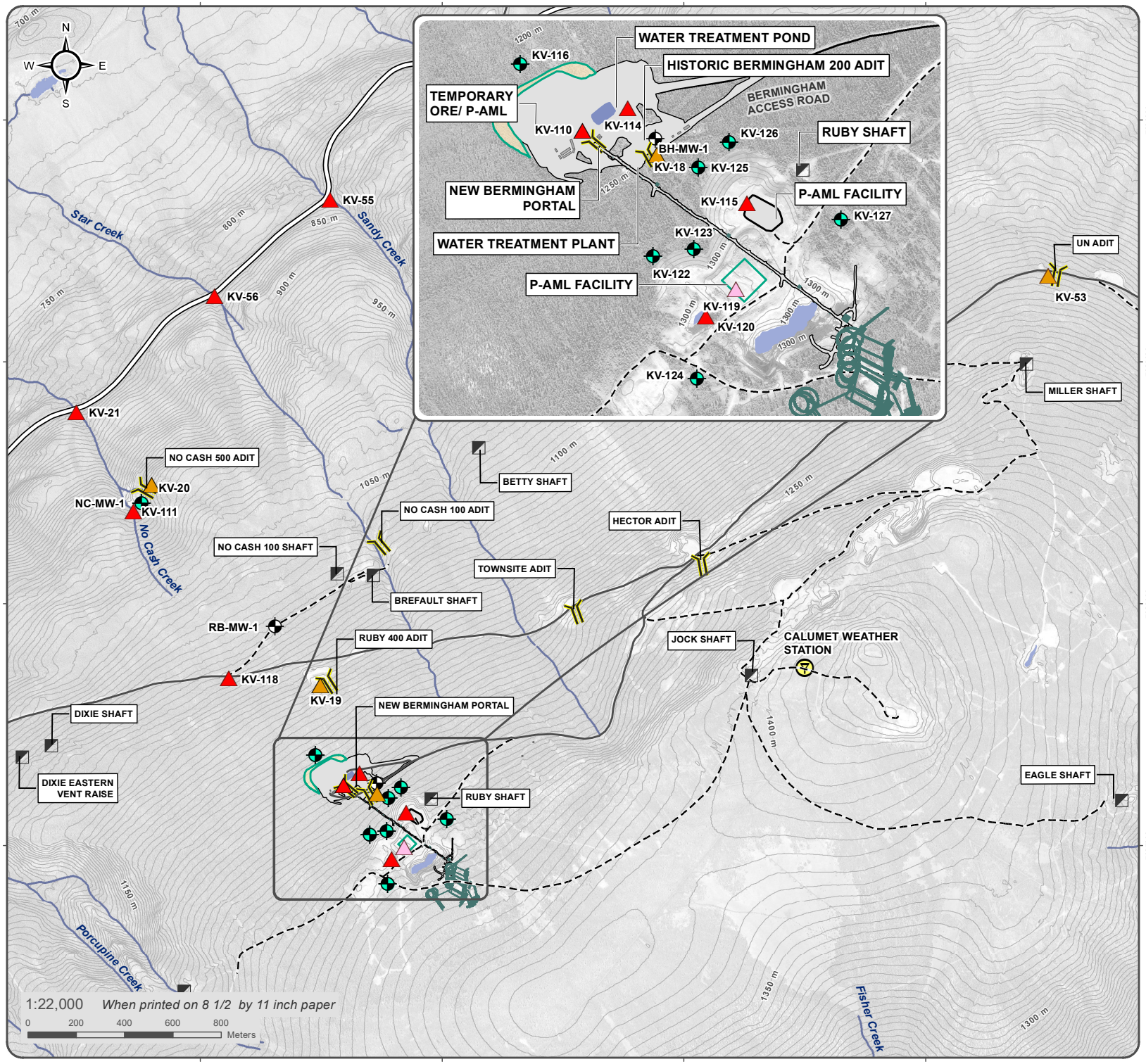
D:\Project\AI\Projects\Keno_Area_Mines\ALL-SITES\02-Map\01_Overview\04-WQ\GW\District\GW_monitoring_locations_District_AMP_20211018.mxd
Last edited by: amattachewska,2021-10-19T15:46 PM)

ALEXCO KENO HILL MINING CORP.

