YESAB

Yukon Environmental and
Socio-economic Assessment Board

Designated Office Evaluation Report

Flame and Moth Development and Production Proposal

Project Number: 2013-0161

Proponent: Alexco Keno Hill Mining Corporation

Assessment Completion Date: October 5, 2014

Mayo Designated Office

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SUMMARY

Alexco Keno Hill Mining Corporation (AKHM) is proposing to develop the Flame and Moth ore deposits located near their existing Mill site near Keno City. Mining of the Flame and Moth deposits is proposed to occur concurrently with mining of AKHM's other licenced mines (Bellekeno, Lucky Queen and Onek) in the area by blending ore from one of the other mines with ore from the Flame and Moth mine at any given time during the mine life. These operations will extend the operation of the Mill to approximately 2021 and require a substantial increase to the current dry stacked tailings storage facility.

During the assessment, numerous comments were received from various levels of government and many individuals. Information gathered at a community forum held in Keno City played an important role in the assessment as community members provided background and descriptions of their direct experience related to effects from existing projects near Keno City. These comments also assisted in understanding the past, current and future character of Keno City from the perspective of Residents.

Through the extensive comment submissions provided along with additional research and analysis by the Designated Office, the following four valued environmental and socio-economic components (VESEC) were identified as adversely affected by the Project:

- Aquatic Resources (Section 5.0)
- Health and Safety (Section 6.0)
- Visual and Auditory Amenity (Section 7.0)
- Community Wellbeing (Quality of Life) (Section 8.0)

The Designated Office concluded that effects to all VESECs identified would be significant and could be mitigation. The terms and conditions recommended in this report are expected to adequately reduce the effects. However, considerable uncertainty remains regarding the effectiveness of mitigation to achieve the desired outcomes as the most critical effects from the Project are socio-economic effects to residents of Keno City. Strict adherence to existing licence conditions, past and current Proponent commitments and the mitigations in this report will provide the highest likelihood of reducing significant effects from the Project, particularly to socio-economic values identified.

The Decision Body(s), Yukon Government, will review the Recommendation and the accompanying reasons described in this Evaluation Report. The Decision Body will issue a Decision Document within 30 days, as prescribed under s. 2 of the *Decision Body Time Periods and Consultation Regulations*, that will either a) accept the recommendation, b) vary the recommendation, or c) reject the recommendation.

Assessment Outcome

Under s. 56(1)(b) of *the Yukon Environmental and Socio-economic Assessment Act*, the Mayo Designated Office recommends to the Decision Bodies that the Project be allowed to proceed, subject to specified terms and conditions. The Designated Office determined that the Project will have significant adverse environmental and socio-economic effects in or outside Yukon that can be mitigated by those terms and conditions.

The terms and conditions of the recommendations are as follows:

1. The Proponent shall revise their site specific water quality objectives (SSWQOs) for As, Cd, Pb, Ag and Zn at station KV-6; for Cd, Pb, Ag and Zn at station KV-7; and for

As, Cd, Cu, Pb, Ag and Zn at KV-81 to reflect the typical background concentration (e.g. mean + two standard deviations) at those stations rather than the upper limit of background. The Proponent shall employ the Canadian Council of Ministers of the Environment (CCME 2003) guidelines for the derivation of site specific water quality objectives in the development of SSWQOs with the intent of reducing, to the extent practicable, the release of contaminants at concentrations in excess of the typical water quality for those stations (i.e. non-degradation).

2. The Proponent shall revise their proposed Effluent Quality Standards (EQS) for water quality station KV-104 to reflect the revised SSWQOs developed in mitigation number one (1). The Proponent shall demonstrate to regulators, by way of updated modelling, that the revised EQS will not produce exceedances of the updated SSWQOs in the receiving environment. In addition, the revised EQS shall include standards for ammonia, nitrate, nitrite and selenium.

3. The Proponent shall provide regulators with supporting rationale for the use of the draft United States Environmental Protection Agency water quality guideline for selenium as opposed to the current Canadian Water Quality Guidelines for the Protection of Aquatic Life. The supporting rationale should include a site-specific discussion of selenium concentrations in reproductive tissues of fish in Christal and Lightning Creeks and how these concentrations are related to selenium concentrations in the water.

4. All water discharged from mine de-watering shall be treated through the proposed water treatment plant prior to discharge to the receiving environment at station KV-104.

5. Any future discharge from the Mill Pond shall be treated through the proposed water treatment plant prior to release.

Rationale: Additional contaminant loadings to Christal Creek in excess of water quality guidelines and/or typical background concentrations are not protective of aquatic life and should not be permitted. It seems inappropriate for the Proponent to be permitted to discharge effluent from the Mill Pond with much higher contaminant concentrations than necessary if a treatment plant exists at the site.

6. In support of the licencing process, the Proponent shall provide regulators with the results of a sensitivity analysis of metal attenuation rates that are lower than predicted by column tests. This analysis shall include a model run assuming no attenuation of metals.

7. In support of the licencing process, the Proponent shall provide regulators with the results of additional depth discrete groundwater monitoring at depths equal to the proposed mine workings to allow for an understanding of the potentiometric groundwater surface to confirm groundwater inflows to the underground workings and the potential for adit discharge at closure. If adit discharge is predicted or cannot be ruled out post closure, the Proponent shall maintain active water treatment on site

until the effectiveness of the passive bioreactor can be demonstrated to achieve necessary protection of aquatic life.

8. In support of the licencing process, the Proponent shall provide regulators with the results of additional depth discrete groundwater monitoring with sufficient coverage to determine the groundwater flow in the area of the Flame and Moth Mine and define any groundwater divides that exist.

9. In support of the licencing process, the Proponent shall provide regulators with the results of a sensitivity analysis of their water balance illustrating the effects of estimated maximum and minimum flows (dry and wet years) for all inflows and outflows of the water balance model.

10. In support of the licencing process, the Proponent shall provide regulators with updated geochemical analysis comparing both non-mineralized and mineralized zones to provide certainty that all of potential contaminants of concern have been identified.

11. The Proponent shall update their Adaptive Management Plan to include reference to the Flame and Moth Mine and corrective actions specific to the Flame and Moth Mine where applicable.

12. The Proponent shall update events 12 and 13 of their Adaptive Management Plan to trigger investigations of sources of contaminants that show trends of increasing contaminant loads before they exceed the water quality objectives to reduce the potential of exceedances and associated significant adverse effects.

13. In support of the licencing process, the Proponent shall provide regulators with an updated Adaptive Management Plan outlining actions to be taken in the event that potentially acid producing or metal leaching waste rock is left on surface during such events as a temporary shutdown of operations.

14. In support of the licencing process, the Proponent shall provide regulators with the results of borehole logs from subsurface investigations in the footprint of the proposed dry stacked tailings storage (DSTF) expansion area. These subsurface investigations should be sufficient in number to provide representative sampling from across the footprint of the proposed DSTF expansion to support the conclusions of the DSTF design and stability analysis. This subsurface monitoring shall include the installation of stability monitoring equipment, ground temperature cables and groundwater monitoring wells to build adequate baseline data prior to construction. These monitoring systems shall be monitored throughout the design life of the facility.

15. In the event that water is observed in monitoring well BH39 in the existing dry stacked tailing storage facility, this water shall be collected and sent for full metals analysis to confirm its origin. The results of this analysis shall be reported to regulators in a timely manner.

Rationale: This mitigation is intended to inform the ongoing expansion of the DSTF to ensure that all pertinent information is available throughout the development of the new facility.