FIGURE 4-3

WATER QUALITY MONITORING LOCATIONS AT BERMINGHAM

NOVEMBER 2021



- Adit/Portal
- Shaft
- Weather Station
- Surface Water Quality Station
- Surface Water Quality Station, Pending
- Adit Water Quality Station, Existing
- Groundwater Quality Monitoring, Existing
- Newly Installed Groundwater Monitoring Well
- Permitted Mine Features
- Proposed Underground Workings
- Waterbody
- Silver Trail Highway
- Road
- Limited-Use Road
- Trail
- Contour (5m interval)

Datum: NAD 83; Map Projection: UTM Zone 8N

AKHM

D:\Project\AllProjects\Keno_Area_Mines\BERM\Maps\02-WQ\01-Surface\SWQ_Berm_wt_Inset_20211101.mxd
(Last edited by: tosberg;11/1/2021/12:03 PM)

4.13.3 MONITORING REQUIREMENTS

Monitoring requirements for groundwater monitoring are described in detail in the Groundwater Monitoring Plan. Quarterly measurement field parameters including water level and measurement by an external laboratory of a suite of standard parameters including dissolved ICP metals, alkalinity, ammonia, phosphorous, sulphate, uranium, selenium DOC, and hardness as specified by WL QZ18-044.

4.13.4 THRESHOLDS

Monthly sampling will be undertaken for each new monitoring well until a minimum of one year of data points are available to provide a baseline for each monitoring well. After these data points are collected, for each well, sampling will revert to quarterly sampling as per the groundwater monitoring plan. Triggers for adaptive management have been developed based on the Yukon Contaminated Sites Regulation Protocol No.10: Determining Background Groundwater quality. Additional thresholds have been established for increasing trends and water quality present in the monitoring wells for the phase 1 and 2 of the DSTF:

- Exceedance of the 95th percentile (calculated based on past ten years of data, where available – 95th percentile employed if greater than 10% of samples exceed YCSR standard) or YCSR groundwater quality standard for dissolved constituents that have a surface water quality objective (Table 4-10 and Table 4-11);
- Statistically significant increasing trend compared to past five years of data (use of Seasonal Mann Kendall test if there is seasonality evident in the data set; if not, then the Mann-Kendall test should be used); and
- Water depth is greater than 30 cm in DSTF monitoring wells and water quality is approaching EQS for KV-83 (BH-39 and KV-107).

Appendix A includes a summary of the updates made to the thresholds in comparison to the previous version of the AMP using a revised 10 year data set. Newly installed wells KV-116, NC-MW-1, and KV-122 through KV-127 have less than one year of data collected. The AMP triggers for these wells will be updated annually until three years of data have been collected upon which future triggers can be based.

4.13.5 RESPONSES

- Increased sampling frequency may be required around the area of the exceedance and will be implemented to help determine potential causes;
- Investigation of the root cause of the exceedance;
- If a root cause of exceedance can be readily identified and remedied, the remedy will be implemented in a timely manner, and the inspector notified of the remedy implementation in a timely manner according to permit requirements; and
- If a root cause cannot be readily identified, a study plan will be outlined and communicated to involve qualified professionals to assist in the identification of the root cause.

Table 4-10: AMP Triggers for Dissolved Constituents in Groundwater Monitoring Wells

	Sulphate	Ammonia-N	Nitrite-N	Nitrate-N	Arsenic	Cadmium	Copper	Lead	Nickel	Selenium	Silver	Uranium	Zinc
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
KV-85D [b]	YCSR	YCSR	nm [a]	nm [a]	0.16	0.00066	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
KV-85S [c]	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
KV-86 [d]	YCSR	YCSR	YCSR	YCSR	YCSR	0.00089	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
KV-87/87N [e]	1320	YCSR	YCSR	YCSR	0.052	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
KV-88D [c]	1809	YCSR	YCSR	YCSR	1.03	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
KV-88S [f]	YCSR	YCSR	nm [a]	nm [a]	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
KV-89D [g]	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
KV-89S [h]	2191	YCSR	YCSR	YCSR	YCSR	0.074	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	114
KV-109 [i]	YCSR	YCSR	YCSR	YCSR	0.17	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
RB-MW-1 [j]	YCSR	YCSR	YCSR	YCSR	0.089	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
KV-116 [k]	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
NC-MW-1 [k]	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
KV-122 [k]	YCSR	YCSR	YCSR	YCSR	YCSR	0.00062	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
KV-123 [k]	YCSR	YCSR	YCSR	YCSR	YCSR	0.0164	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	1.29
KV-125 [k]	YCSR	YCSR	YCSR	YCSR	YCSR	0.00070	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
KV-126 [k]	YCSR	YCSR	YCSR	YCSR	0.067	0.00221	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR

[a] nm indicates no data available as parameter not monitored

[b] Data range from September 2011 to June 2013; Well has been frozen or dry since 2013

[c] Data range from October 2011 to July 2021

[d] Data range from July 2011 to November 2020

[e] Combined data range from September 2011 to May 2018 for KV-87 and December 2020 to August 2021 for KV-87N which replaced KV-87

[f] Data from June 2012; Well has been mostly frozen or dry between 2011 and 2020

[g] Data range from October 2011 to October 2017

[h] Data range from June 2018 to July 2021

[i] Data range from June 2018 to July 2021

[j] Data range from September 2013 to July 2021

[k] Data range from November 2020 to August 2021

Table 4-11: YCSR Groundwater Guidelines

Constituent	YCSR Guideline (mg/L)		Constituent	YCSR Guideline (mg/L)
Sulphate	1,000		Lead [c]	0.04 at H < 50
Ammonia-N [a]	1.31 at pH ≥ 8.5			0.05 at H = 50 to < 100
	3.70 at pH 8.0 to < 8.5			0.06 at H = 100 to < 200
	11.3 at pH 7.5 to < 8.0			0.11 at H =200 to < 300
	18.5 at pH 7.0 to < 7.5			0.16 at H ≥ 300
	18.4 at pH < 7.0		Nickel [c]	0.25 at H < 60
Nitrite-N [b]	0.2 at Cl < 2			0.65 at H = 60 to < 120
	0.4 at Cl = 2 to < 4			1.1 at H = 120 to < 180
	0.6 at Cl = 4 to < 6			1.5 at H ≥ 180
	0.8 at Cl = 6 to < 8		Selenium	0.01
	1.0 at Cl = 8 to < 10		Silver [c]	0.0005 at H ≤ 100
	2.0 at Cl ≥ 10			0.015 at H > 100
Nitrate-N	400		Uranium	3
Arsenic	0.05		Zinc [c]	0.075 at H < 90
Cadmium [c]	0.0001 at H < 30			0.15 at H = 90 to < 100
	0.0003 at H = 30 to < 90			0.90 at H = 100 to < 200
	0.0005 at H = 90 to < 150			1.65 at H = 200 to < 300
	0.0006 at H = 150 to < 210			2.40 at H = 300 to < 400
Copper [c]	0.02 at H < 50			
	0.03 at H = 50 to < 75			
	0.04 at H = 75 to < 100			
	0.05 at H = 100 to < 125			
	0.06 at H = 125 to < 150			
	0.07 at H = 150 to < 175			
	0.08 at H = 175 to < 200			
	0.09 at H ≥ 200			

[a] Standard varies as a function of pH and temperature. Values in table assumes a temperature of 10°C

[b] Cl is chloride as mg/L

[c] H is hardness as mg/L $CaCO_3$

4.14 EVENT 14: FUGITIVE DUST RESULTS IN THE EXCEEDANCE OF AMBIENT AIR QUALITY STANDARDS AND/OR METAL GUIDELINES

4.14.1 DESCRIPTION

The DSTF contains fine grained material that could be subject to wind blown transport. Given the presence of metals in the tailings contained in the DSTF, and the potential health and environmental effects from degraded air quality resulting from dust generation, an adaptive management strategy has been developed. Additional sources of fugitive dust may include mineral processing (primary and secondary crushing, wet grinding and various material transfers and handling) and unpaved roads.

4.14.2 LOCATIONS

Air quality monitoring stations AQ1, AQ2 and AQ3.

4.14.3 MONITORING REQUIREMENTS

Air quality monitoring is undertaken 3 times per month at each air quality monitoring station. Results are analysed by an approved analytical laboratory for TSP, $PM_{10,}$ $PM_{2.5\ and}$ metals.

4.14.4 SPECIFIC THRESHOLDS

The specific thresholds that will initiate an adaptive management response include:

- An increasing trend in fugitive dust as shown by TSP, PM_{10} or $PM_{2.5}$ measurements or in metal concentrations towards Yukon Ambient Air Quality Standards or Ontario Ambient Air Quality Criteria for metals;
- An exceedance of the Yukon Ambient Air Quality Standards for particulate matter at AQ3; and
- An exceedance of the Ontario Ambient Air Quality Criteria for metals in TSP at AQ3.

4.14.5 APPROACHES TO RESPONSES

As per the general approach to the adaptive management plan, a staged response to the development of air quality degradation will be implemented if the threshold is triggered. The initial response to degraded air quality from fugitive dust, is to prevent conditions conducive to dust transport, including the initiation of dust suppression activities. If necessary, additional mitigative measures will be undertaken, including potential acceleration of the progressive reclamation of the DSTF. The final stage will be to monitor the area to watch for signs of continued fugitive dust generation.