16. The Proponent shall install a geosynthetic liner beneath the expanded DSTF to contain and capture any seepage that may occur from the facility in future and allow for treatment prior to release to the receiving environment.
17. In support of the licencing process, the Proponent shall provide regulators with a discussion and analysis of the potential effects of blasting at the Flame and Moth Mine to the integrity of long-term monitoring wells and instrumentation in the area of the Mill and DSTF.
18. The Proponent shall implement the revised Dust Abatement and Monitoring Plan, which shall be reflected in an updated Monitoring and Surveillance Plan and Adaptive Management Plan.
19. The Proponent shall monitor levels of TSP, PM10, PM2.5 and metals speciation of TSP.
20. The Proponent shall revise the trigger values for initiating the Adaptive Management Plan to include consideration of the ability to identify events when metal levels in TSP on the site are elevated above health-based criteria. Use of a long-term historical average that is derived from periods without active milling may be an appropriate revision/method for the trigger value.
21. The mitigations with respect to groundwater wells and monitoring identified in Section 5.0 Aquatic Resources must be implemented.
22. The AMP event shall be revised to include the potential for groundwater contamination from Flame and Moth, in addition to Onek 990, until such time as the groundwater flow can be adequately characterized to rule out this possibility. The wording of the AMP event shall be revised to allow for the AMP response to be initiated when there is uncertainty regarding the source of the contamination.
23. The narrative trigger in the AMP should capture increasing trends in concentrations of a wider range of contaminants that proactively mitigates for exceedances to the Canadian Drinking Water Quality guidelines before they occur.
24. In addition to notifying the Water Inspector, residents shall be immediately notified if there are exceedances to any parameters listed in the Canadian Drinking Water Quality Guidelines. Notification shall also include instructions on where to obtain water, if necessary, (e.g. identified back up well), and other information on health-related risks, measures, and actions being taken.
25. A suitable back up well shall be identified and monitored, in addition to other groundwater wells.
26. Blasting shall not be undertaken during unfavourable weather conditions (e.g. westerly winds, lower than average humidity) to avoid deposition of dust on

neighbours and the delayed dissipation of visible dust from the atmosphere. The conditions under which blasting shall not be undertaken shall be explicitly identified for the residents of Keno City.

27. In addition to notifications regarding traffic increases, the Proponent shall post and/or notify their operation schedules and potential dust-generating events in a manner that is approved by Keno City residents and that allows sufficient time to plan (e.g. regular meetings, approved posting locations, approved frequency of posting and meetings, etc.)

28. The Proponent shall include a section in their Annual Report for Social Impacts Monitoring, in consideration of monitoring and implementation of mitigation for valued components identified in the Socio-economic Mitigation Plan, including visual aesthetic factors.

29. The DSTF shall be reclaimed in consideration of improving the visual amenity of the site in addition to long-term stability. Visual amenity objectives shall be identified by the community of Keno City.

30. Prior to commencing operations, the Proponent shall install a noise reducing cover over the mill crusher.

31. To reduce impacts from low frequency noise, the Proponent shall not operate the crusher, DSTF track excavator or DSTF packer between the hours of 19:00 and 07:00.

32. The Proponent shall employ a neutral, third party mediator with proven education, training and experience in mediation and dispute resolution to administer engagement between the Proponent and the residents of Keno City to collaboratively develop the following:

a. A comprehensive sound monitoring and mitigation plan that is administered by an independent third party noise specialist and reported on annually as part of the reporting requirements in the Proponent's quartz mining licence. The primary objectives of this plan shall include the development and implementation of a comprehensive and defensible sound monitoring program aimed at monitoring noise, including low frequency noise, at sensitive receptors in the community.

b. Based on ongoing monitoring, the independent noise specialist shall provide the residents of Keno City and the Proponent with a comprehensive list of additional mitigations available to address concerns of noise from the Proponent's ongoing operations.

c. To address any outstanding concerns of noise, the mediator shall administer discussions between the Proponent and the residents of Keno City to identify reasonable noise reducing mitigations. These mitigations shall include consideration of appropriate compensation as a possible mitigation. The Proponent shall implement

noise mitigations including compensation as soon as practicable following identification of appropriate noise reducing measures.

d. The Proponent and residents of Keno City through guidance from a mediator shall develop a noise compliant and resolution protocol to be administered by an independent third party to accept and investigate reasonable complaints of noise. Complaints and any corrective actions shall be documented and reported quarterly with reports distributed to the Proponent, the regulator and the residents of Keno City.

The mitigation recommended in Sections 6 and 7 of this Report, including the Proponent's Commitments, as set out in the recommended terms and conditions. However, the mitigation below expands on previous mitigation for socio-economic values.

33. The Proponent shall employ a neutral, third-party mediator with proven education, training and experience in mediation and dispute resolution to administer engagement between the Proponent and the residents of Keno City, to collaboratively develop a Keno City Socio-Economic Mitigation Plan, that includes at least the following components:

a. The formal identification of socio-economic values affected by the Proponent's activities and specific objectives and actions to meet identified objectives (e.g. noise objectives met through restrictions on air brake use in and around Keno City etc.).

b. The comprehensive sound monitoring and mitigation plan, the purpose and contents of which are outlined in Section 7.3.3, under term and condition #32 a, b, c, and d.

c. The establishment of a Communication Protocol to achieve consistency and fairness in the means, method and timing and frequency of communications between the Proponent and residents, including the communication requirements for different activities (notification, meeting, etc.). All communications shall be documented and reported with an agreed upon frequency that is reasonable for both the Proponent and residents.

d. Inclusion of a formal complaint resolution protocol to be administered by an independent third party to accept and investigate reasonable complaints relating to noise, dust, traffic, and any other concern related to the Proponents activities that may directly affect Keno City residents quality of life, as outlined in the Socio-Economic Mitigation Plan. Government bodies who may have received complaints should also advise the third party charged with receiving complaints. Complaints and any corrective actions shall be documented and reported quarterly with reports distributed to the Proponent, the regulator and the residents of Keno City.

e. The identification and implementation of actions by the Proponent to offset impacts to the local economy from their operations (e.g. from reduced property values, impacts to tourism, etc.).

f. Mitigation for impacts affecting community wellbeing, (including impacts to the local economy, reduced quality of life from noise, etc.), shall include consideration of appropriate compensation.

34. The Keno City Socio-economic Mitigation Plan shall be developed immediately, prior to Project implementation, and shall be reported on annually.

35. To reduce uncertainty, the Proponent shall begin early engagement with the residents of Keno City, via a third-party mediator, to discuss the Proponent's preferred long-term regional plan/vision that includes a transparent assessment of potential future alternatives for tailings and mill site infrastructure. This engagement shall be documented and reported to the regulator.

Report Prepared by Adam Wrench and Stephanie Routley

For more information, please contact:

Name: Adam Wrench

Title: Manager, Designated Office

Mayo Designated Office

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ACRONYMS

ABA	*Acid Base Accounting*
AKHM	*Alexco Keno Hill Mining Corp.*
AMP	*Adaptive Management Plan*
AR	*Adequacy Review*
ARD	*Acid rock drainage*
BCMOE	*British Columbia Ministry of Environment*
CABIN	*Canadian Aquatic Biomonitoring Network*
CCME	*Canadian Council of Ministers of the Environment*
COC	*Contaminant of concern*
CSQG	*Canadian Sediment Quality Guidelines*
CWQG - PAL	*Canadian Water Quality Guidelines for the Protection of Aquatic Life*
DSTF	*Dry stack tailings facility*
EC	*Environment Canada*
EEM	*environmental effects monitoring*
EQS	*Effluent Quality Standards*
HC	*Humidity Cell*
IJC	*International Joint Commission*
IR	*Information Request*
KHSD	*Keno Hill Silver District*
LHS	*Longhole Stoping*
ML	*metal leaching*
N-AML	*Non-acid metal leaching*
NND	*First Nation of Na-Cho Nyäk Dun*
NPR	*neutralizing potential ratio*
OCF	*Overhand Cut and Fill*
P-AML	*Potentially Acid Metal Leaching*
PEL	*probable effects level*
RCP	*Reclamation and Closure Plan*
SSWQO	*Site Specific Water Quality Objectives*
SV&I	*Seeking Views and Information*
tpd	*tonnes per day*
tph	*tonnes per hour*
TSP	*total suspended particulate*
TSS	*total suspended solids*
UKHM	*United Keno Hill mines*
USEPA	*United States Environmental Protection Agency*
WQO	*water quality objectives*
WRMP	*Waste Rock Management Plan*
WRSF	*waste rock storage facilities*
YESAA	*Yukon Environmental and Socio-economic Assessment Act*
YOR	*YESAB Online Registry*

PART A. BACKGROUND

Part A provides the context and background information required for the assessment of the Project. Section 1.0 identifies the requirement for an assessment under the *Yukon Environmental and Socio-economic Assessment Act*, while Sections 2.0 and 3.0 provide information and baseline data for the Project and Project area. Section 4.0 identifies the scope of the assessment, including matters that were considered in evaluating the significance of potential effects of the Project.

1.0 REQUIREMENT FOR AN ASSESSMENT

The purpose of the proposed Project is to develop a quartz mine. While several activities are likely to be undertaken in conjunction with this Project, under s. 47 of the *Yukon Environmental and Socio-economic Assessment Act,* the Project is subject to an assessment by the Mayo Designated Office due to the following circumstances:

- The proposed activity is listed in column 1 of Schedule 1 of the *Assessable Activities, Exceptions and Executive Committee Projects Regulations* (Activity Regulations); and not listed in column 2 as excepted. The proponent proposes to undertake activities listed in Part 1, item 3 and Part 9, item 12 of the Activity Regulations. The specific activity is listed as:

  "On other than an Indian reserve, construction, operation, modification, decommissioning or abandonment of or other activity in relation to, a mine"; and "Other than for an electrical power undertaking, the deposit of waste into water or in any other place under conditions in which the waste, or any other waste that results from the deposit, may enter water"

- Is proposed to be undertaken in the Yukon; and
- An authorization or the grant of an interest in land by a government agency, independent regulatory agency, municipal government, or First Nation is required for the activity to be undertaken.