4.15 EVENT 15: ATTENUATION OF CONSTITUENTS IN THE FLAME & MOTH DISCHARGE TO CHRISTAL CREEK OR BERMINGHAM DISCHARGE TO NO CASH CREEK DOES NOT PERFORM AS PREDICTED

4.15.1 DESCRIPTION

Natural attenuation of selected constituents of interest was incorporated in the modelling of the effects of the Flame & Moth water treatment plant (WTP) discharge on Christal Creek water quality. Attenuation of 50% was assumed as part of the water quality model for arsenic, cadmium, nickel, and zinc between the Flame & Moth WTP discharge and the existing monitoring station in Christal Creek (KV-6). Should natural attenuation not remove metals to the degree expected, water quality in Christal Creek may be degraded and not meet the water quality objectives (Event 12 - Section 4.12).

Additionally, the modelling for the proposed Bermingham Mine included natural attenuation of 50% for several parameters (ammonia, arsenic, copper, lead, nickel, and silver). This was based on the well documented natural attenuation that occurs year-round in No Cash Creek (Interralogic, 2013). Although upstream water treatment is expected to minimize any reliance on natural attenuation, lower natural attenuation than predicted may result in degraded water quality in No Cash Creek such that water quality objectives may not be met.

4.15.2 LOCATIONS

The Flame & Moth WTP pond decant (KV-104) and downstream monitoring sites in Christal Creek (KV-50 and KV-6) are the principal monitoring locations to assess natural attenuation. The proposed Bermingham water treatment pond decant (KV-114) will discharge into the No Cash Creek catchment, which may go to ground or become part of the No Cash Creek at KV-111 seasonally or at KV-21 in No Cash Creek at the Silver Trail Highway.

4.15.3 MONITORING REQUIREMENTS

Routine water quality monitoring will be conducted as part of the Monitoring, Surveillance and Reporting Plan and Christal Creek Attenuation Study which will be used to determine the extent of natural attenuation. During periods when the Flame & Moth WTP is discharging, water quality sampling and flow monitoring will occur weekly at sites KV-104, KV-50, and KV-6. Monitoring for the proposed discharge for Bermingham includes KV-114, KV-111 and KV-21.

4.15.4 SPECIFIC THRESHOLDS

The degree of natural attenuation for those constituents that were modelled to experience 50% natural attenuation) between KV-104 and both KV-50 and KV-6 in Christal Creek (arsenic, cadmium, nickel, and zinc) and KV-114 and both KV-21 and KV-111 in No Cash Creek (ammonia, arsenic, copper, lead, nickel, and silver) will be calculated monthly. An AMP response will be triggered if the calculated natural attenuation at KV-50, KV-6, KV-111, or KV-21 is less than 50% for the constituents and the WQOs in Table 4-9 are exceeded.

4.15.5 RESPONSES

If natural attenuation of arsenic, cadmium, nickel, or zinc falls below the 50% threshold and results in an exceedance of the KV-50, KV-6, KV-111, or KV-21 WQOs, the AMP responses for Event 12 (Exceedance of Water Quality Objectives in the Receiving Environment; Section 4.12) will be enacted.

If no WQO exceedance is noted, but the concentration of parameters of interest at KV-50, KV-6, KV-111, or KV-21 have increased to within 10% of their maximum WQO (95th percentile or BCMOE/CCME-based WQO), then the causes of the reduced natural attenuation will be investigated. This may include:

- Visual inspection of the WTP decant pond discharge flow path to Christal Creek or No Cash Creek for evidence of significant channel formation that may be limiting interaction with soil and vegetation substrate, potentially limiting natural attenuation;
- Evaluation of any water quality changes in WTP pond decant (KV-104 or KV-114) that may be limiting effectiveness of natural attenuation; and
- Additional water sampling to identify any sources of increased load. Such sampling may include:
- End of the overland discharge from the WTP decant pond to check natural attenuation effectiveness there;
- Upstream of KV-50 for any potential load sources that may be masking natural attenuation;
- Christal Lake to check on lake processes that may be providing metal load; and
- No Cash 500 adit discharge water quality.

Depending on the results of the investigation, corrective measures may be considered such as:

- Reduce Flame & Moth Pond decant discharge rate to Christal Creek or move all discharge to Lightning Creek until corrective actions are implemented;
- Relocating the WTP decant diffuser to an area that is not affected by flow path channelization;
- Replace with a larger diffuser to better spread the overland flow path of the discharge and enhance interaction with underlying soils; and
- Water treatment improvements (e.g., upgrades to clarifier) to account for lack of natural attenuation capacity in Christal Creek and/or No Cash Creek discharge area.

5. REFERENCES

Alexco Environmental Group Inc. (2019). Mass Load Model for Bermingham Productions and Development Program, December 2, 2019.

EBA Engineering Consultants Ltd. Operation, Maintenance, and Surveillance Manual Dry Stack Tailings Facility Keno Hill District Mill, TY, September 2010.

Canada Gazette, *Metal Mining Effluent Regulations,* Published September 2017

Golder Associates (2013). Chronic Effects Benchmarks. Report prepared for Shell Canada Energy, October 2013. Available at: https://www.ceaa-acee.gc.ca/050/documents_staticpost/59539/95925/Appendix_3-6.pdf

Interralogic, Inc. (2013). *Natural Attenuation Evaluation Summary Report, United Keno Hill Mines, Elsa, YT*. Prepared for Elsa Reclamation and Development Company Ltd., November 2013.

APPENDIX A

KHSD MINING OPERATIONS ADAPTIVE MANAGEMENT PLAN ASSESSMENT OF WATER QUALITY TRIGGERS

Memorandum

To: Linda Broughton, Alexco Resource Corp.

From: Rachelle Kleinberger and Andrew Gault, Ensero Solutions Canada, Inc.

CC: Kai Woloshyn, Ensero Solutions Canada, Inc.

Date: October 29, 2021

Re: Keno Hill Silver District Mining Operations Adaptive Management Plan Assessment of Water Quality Triggers

1 INTRODUCTION

The Adaptive Management Plan (AMP) triggers for surface water and groundwater (AMP Events 12 and 13, respectively) were based on the past 5 years of water quality data (where available). In their review of the AMP as part of the Quartz Mining License review process, Yukon Environment indicated that a longer data set (e.g., 10 years) should be evaluated for AMP trigger development. This memorandum presents a comparison of the AMP triggers developed using the original 5-year data set (August 2015 to July 2020) and the larger 10-year data set that also incorporates more recent data (July 2011 to August 2021).

2 COMPARISON OF AMP TRIGGERS WITH UPDATED DATA SET

2.1 EVENT 12 – SURFACE WATER RECEIVING ENVIRONMENT

Water quality objectives (WQOs) for No Cash Creek (KV-21, KV-111), Star Creek (KV-56), Christal Creek (KV-50, KV-6, and KV-7), Lightning Creek (KV-81), and the South McQuesten River (KV-2) were established using generic CCME or BCMoE guidelines or using the background concentration procedure (BCP). The background concentration procedure was used to develop WQOs for constituents that frequently exceed the CCME and BCMoE guidelines (i.e., greater than 10% of samples exceed guideline). Short-term maximum and long-term average threshold concentrations were developed from the 95th percentile (P95) and upper confidence level (95%) mean (UCLM) of the data set.

The WQOs used as triggers for the AMP based on the 5-year and 10-year data set are presented in Table 2-1 and Table 2-2, respectively. In most cases, the generic CCME or BCMoE guideline still applies as the AMP trigger. Where the triggers are based on the BCP-based approach (i.e., P95 and UCLM), the changes are summarized below by station.

- KV-50
    - Comparable P95 and UCLM concentrations for total arsenic for the 5- and 10-year data sets.
    - Higher total copper P95 and UCLM concentrations for the 10-year data set owing to sporadic annual peak copper concentrations measured in 2011 and 2012.
    - Lower total zinc P95 and UCLM concentrations for the 10-year data set due to broadly sustained higher concentrations measured since 2017.
    - Higher sulphate P95 for the 10-year data set due to sustained elevated that occurred in 2012-2013; UCLM was comparable.
- KV-6:
    - Lower BCP-based thresholds were obtained for arsenic and zinc for the 10-year data set compared with the 5-year period. This is due to the higher concentrations observed in more recent years, notably in 2020, possibly due to higher flows and greater flushing of Mackeno tailings.
    - Lower total silver P95 and UCLM for the 10-year data set due to higher annual peak concentrations measured in 2017 to 2020.
    - Comparable P95 and UCLM concentrations observed for total cadmium and copper for the 5- and 10-year data sets.
- KV-7:
    - Higher total cadmium P95 and UCLM concentrations for the 10-year data set owing to higher annual peak cadmium concentrations during freshet for 2011 to 2014 than those observed in more recent years.
    - Comparable P95 and UCLM concentrations observed for total arsenic and copper for the 5- and 10-year data sets.
- KV-81:
    - Comparable P95 and UCLM concentrations observed for dissolved copper for the 5- and 10-year data sets.
- KV-21:
    - Comparable P95 and UCLM concentrations observed for dissolved cadmium, copper, zinc, and sulphate for the 5- and 10-year data sets.