Table 1: The Decision Body and the triggering authorizations required for the Project. This information is based on the project proposal and other information submitted to the Designated Office during the assessment.

Decision Body	Authorization Required	Act or Regulation
Government of Yukon, Energy, Mines and Resources – Mineral Resources Branch	Water Use License Amendment	*Yukon Waters Act* *Waters Regulation*
	Quartz Mining License Amendment (QML-0009)	*Quartz Mining Act*

2.0 PROJECT DESCRIPTION

2.1 Proponent Information

The Proponent for the proposed project is Alexco Keno Hill Mining Corp (AKHM). AKHM is a wholly owned subsidiary of Alexco Resources Corp (Alexco) and has been incorporated for operation and mineral extraction in the Keno Hill Silver District. The primary contact for the Project was Kai Woloshyn, Environmental Manager, Alexco Resources Corp. Contact information for the Proponent/contact is as follows:

ALEXCO Keno Hill Mining Corp.

Suite 1150 – 200 Granville Street

Vancouver, BC, V6C1S4

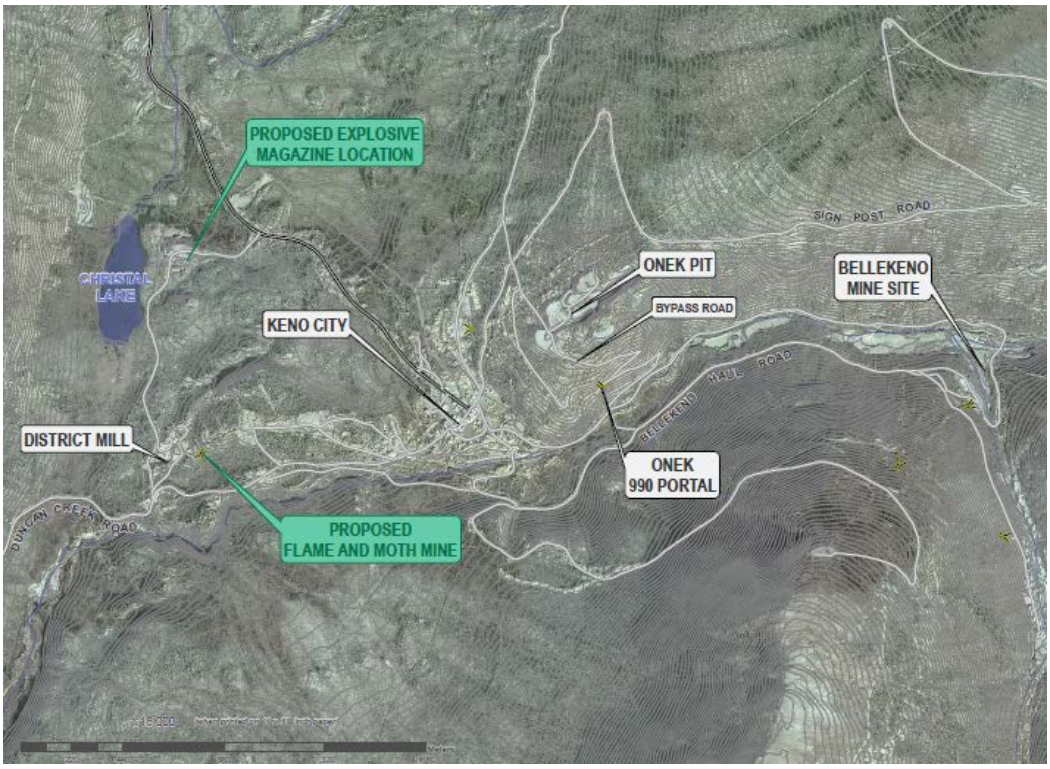
Contact: Kai Woloshyn

E: kwoloshyn@alexcoresource.com

P: 867-633-4881 ext. 233

2.2 Geographical Context

Table 2: Project location, coordinates and geographical parameters



Project Coordinates: Map Sheet: 105M14	**UTM** Zone 8 485132E 7086876N **Degrees, Minutes, Seconds** 63˚ 54′ 31″ N 135˚ 18′ 11″ W **Decimal Degrees** 63.91˚ N 135.30˚W
First Nation Traditional Territories Involved:	First Nation of Na-Cho Nyäk Dun
Drainage Region:	*Major Drainage Area*: Yukon River Drainage *Sub Drainage Area*: Stewart *Sub-sub Drainage Area*: Upper Stewart; Lower Stewart
Nearby Watercourses or Waterbodies:	Christal Lake, Christal Creek, Lightning Creek

2.3 Project History

The proposed project is an addition to operations in the Keno Hill Silver District currently undertaken by Alexco Keno Hill Mining Corp, a subsidiary of Alexco Resources Corp. AKHM is licensed under QML-0009 and Water License QZ-12-053 to operate an underground mine at Bellekeno, approximately 5 km northeast of the community of Keno City, and at the underground deposits of Lucky Queen and Onek. The portal for the Onek deposit is approximately 500 m from Keno City, while Lucky Queen is approximately 4 km from the community. Mining operations at these deposits are licensed to transport and process ore at the Keno District Mill, located approximately 1 km from Keno City, or 700 m from the nearest residence. The following description provides a history of operations and assessed activities for Bellekeno, Lucky Queen, Onek, and the Flame and Moth deposit. Project history with respect to the assessments and community reaction to these developments is described in Section 3.3 Socio-economic Environment.

2.3.1 Historic and existing mining activity

Various operators, most significantly United Keno Hill Mines (UKHM), have operated mines in the Keno Hills Silver District since 1913. During the 1920s a mill was established in Keno City, but was moved in 1935 to Elsa where it remained until 1989, when the main mining operations in the Keno Hills Silver District ceased, at which point the town of Elsa was abandoned. In early 2001, the Government of Canada declared the site abandoned and placed it under “care and maintenance”. This involved lime treatment to reduce metals at various adit discharges and the Valley Tailings Facility to prevent further environmental degradation.

In order to make the mine site viable for the private sector, the federal government agreed to limit the liability to any potential purchaser. Financial responsibility for the existing historical liability would remain with the federal government. In July 2005, Alexco Resource Corporation (Alexco) was chosen as the preferred purchaser, and the sale was approved in 2006. Once Alexco obtained a water licence for care and maintenance of the site (QZ06-074), in November 2007, final conveyance of ownership was granted to the company. Alexco now has sole ownership of the site while the federal government retains financial liability for the environmental impacts resulting from work done on the site prior to devolution. Under the Subsidiary Agreement between Alexco and Aboriginal Affairs and Northern Development Canada, any new liabilities arising from the issuance of licences or permits for new work at the site will not be added to the federal government's liability but will be the responsibility of Alexco.

2.3.1.1 Bellekeno

Underground mining at the Bellekeno deposit was proposed in late 2008 after several years of advanced underground exploration, and was submitted to the Mayo Designated Office of YESAB for assessment in 2008. The assessment was completed in June, 2009, and the project was recommended to proceed with terms and conditions. The final licenses issued allowed for processing of approximately 613 000 t of ore (QML-0009) and storage of 322 000 t of tailings in a Dry Stack Tailings Facility (DSTF). The DSTF was to be located at the Flame and Moth mill site approximately 700 m from the nearest resident in Keno City. The original proposal for the Bellekeno mill site was at Christal Lake, but was moved to the Flame and Moth site at the end of the public comment period (Seeking Views and Information period) after the Christal Lake site became a source of significant concern and contention for the community. The public was not provided with additional time to review the proposed change to the mill site location. The final mill

and mill site was assessed as having a 5-year operational period for operations corresponding to the predicted temporal scope of operations at the Bellekeno Mine.

The water license issued for operations at and supporting Bellekeno Mine (QZ09-092) includes water use at the operation of a water treatment facility at Bellekeno 625 adit and the Flame and Moth mill site; and the deposition of the treatment facility sludge at the Valley Tailings Facility, the existing tailings facility near Elsa used by Unite Keno Hill Mining Corp. The license set the discharge criteria for several contaminants of concern as outlined below. Specifically, Alexco is licensed for Bellekeno to discharge the following contaminant concentration limits from the Bellekeno 625 adit (Table 1):

Table 3: Current Effluent Quality Standards at Bellekeno Mine 625 Adit.