- KV-56:
    - Higher P95 total cadmium for the 10-year data set due to higher annual peak freshet cadmium levels for the pre-2017 period. The cadmium UCLM concentrations were comparable between the 5- and 10-year data sets.
    - The CCME guideline is employed for zinc for the 10-year data set due to relatively few exceedances (i.e., <10% of samples). The higher incidence of CCME exceedances for the 5-year data set used for the previous version of the AMP was due to the lack dissolved organic carbon (DOC) data available for samples collected prior to 2018. In the absence of DOC measurements, the low end of the accepted DOC range for the calculation of the zinc CCME guideline was initially used for the pre-2018 data, which resulted in the bulk of the guideline exceedances. This is considered overly conservative; therefore, the percent of samples exceeding the CCME guideline was calculated again using only samples for which DOC was measured. This resulted in the retention of the CCME guideline as the zinc WQO for KV-56 since less than 10% of samples exceeded the CCME guideline.
- KV-111:
    - Since this station was established within the past 5 years, the only difference between the "5-year" and "10-year" data sets is the additional year of data (i.e., Aug 2020 to Aug 2021) available for this AMP update. This resulted in slightly lower BCP-based WQOs for cadmium and zinc compared to the data set used for the previous AMP.
- KV-2:
    - Lower total copper P95 and UCLM concentrations for the 10-year data set owing to a lower concentration range observed for the 2011-2015 period compared to that observed in more recent years.
    - Comparable P95 and UCLM concentrations observed for total cadmium and zinc for the 5- and 10-year data sets.

Table 2-1: Water Quality Objectives for Christal Creek, Lightning Creek, No Cash Creek, Star Creek, and South McQuesten River (mg/L) (5-year Data Set)

	KV-50	KV-6	KV-7	KV-81[a]	KV-21[a]	KV-56	KV-111[a]	KV-2
Ammonia-N	CCME	CCME	CCME	CCME	CCME	CCME	CCME	CCME
Nitrate-N	CCME	CCME	CCME	CCME	CCME	CCME	CCME	CCME
Nitrite-N	CCME	CCME	CCME	CCME	CCME	CCME	CCME	CCME
Arsenic	0.0415[b], 0.0297[c]	0.0207[b], 0.0121[c]	0.0106[b], 0.00479[c]	CCME	0.025[f]	CCME	CCME	CCME
Cadmium	BCMoE	0.00234[b], 0.00157[c]	0.00167[b], 0.000839[c]	BCMoE	0.0398[b], 0.0193[c]	0.000207[b], 0.000130[c]	0.000693[d], 0.000336[e]	0.000944[g], 0.000690[h]
Copper	0.00210[b], 0.00155[c]	0.00290[b], 0.00126[c]	0.00772[b], 0.00284[c]	0.00148[b], 0.00062[c]	0.00352[d], 0.00188[e]	BCMoE	BCMoE	0.00893[g], 0.0049[h]
Lead	BCMoE	BCMoE	BCMoE	BCMoE	BCMoE	BCMoE	BCMoE	BCMoE
Nickel	CCME	CCME	CCME	CCME	CCME	CCME	CCME	CCME
Silver	CCME	0.000603[b], 0.000215[c]	CCME	CCME	CCME	CCME	CCME	CCME
Uranium	CCME	CCME	CCME	CCME	CCME	CCME	CCME	CCME
Zinc	0.305[b], 0.243[c]	0.463[b], 0.234[c]	0.173[b], 0.111[c]	CCME	4.26[b], 2.04[c]	0.0393[b], 0.0197[c]	0.212[d], 0.0788[e]	0.161[g], 0.115[h]
Sulphate	505[b], 403[c]	BCMoE	BCMoE	BCMoE	524[b], 360[c]	BCMoE	BCMoE	BCMoE
Selenium	BCMoE	BCMoE	BCMoE	BCMoE	BCMoE	BCMoE	BCMoE	BCMoE
Radium	-	0.037 Bq/L	-	0.037 Bq/L	-	-	0.037 Bq/L	-

a) Objectives for KV-81, KV-21, and KV-111 metals are dissolved
b) 95th percentile from August 2015 to July 2020 data set
c) Upper confidence level mean from August 2015 to July 2020 data set
d) 95th percentile from July 2017 to July 2020 data set; the BCP-based WQOs developed for KV-111 previous erroneously omitted some monthly data. This has been corrected herein.
e) Upper confidence level mean from July 2017 to July 2020 data set
f) Site specific based on Golder (2013) presented in Bermingham Water Quality Model (AEG, 2019)
g) 95th percentile from January 2015 to October 2019 data set
h) Upper confidence level mean from January 2015 to October 2019 data set

Table 2-2: Water Quality Objectives for Christal Creek, Lightning Creek, No Cash Creek, Star Creek, and South McQuesten River (mg/L) (10-year Data Set)

	KV-50	KV-6	KV-7	KV-81[a]	KV-21[a]	KV-56	KV-111[a]	KV-2
Ammonia-N	CCME	CCME	CCME	CCME	CCME	CCME	CCME	CCME
Nitrate-N	CCME	CCME	CCME	CCME	CCME	CCME	CCME	CCME
Nitrite-N	CCME	CCME	CCME	CCME	CCME	CCME	CCME	CCME
Arsenic	0.0432[b], 0.0277[c]	0.0167[b], 0.0098[c]	0.0102[b], 0.0043[c]	CCME	0.025[f]	CCME	CCME	CCME
Cadmium	BCMoE	0.00218[b], 0.00142[c]	0.00251[b], 0.000945[c]	BCMoE	0.0445[d], 0.0209[e]	0.000297[d], 0.000132[e]	0.000541[b], 0.000258[c]	0.000941[b], 0.000647[c]
Copper	0.00602[d], 0.00280[e]	0.0321[d], 0.00115[e]	0.00726[b], 0.00216[c]	0.00148[b], 0.00070[c]	0.00359[d], 0.00193[e]	BCMoE	BCMoE	0.00651[b], 0.00376[c]
Lead	BCMoE	BCMoE	BCMoE	BCMoE	BCMoE	BCMoE	BCMoE	BCMoE
Nickel	CCME	CCME	CCME	CCME	CCME	CCME	CCME	CCME
Silver	CCME	CCME	CCME	CCME	CCME	CCME	CCME	CCME
Uranium	CCME	CCME	CCME	CCME	CCME	CCME	CCME	CCME
Zinc	0.271[b], 0.205[c]	0.367[b], 0.207[c]	0.220[b], 0.120[c]	CCME	4.94[d], 2.28[e]	CCME	0.179[b], 0.0602[c]	0.152[b], 0.103[c]
Sulphate	544[b], 409[c]	BCMoE	BCMoE	BCMoE	539[d], 349[e]	BCMoE	BCMoE	BCMoE
Selenium	BCMoE	BCMoE	BCMoE	BCMoE	BCMoE	BCMoE	BCMoE	BCMoE
Radium	-	0.037 Bq/L	-	0.037 Bq/L	-	-	0.037 Bq/L	-

a) Objectives for KV-81, KV-21, and KV-111 metals are dissolved
b) 95th percentile from July 2011 to August 2021 data set, except for KV-111 which ranges from September 2017 to August 2021
c) Upper confidence level mean from July 2011 to August 2021 data set, except for KV-111 which ranges from September 2017 to August 2021
d) 95th percentile from July 2017 and June 2018 to August 2021 data set for KV-21 and KV-56, respectively
e) Upper confidence level mean from July 2017 and June 2018 to August 2021 data set for KV-21 and KV-56, respectively
f) Site specific based on Golder (2013) presented in Bermingham Water Quality Model (AEG, 2019)

2.2 EVENT 13 – GROUNDWATER

The majority of the groundwater AMP triggers are based on the Yukon Contaminated Site Regulation (YCSR) standards. YCSR standards continued to dominate the AMP triggers with the expansion of the water quality data set. The WQOs used as triggers for the AMP based on the 5-year and 10-year data set are presented in Table 2-3 and Table 2-4, respectively. Changes to the AMP triggers that are based on the P95 (i.e., where greater than 10% of samples exceeded the YCSR) are summarized below by station.

- KV-85D:
    - The P95 triggers for arsenic and cadmium were the same since the data range (2011 to 2013 – well frozen since 2013) is the same for the 5- and 10-year span
- KV-85S:
    - YCSR was used as thew cadmium trigger for the 10-year data set compared to P95 for the 5-year data set. This was due to the lower percent exceedances for dissolved cadmium for the 10-year data set owing to a higher concentration range observed only between May 2017 and October 2019, resulting in the same three exceedances counted over a larger sample set.
- KV-86:
    - Higher P95 trigger for dissolved cadmium for the 10-year data set owing to a higher concentration range observed between May 2011 and October 2013.
- KV-87/87N:
    - The 10-year dataset for KV-87 (September 2011 to May 2018) was updated with data from well KV-87N (data available from December 2020 to August 2021). Well KV-87 became blocked in 2018 and was replaced by well KV-87N in late 2020.
    - Similar P95 sulphate arsenic trigger for the 5-year (1333 and 0.055 mg/L, respectively) and 10-year (1320 and 0.052 mg/L, respectively) data sets
- KV-88D
    - Similar P95 sulphate and arsenic trigger for the 5-year (1844 and 1.04 mg/L, respectively) and 10-year (1809 and 1.03 mg/L, respectively) data sets
- KV-89D:
    - YCSR was used for the cadmium AMP trigger the 10-year data set compared to P95 for the 5-year data set. This was due to lower percent exceedances for dissolved cadmium for the 10-year data set.
- KV-89S:
    - Similar P95 for dissolved cadmium for the 5- and 10-year data sets.