Parameter	Maximum Concentration in a Grab
pH	6.5to 9.5pHUnits
SuspendedSolids	25mg/L
AmmoniaNitrogen	5mg/L
Arsenic(total)	0.1mg/L
Cadmium(total)	0.01mg/L
Copper(total)	0.1mg/L
Lead(total)	0.2mg/L
Nickel(total)	0.5mg/L
Radium226	0.37BQIL
Silver(total)	0.01mg/L
Zinc(total)	0.5mg/L
AcuteToxicity Testing	
96-hourRainbowTrout	Non-Toxic,LCsoOOO%)

The following discharge limits have been applied to the mill site water treatment system (licensed in conjunction with the Bellekeno Mine) (Table 2):

Table 4: Current Effluent Quality Standards for Mill Site Water Treatment System

Parameter	Maximum Concentration in a Grab Sample
pH	6.5to9.5pHUnits
SuspendedSolids	25mg/L
AmmoniaNitrogen	5mg/L
Arsenic(total)	0.1mg/L
Cadmium(total)	0.01mg/L
Copper(total)	0.1mg/L
Lead(total)	0.2mg/L
Nickel(total)	0.5mg/L
Radium226	0.37BQ/L
Silver (total)	0.02mg/L

Zinc (total)	0.5 mg/L
Acute Toxicity Testing	
96-hour Rainbow Trout	Non-Toxic LC_{50} (100%)

2.3.1.2 Lucky Queen and Onek

In December, 2011, AKHM submitted a proposal to the Mayo Designated Office to conduct underground mining operations at both the Lucky Queen and Onek deposits. The Lucky Queen deposit was originally mined by Treadwell Yukon Limited from 1927-1932 when reserves were thought to be exhausted. The Lucky Queen vein and strike extensions were explored intermittently throughout the 1950's, 1960's, 1970's and early 1980's. Between 1985 and 1987 UKHM constructed an 1 800 m long exploration drift, which was designed to intersect the ore structure beneath the historic mine workings. The company faced insolvency prior to completing the work, and further exploration work of the Lucky Queen strike was undertaken by AKHM. By the time exploration under UKHM ceased at the Lucky Queen deposit approximately 62 000 tonnes (t) of waste rock had been deposited on the surface at the historic waste rock dump.

In 1922, the Onek Mining Company Ltd. explored the core Onek claims via a number of underground workings and open cuts. From 1950-1952, UKHM re-opened the workings and developed an additional adit, driving rises into historic workings for approximately 400 m at the 400 level. All mining at Onek ceased in 1965 until 1980 when a 20 - 40 m open pit was developed above the historic underground workings. The historic Onek site consists of two adjoining open pits and 400 level adit with various mine workings in-between the surface expression of mining and lowest level of underground mining. Given the historic nature of the site there are existing waste rock dumps containing over 600 000 t. Additionally, there are low-grade ore stockpiles that were never processed. The pit and historic workings are hydraulically connected via the Fisher shaft; and as such, the 400 level adit drains water both from the historic pit, and the underground workings.

The AKHM 2011 proposal was to amend the licenses issued with respect to Bellekeno Mine (YESAB #2009-0030) to include processing of ore from Lucky Queen and Onek, and the deposit of tailings into the Dry Stack Tailings Facility. The proposal did not include increasing the total volume of ore processed or tailings placed into the DSTF, but rather, was to allow the source of the ore and tailings to include Lucky Queen and Onek. Similarly, no changes to the effluent criteria at existing discharge points were proposed; however, additional discharge points and a water treatment facility at the Onek 400 level adit were proposed and subsequently licensed. It is not clear to the Designated Office whether the Onek 400 adit is a production unit for AKHM, or if the water is being treated as an historical liability and is therefore under the management of the Elsa Development Reclamation Corporation (ERDC). The sludge generated at the Onek 400 adit would be deposited into the Valley Tailings Facility sludge cell. However, depending on whether it is production sludge (i.e. the responsibility of AKHM) or historical liability sludge (i.e. the responsibility of ERDC), the sludge would be deposited into the corresponding sludge cell.

The Quartz Mining License and Water License amendments allowed AKHM to develop and decommission all underground mine workings; store both N- and P-AML generating and metal leaching waste rock; use water; operate an additional water treatment facility at Onek; construct a power line; store fuel; develop a new access; and increase camp size at Flat Creek. The Water License was issued in May, 2013.

2.3.1.3 Flame and Moth

The Flame and Moth site had shallow underground workings in the 1920's. In the 1980's these were followed up by a small open pit mine to recover the crown pillar. After the assessment of the Bellekeno Mine, AKHM backfilled the small open pit to prepare for construction of the Flame and Moth mill (now referred to as the Keno District Mill).

2.4 Project Details

2.4.1 Overview

The Project is for the development of an underground silver/lead/zinc mine at the Flame and Moth deposit located below the Keno District Mill approximately 1 km from the community of Keno City. The Proponent is seeking to amend the existing license (QML-009) to include an additional 1 000 000 tonnes of ore (from 613 000 tonnes), to be processed at the Keno District Mill. The current licensed mill rate of 400 tpd has not been proposed to change, but the mill will require an additional seven (7) years of operation to accommodate processing ore from the Flame and Moth mine. As such, the proposed amendment to the term of the QML is to expire in 2031, six years beyond the current license term of 2025. This period includes a mandatory 10-year post-closure term of the license for closure and reclamation activities.

The Project proposes to expand the current Dry Stack Tailings Facility (DSTF) from 322 000 tonnes to a total of 907 000 tonnes, with an expanded footprint of 31 000 m^2. The expanded DSTF is proposed to be located within the boundaries of the existing mill site (Flame and Moth land lease), adjacent to the existing DSTF. Approximately 325 m of the Bellekeno haul road will have to be rerouted to accommodate the DSTF expansion. The mill site, in addition to the DSTF, will require additional infrastructure to support Flame and Moth operations, including the portal; vent raise; expanded coarse ore storage pad; a new laydown area; temporary P-AML storage area; two additional proposed ponds; a water treatment plant adjacent to the mill; a mill yard expansion area; and a 175 m haul road.

The Project involves water use, water treatment, and the discharge of treated water into both Christal Creek and Lightning Creek drainages. The total estimated discharge rate is 35 l/s, with 23 l/s reporting to Christal Creek, and where/if required, 12 l/s reporting to Lightning Creek.

The following summary of Project details is from all proposal documents on the YOR including responses to information requests. Many important aspects of the Project have changed from the original proposal and so the most recent project information is summarized below . The reader should view additional detailed project information by referring to all referenced documents.

2.4.2 Mining Methods and Underground Development

The Project is proposed as an underground mine. The Proponent describes the sequence of underground development in their project proposal as follows:

The sequence of underground development will entail shooting line and grade, marking up the face for jumbo drilling, drilling, loading holes for blasting, excavation and transportation of broken rock to pre-determined destinations, roof and rib bolting after the mucking sequence assessment and sampling of the new face by the geologist and then repetition of the drill, blast, muck, bolt and assessment cycle. Utility piping, power cable and ventilation will be installed as the decline progresses.[1]

The Flame and Moth decline is proposed to be approximately 3.7 m wide (W) x 3.7 m high (H), allowing for smaller haul trucks (15 t) to be used than those used at the Bellekeno Mine. The portal is proposed to

[1] FM- Production Project – YESAB Proposal – YOR 2013-0161-003-1

be located approximately 50 m from the mill building, as shown in Figure 1 below. It is estimated that the primary decline will be 750 m in length to reach the ore body, and will require additional primary development as mining continues. The decline will be driven at a grade of approximately minus 15 percent. Equipment used to drive the decline include rubber tire load-haul dump scoops, 15 ton trucks, jumbo and mechanized rood bolter, and fleet of mechanized utility equipment.

In addition to the decline, other required developments include ore access (e.g. associated ramps) and the ventilation raise. Ore access heading dimensions are expected to be 3.7 m W x 3.7 m H, while the ventilation raise is proposed to be 3.0 m bored diameter above 720 elevation, and 2.4 m W x 2.4 m H below 720 elevation. The schematic shown in Figure 2 shows the underground mine plan, and the location of the ramps, main sump, and vent raises, while Figure 3 shows the deposit plan view relative to surface features.