- Lower P95 trigger for sulphate and dissolved zinc for the 10-year data set owing to generally lower concentrations observed in the 2011 to 2016 data period. Peak concentrations observed in July 2015, and June and July 2018.

- KV-109:
  - Similar P95 for dissolved arsenic for the 5- (0.166 mg/L) and 10-year (0.172 mg/L) data sets.

- RB-MW-1:
  - Similar P95 for dissolved arsenic for the 5- (0.091 mg/L) and 10-year (0.089 mg/L) data sets.
  - YCSR was used for the cadmium AMP trigger for the 10-year data set compared to P95 for the 5-year data set. This was due to lower percent exceedances for dissolved cadmium for the 10-year data set owing to peak concentrations observed in July 2015 and May 2018, resulting in the same two exceedances counted over a larger sample set.

Table 2-3: AMP Triggers for Dissolved Constituents in Groundwater Monitoring Wells (5-year Data Set)

	Sulphate	Ammonia-N	Nitrite-N	Nitrate-N	Arsenic	Cadmium	Copper	Lead	Nickel	Selenium	Silver	Uranium	Zinc
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
KV-85D [b]	YCSR	YCSR	nm [a]	nm [a]	0.16	0.00066	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
KV-85S [c]	YCSR	YCSR	YCSR	YCSR	YCSR	0.0017	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
KV-86 [d]	YCSR	YCSR	YCSR	YCSR	YCSR	0.00067	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
KV-87 [e]	1333	YCSR	YCSR	YCSR	0.055	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
KV-88D [c]	1844	YCSR	YCSR	YCSR	1.04	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
KV-88S [f]	YCSR	YCSR	nm [a]	nm [a]	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
KV-89D [g]	YCSR	YCSR	YCSR	YCSR	YCSR	0.00069	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
KV-89S [c]	2869	YCSR	YCSR	YCSR	YCSR	0.077	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	201
KV-109 [h]	YCSR	YCSR	YCSR	YCSR	0.166	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
RB-MW-1 [c]	YCSR	YCSR	YCSR	YCSR	0.091	0.00074	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR

[a] nm indicates no data available as parameter not monitored
[b] Data range from September 2011 to June 2013; Well has been frozen or dry since 2013
[c] Data range from July 2015 to June 2020
[d] Data range from July 2015 to October 2019
[e] Data range from October 2015 to May 2018
[f] Data from June 2012; Well has been mostly frozen or dry between 2011 and 2020
[g] Data range from July 2015 to October 2017
[h] Data range from June 2018 to May 2020

Table 2-4: AMP Triggers for Dissolved Constituents in Groundwater Monitoring Wells (10-year Data Set)

	Sulphate	Ammonia-N	Nitrite-N	Nitrate-N	Arsenic	Cadmium	Copper	Lead	Nickel	Selenium	Silver	Uranium	Zinc
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
KV-85D [b]	YCSR	YCSR	nm [a]	nm [a]	0.16	0.00066	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
KV-85S [c]	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
KV-86 [d]	YCSR	YCSR	YCSR	YCSR	YCSR	0.00089	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
KV-87/87N [e]	1320	YCSR	YCSR	YCSR	0.095	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
KV-88D [c]	1809	YCSR	YCSR	YCSR	1.03	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
KV-88S [f]	YCSR	YCSR	nm [a]	nm [a]	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
KV-89D [g]	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
KV-89S [h]	2191	YCSR	YCSR	YCSR	YCSR	0.074	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	114
KV-109 [i]	YCSR	YCSR	YCSR	YCSR	0.17	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR
RB-MW-1 [j]	YCSR	YCSR	YCSR	YCSR	0.089	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR	YCSR

[a] nm indicates no data available as parameter not monitored
[b] Data range from September 2011 to June 2013; Well has been frozen or dry since 2013
[c] Data range from October 2011 to July 2021
[d] Data range from July 2011 to November 2020
[e] Combined data range from September 2011 to May 2018 for KV-87 and December 2020 to August 2021 for KV-87N which replaced KV-87
[f] Data from June 2012; Well has been mostly frozen or dry between 2011 and 2020
[g] Data range from October 2011 to October 2017
[h] Data range from June 2018 to August 2021
[i] Data range from June 2018 to July 2021
[j] Data range from September 2013 to July 2021

3 REFERENCES

Alexco Environmental Group Inc. (2019). Mass Load Model for Bermingham Productions and Development Program, December 2, 2019.

Golder Associates (2013). Chronic Effects Benchmarks. Report prepared for Shell Canada Energy, October 2013. Available at: https://www.ceaa-acee.gc.ca/050/documents_staticpost/59539/95925/Appendix_3-6.pdf