Figure 1: Flame and Moth Portal Location[2]

[2] YOR 2013-0161-003-1, *Figure 3-1, page 14.*

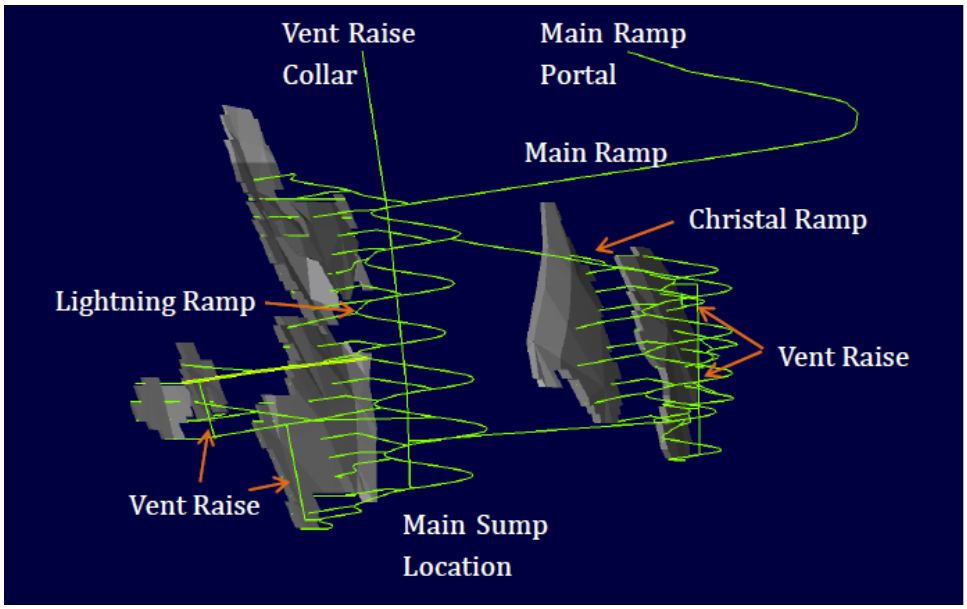


Figure 2: Flame and Moth Underground Mine Plan showing declines, sump and vent raises.[3]

[3] *Ibid, Figure 3-4, page18.*

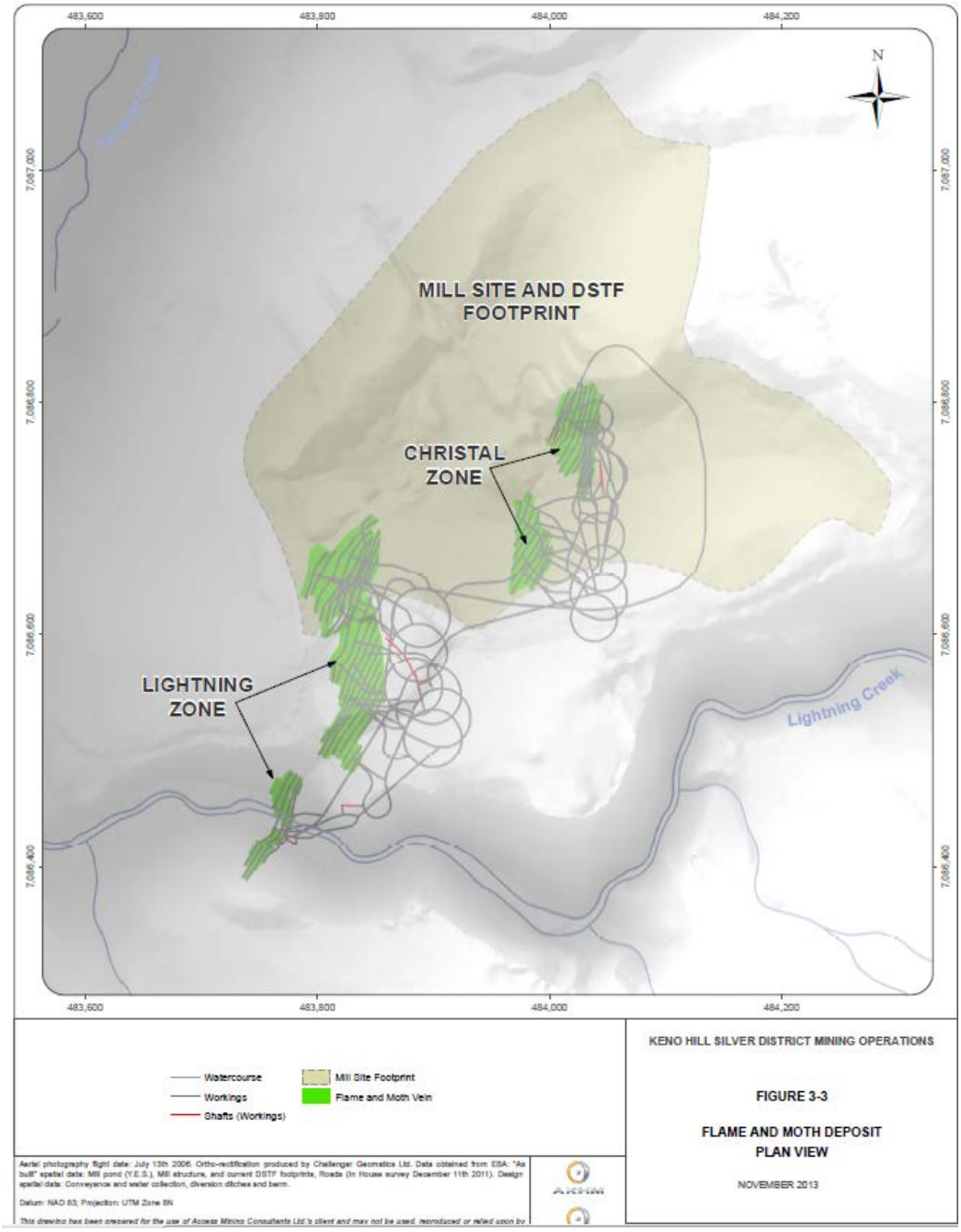


Figure 3: Flame and Moth Deposit Plan View [4]

Mining methods used for the Project will be Overhand Cut and Fill (OCF) and Longhole Stoping (LHS). The OCF method begins mining from the bottom of a mining block (i.e. stope) advancing upward in lifts. Drifts will be driven through the mineralized zone, which will be filled with cemented back-fill (consisting of tailings or waste rock). Once the cut is filled, a new access is drilled down off the main haulage ramp to

[4]YOR 2013-0161-003-1*, Figure 3-3, Flame and Moth Deposit Plan View*

access the next lift above the filled cut. This process continues until the top of the stope is reached. The Proponent indicates that the OCF method has been employed at Bellekeno and is well demonstrated.

With the longhole method, drifts are used to access the top and bottom of the stope, for which slot raises are created (vertical openings). Long holes are then drilled to blast off vertical slabs from the stope, which is then scooped from a lower draw point by a loader. The Proponent notes that longhole blocks are typically pulled out last, unless doing so does not interfere with operations. This method will be used where rock that is more competent supports its use, and toward the end of mine life to recover remaining pillars.

2.4.3 Waste Rock Management

The proposal indicates that the total volume of waste rock broken underground is estimated at 347 000 tonnes, with 210 000 tonnes being used for Flame and Moth backfill, along with 172 000 kt of dry filtered tailings. Surface construction is estimated to require 137 000 tonnes of N-AML waste rock. According to the Proponent, the rock encountered at Flame and Moth will be managed according to the revised Waste Rock Management Plan,[5] for which the previous iteration is approved and licensed under QML-0009.The WRMP describes the method by which rock is screened and categorized. This plan has a three-tiered categorization and management approach, described in Section 6.3 “Rock Management Categories” of the project proposal as follows:[6]

1. *Non-Acid Metal Leaching Waste Rock (N-AML):* Rock of non-economic grade with no significant potential for the generation of metal leach or net acidity. Rock field-classified as N-AML will be used for general construction purposes as required or backfilled underground.
2. *Potential-Acid Metal Leaching (P-AML)*: Waste rock and mineralized waste rock of no economic interest. Rocks field-classified as P-AML that is brought to surface will be temporarily stored in designated lined P-AML waste rock storage facilities (WRSF) prior to being backfilled underground. In addition to P-AML wall rocks, some material especially along the margins of zoned veins contain mostly gangue minerals such as siderite, pytriite and quartz, but do not contain economic amounts of silver (Ag), zinc (Zn), or lead (Pb) minerals and therefore are of no economic interest. Due to their increased likelihood for acidic or metal leaching, all such mineralized non-economic rocks is considered to be P-AML and will be stored in the temporary P-AML WRSF until used as rock backfill.
3. *Mineralized Rock and Ore*: Ore and vein material which contains significant Ag, Zn, or Pb minerals may be temporarily stockpiled at the surface at the mine site before being transported to the mill. Confirmatory assay will determine whether this rock is milled, or is sent to the temporary P-AML WRSF or hauled back underground to be incorporated in the cemented backfill material.

The Proponent further indicates that 137 000 t of waste rock will be brought to surface over the production life of the mine, with 137 000 t being the estimated total permanent excavation tonnage to be used in construction (i.e. is N-AML rock). A temporary P-AML storage facility is proposed to be located near the portal entrance using the typical WRSF design[7] to be used during the initial development, after which time all P-AML development rock could remain underground. P-AML stored in the temporary facility would then also be returned underground. The Proponent expects that there will be no long-term P-AML WRSF on surface; however, in the event that long-term WRSF are required for P-AML, the Proponent indicates that the WRSF will be located in the footprint of the millsite and will be constructed according to

[5] Appendix L - Waste Rock Management Plan, Revision 4, YOR 2013-0161-017-1
[6] FM- Production Project – YESAB Proposal – YOR 2013-0161-003-1, Section 6.3, page 49
[7] Typical Waste Containment Facility Design Keno Hill Silver District, YOR 2013-161-110-1

the typical design.[8] The table below presents the management of waste rock that will be brought to surface, but does not represent the full volume and corresponding lithology of all waste rock (347 000 t) that will be generated via the mine development and that is expected to remain underground and/or processed.

Table 5: Flame and Moth Waste Rock Management[9]

Lithology	Total estimated tonnage	Tonnage P-AML	Tonnage N-AML	P-AML Rock Management	N-AML Rock Management
Quartzite	92,888	3,716	89,172	Underground backfill utilizing temporary storage on surface or permanent storage on surface in approved EBA generic design	Toe berm and base drainage layer for DSTF expansion, construction/ upgrade material; road upgrade and maintenance and general construction, underground backfill
Graphitic Schist	20,490	8,196	12,294		
Greenstone	3,048	0	3,048		
Sericite Schist	20,679	0	20,679		
Project Proposal Total	137,105	11,912	125,193		

Cemented backfill, consisting of a mixture of five percent cement by weight, rock, and water, will be used to fill longhole stopes. Waste rock will be stored on surface when there are no backfill locations immediately available, and brought back underground for use as backfill as required. N-AML waste rock will be used for various construction projects, including the portal pad, laydown areas, haul road, coarse ore stockpile expansion, DSTF embankment and mill yard expansion. Waste and vein material will be handled underground and on the surface by 15-tonne capacity haul trucks; trucks will go directly from the remuck bays on ramp systems to either the coarse ore stockpile at the crusher or to the waste rock dump location; both these locations are ~175 m from the portal. A temporary surface stockpile will be used for P-AML waste storage; P-AML material will be the first material used for backfill, and it is expected that 100 percent of P-AML waste will be used for underground backfill.

Approximately 347 000 tonnes of waste rock is expected underground, from which 210 000 t will be used for Flame and Moth backfill, in addition to 172 000 kt of dry filtered tailings. The remaining waste rock (~137 000 t) will be used for surface construction. All waste rock will be inspected and tested as per the updated Waste Rock Management Plan, which segregates all waste rock as either potentially acidic/metal leaching (P-AML) or not (N-AML).

2.4.4 Milling and Millsite Infrastructure

Ore and mineralized rock will be processed at the Keno District Mill using conventional flotation milling technology. The Keno District Mill and operations were assessed during the Bellekeno Mine assessment as the Flame and Moth mill, and licensed under QML-0009 and QZ09-092. The assessment of mine development of Lucky Queen and Onek deposits considered the milling of Lucky Queen and Onek deposit ore and the deposition of the composite tailings into the DSTF. Ore from Flame and Moth will be milled together with these three other deposits (Bellekeno, Lucky Queen and Onek) and the composite tailings deposited into the previously licensed Dry Stack Tailings Facility, as well as the proposed expanded DSTF. The expanded DSTF and tailings storage is described in Section 2.4.5 below.

[8] FM- Production Project – YESAB Proposal – YOR 2013-0161-003-1, page 23.
[9] *Ibid*, Table 6-3, page 50

Ore would be hauled approximately 175 m to the coarse ore pad and crusher in 15 tonne trucks. Additional infrastructure to support milling activities includes the expansion/development of a coarse ore storage pad to accommodate new volumes, a laydown yard, mill yard expansion, a temporary P-AML storage area adjacent to the portal, and additional proposed ponds and water treatment. The P-AML storage area and ponds are described in other sections, as well as proposed roads. Figure 4 below shows proposed millsite infrastructure:

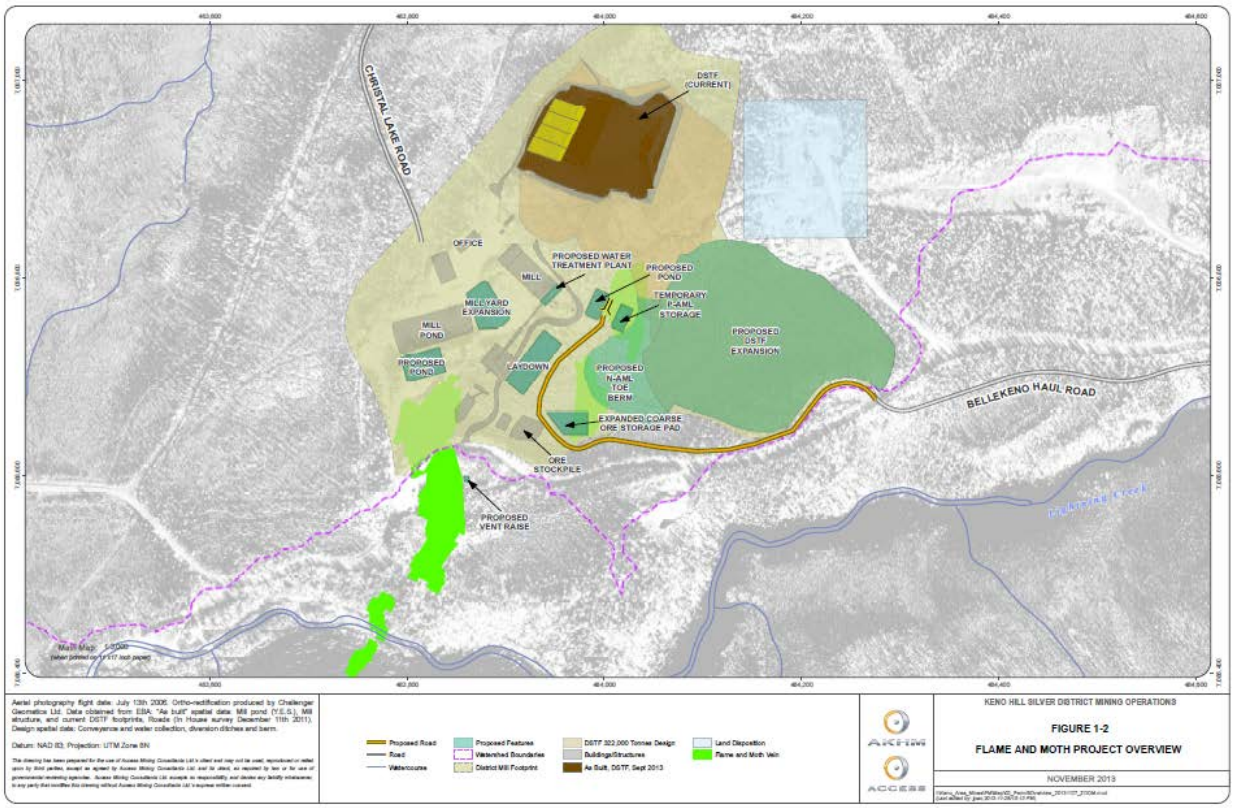


Figure 4: Flame and Moth Project Overview[10]

2.4.5 Tailings Management

The Proponent estimates that the Project will generate approximately 612 570 tonnes of tailings from 2015 to 2020.[11] Approximately 172 100 tonnes of tailings are proposed to be used as backfill into the Flame and Moth underground workings, while the rest will be deposited into an expanded Dry Stack Tailings Facility (DSTF) with a capacity of 585 000 tonnes located adjacent to the existing DSTF. The expanded DSTF has a footprint of approximately 31 000 m^2. The preliminary engineering design is presented in Figure 5 below. Further, some Flame and Moth tailings may be deposited into the existing DSTF. The expanded DSTF is being constructed to conservatively allow for most of the tailings to be deposited into the expanded DSTF, in the event that the expected volume cannot be backfilled.[12] However, deposition of tailings into the existing DSTF is not explicitly part of this assessment, as that facility is licensed to accommodate 322 000 tonnes of tailings.

[10]FM- Production Project – YESAB Proposal – YOR 2013-0161-003-1, Figure 1-2, page 4
[11]*Ibid,* Table 3-3 Flame and Moth Production Schedule, page 22
[12]Flame and Moth IR Response, January 2014. YOR 2013-0161-040-1.

Tailings are dewatered/filtered to approximately <10 percent moisture and then deposited via a conveyor belt to a concrete storage pad outside the building. From there, the tailings are periodically transported via haul trucks to the DSTF, where they are deposited into thin lifts (~300 mm) and compacted using a 10-t vibratory compactor. Tailings are managed to reduce moisture infiltration into the DSTF, and will undergo progressive reclamation to reduce the active surface of the facility.

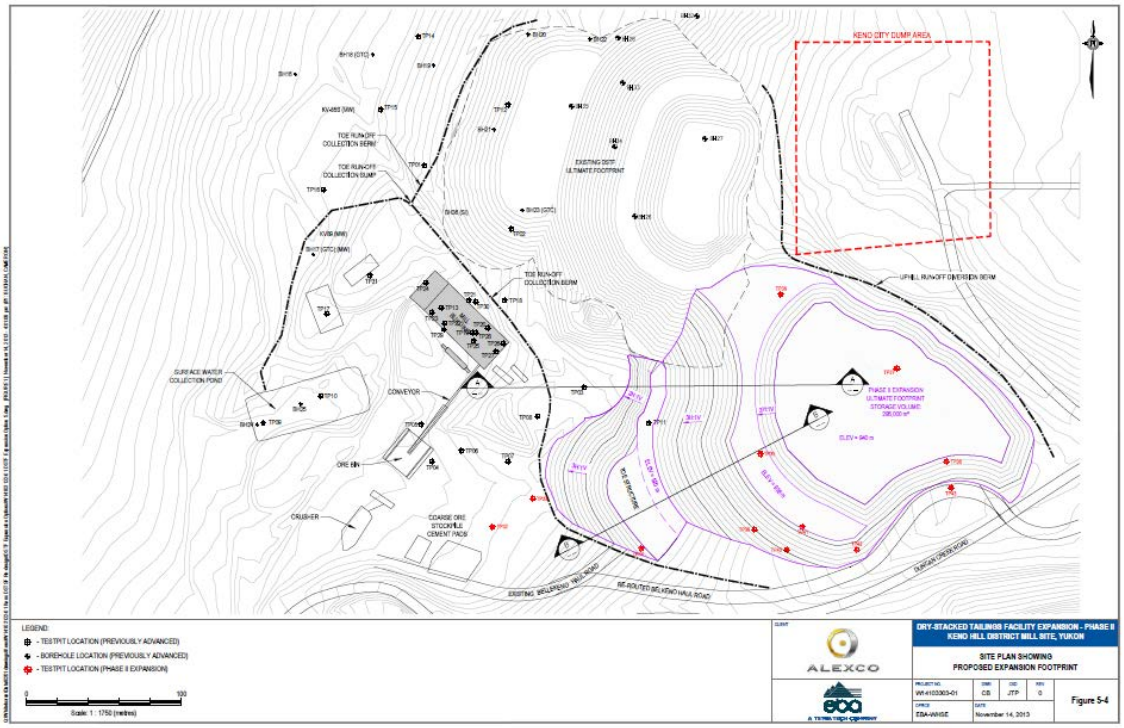


Figure 5: Engineering site plan of expanded DSTF footprint showing re-routed Bellekeno Haul Road.[13]

2.4.6 Water Management

2.4.6.1 Operational Period

Water Use

The development and mining of the Flame and Moth deposits will require direct water use of up to 141.1 m^3/day to support mining activities, including:

- Percussion drilling
- Dust suppression
- Equipment cooling
- Sanitation

Water for the Flame and Moth Mine will be recycled to the extent possible from reused process water from the underground workings. The process water will be supplemented with groundwater encountered

[13] *Ibid,* Figure 5-4, Site Plan Showing Proposed Expansion Footprint.

during the development of the underground workings. During initial development (before groundwater is encountered), water will be sourced from the existing well supplying the mill and licenced for 81 m^3/day.

In addition to the water used for the Flame & Moth Mine, 121.1 m^3/day of water will be required to maintain the mill operation at 400 tpd. Water for the mill will be sourced from reuse water from the underground, the water treatment plant or from the existing well licenced for the purpose of mill water supply. The quality of the various water sources will be the primary deciding factor in the source of water used in the mill.

Dewatering

The Flame and Moth Mine will be developed below the existing groundwater table and will therefore require active de-watering of up to ~35 litres per second (L/s) at the maximum depth of the Mine (270 m below ground surface). The water table is expected approximately 20 m below ground surface.

The first 23 L/s of discharge water from the Flame and Moth Mine will be discharged via the water treatment plant to Christal Creek while the remaining 12 L/s (if encountered) will be discharged via the water treatment plant to Lightning Creek.

Due to the mineralogy of the deposit, the underground water will contain elevated concentrations of various contaminants. Therefore, this water will be routed through a proposed water treatment plant before being discharged to the receiving environment.

Water Treatment Plant

The Proponent is proposing to construct a water treatment plant adjacent to the Keno District Mill. The plant will treat water pumped from the underground mine. The plant design is based on the water treatment process at the Bellekeno, Silver King, Galkeno 300 and Galkeno 900 treatment sites. The main water treatment processes will include gravitational/physical treatment (hydrocyclone, clarifier, and thickener) and chemical treatment (aeration, solids precipitation, pH adjustment and polishing step) in order to remove contaminants from the water. The project proposal includes a flow chart of the proposed water treatment plant (reproduced below) that outlines the proposed treatment sequencing (Figure 6).[14]

[14] Figure 8-16 of the project proposal YOR 2013-0161-004-1, page 83.

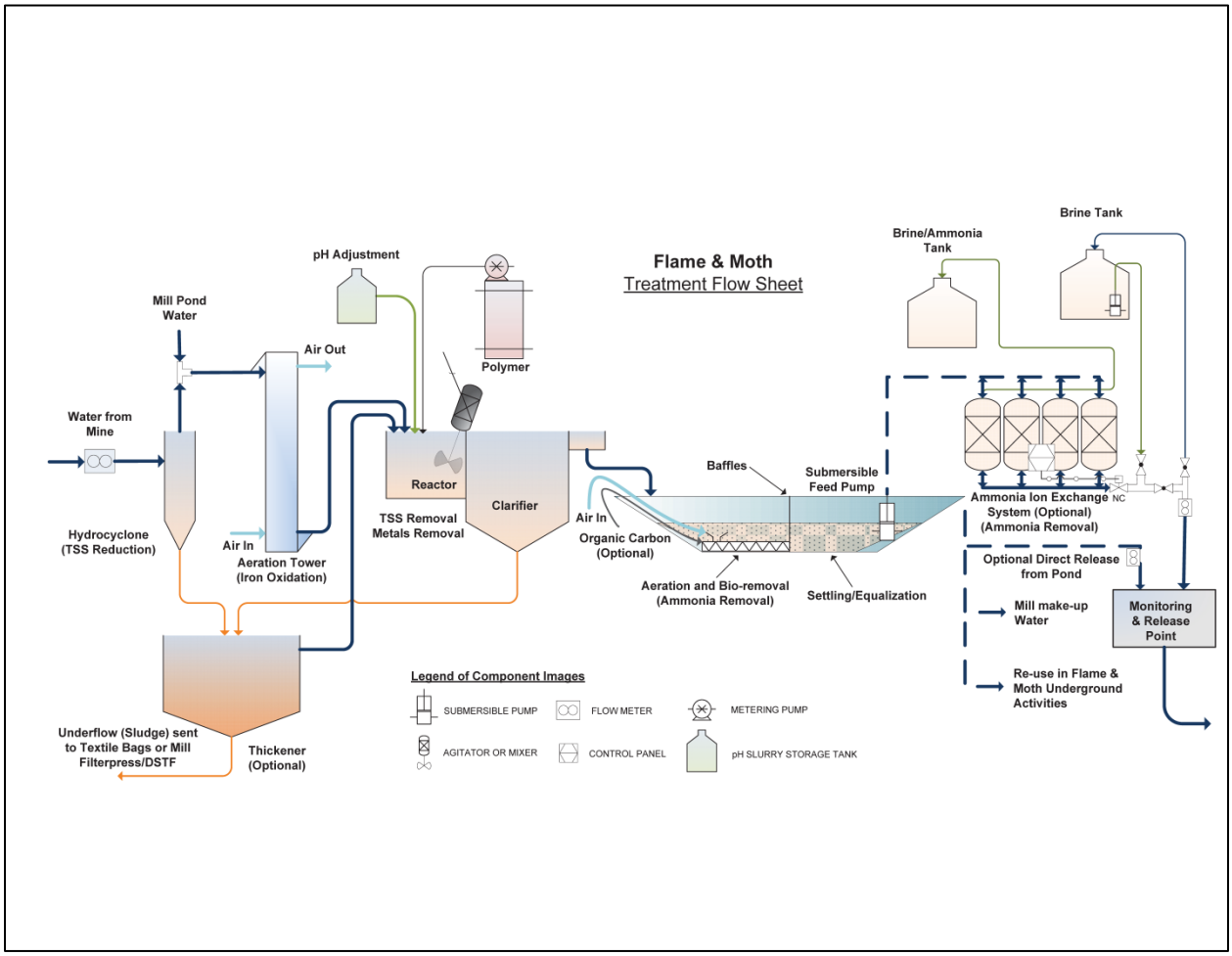


Figure 6: Flow chart of proposed water treatment process, Flame and Moth water treatment plant.[15]

Gravitational separation of heavy particles:

Water passes through a hydrocyclone where heavier particles are separated from the water. This process removes the total suspended solids (TSS).[16]

Removal of metals and ammonia:

Water then passes through an aeration tower where the addition of air oxidizes the iron in the water so that during the precipitation of metals, iron is in an oxidized form (Fe^{3+}) which will aid in metal removal. Aeration will also remove ammonia from the water.[17]

Water is then mechanically agitated in a mix tank while lime ($Ca(OH)_2$) and ferric chloride ($FeCl_2$) are added. According to the Proponent, agitating the water, lime, and iron mixture results in the precipitation of an amorphous hydrous ferric oxide solid (sludge). The addition of lime increases the pH to

[15] YOR 2013-0161-004-1
[16] Section 8.2.3 of project proposal YOR 2013-0161-004-1.
[17] ibid

approximately pH 9.5. Increasing to pH 9.5 allows metals such as iron, zinc and copper to precipitate as hydroxides. At pH 9.5 ammonia can be removed as well. Metals such as nickel and cadmium precipitate at higher pH levels (pH 10.5 to 11; Aube and Zinck, 2003). The main components of the sludge produced at the Bellekeno treatment plant included calcium (13 percent), iron (3.3 percent), lead (1.7 percent), sulfur (1.5 percent) and zinc (1.1 percent). The sludge also contained (but not limited to) aluminum, arsenic, copper, magnesium, manganese, sodium, phosphorus, antimony, selenium, strontium and silver.[18] The solids which precipitate in the mix tank (sludge) are separated from the water in a clarifier (settling tank). Water from the clarifier will enter a lined pond.[19]

Polishing step:

The polishing step refers to the final treatment stage before water is discharged into the receiving environment. The water in the pond will again be aerated to promote the removal of ammonia. If needed, a carbon and phosphate source will be added to the pond to aid in the removal of ammonia by encouraging its biological breakdown. The pond will contain baffling which will separate the aeration/ammonia removal processes from the final particle settling process.

If further ammonia removal is required, the water will be pumped into an ion-exchange system.

Finally, the water will pass through a lined pond that acts as a Monitoring and Release Point, and then discharged into the receiving environment. The quality of the discharge water from the water treatment plant is expected to approximate the discharge quality from the existing water treatment plant at Bellekeno, measured at station (KV-43) outlined in Table (6).

Sludge Management

The water treatment plant will produce a material of precipitated solids containing, among other things, the metals removed during the water treatment process. This material is referred to as sludge. Ongoing maintenance of the water treatment plant will include sludge removal and disposal.

In the original proposal the Proponent stated that sludge will be disposed of in a cell within the historic Valley Tailings disposal site. When additional information was requested to understand the potential environmental effects of depositing sludge at this facility, the Proponent provided an alternative disposal scheme that would see sludge co-disposed with tailings into the DSTF. This is the disposal method discussed in further detail below and evaluated in this assessment.

The slurry, a combination of the precipitated solids (sludge) and water, are collected from the clarifier (settling tank), and sent to a thickener where it is added to the tailings slurry. The thickener, with the addition of flocculants, increases the percent solid constituent within the slurry. The sludge/tailings mixture will be filtered by up to two filter presses with a total capacity of 14.4 tph. After moisture removal, the sludge is estimated to account for 0.15 percent of the total volume of solids to be deposited into the Dry Stack Tailings Facility.[20]

A study on the stability of sludge from the Galkeno 900 treatment facility showed that after short- to medium-term stability testing at pH 5 certain metals, such as cadmium and lead, remained stable in the sludge; however, 17 mg/L of zinc and 3.1 mg/L of nickel was released into solution (Fiset et al. 2003). This study gives insight into the stability of the sludge to be produced at the Flame and Moth water treatment plant.

[18] Bellekeno sludge samples YOR 2013-0161-123-1.
[19] YOR 2013-0161-004-1.
[20] IR response July 23, 2014 YOR 2013-0161-145-1.

Water Routing & Diversions

Water management at the site will include the diversion of surface water away from the Flame and Moth adit and away from the DSTF. This water will be directed around these site features by a diversion ditch that will terminate at the Mill Pond. This water will then be discharged to the receiving environment. The water conveyance infrastructure is sized to accommodate the maximum predicted 24-hour rain event at the site.

2.4.6.2 Closure Period

During the closure period, surface water discharge is not expected from any of the mine workings. However, as a contingency measure, the Proponent has committed to treating any seepage that might occur from the DSTF and or the Flame and Moth adit through a bioreactor located where the Mill Pond is situated during the operational period. For the purposes of conservatism and to provide a sensitivity analysis, the Proponent assumed an adit discharge to the bioreactor as a source load in their modelling of the closure period. The mass load model is discussed further in Section 2.4.8.

Following the flooding of the underground workings (expected approximately 1-year post closure), groundwater flows of 5.58 L/s are expected to report to the receiving environment somewhere near Christal Lake. Because the groundwater divide between the Christal and Lightning Creek drainages is uncertain, as an additional sensitivity analysis, the Proponent also modelled a portion (33 percent or 1.84 L/s) of the 5.58 L/s groundwater discharge to Lightning Creek. The chemistry of this water will depend on numerous factors including the chemistry of the inflow water and the reactivity of the underground workings. The predicted water quality of the underground water post closure is presented in Table 6 of the mass load model report.[21]

During closure, the Proponent has committed to in-situ mine pool treatment along with treatment of surface discharge through a bioreactor if required. In support of these two treatment methods, the Proponent provided performance data from in-situ mine pool treatment at other locations with similar COC distributions along with data from their bioreactor tests at the Galkeno 900 adit from 2008-2011. These results are discussed and presented in the mass load model report.[22]

2.4.7 Proposed Water Quality Objectives and Effluent Quality Standards

2.4.7.1 Proposed Water Quality Objectives

Water quality objectives were provided for both Christal and Lightening Creeks. As the water quality in these two streams is degraded from historic loadings, the Proponent employed a combination of water quality guidelines for the protection of aquatic life and the use of the 95th percentile of background concentrations to develop site-specific water quality objectives for these two systems respectively (Table 4). The methodology used to derive these objectives is provided in Attachment F of the mass load model report.[23]

The water quality objectives for the closure period will need to protect the restoration goals for the drainage following implementation of the district closure plan. These objectives will likely be different from the objectives proposed for the Flame and Moth Mine at this time.

[21] Table 6 the Christal Creek and Lightning Creek Mass Load Model Report YOR 2013-0161-146-1
[22] Christal Creek and Lightning Creek Mass Load Model Report YOR 2013-0161-146-1 to 150-1
[23] Attachment F of the Christal Creek and Lightning Creek Mass Load Model Report YOR 2013-0161-150-1.

Table 6: Site Specific Water Quality Objectives for Christal Creek and Lightening Creek (mg/L). Water quality monitoring stations KV-6 and KV-7 are located on Christal Creek while station KV-81 is located on Lightning Creek.[24]

	KV-6	KV-7	KV-81
Ammonia-N	0.855-1.916[a]	0.413-1.916[a]	0.855-1.916[a]
Nitrate-N	3[b]	3[b]	3[b]
Nitrite-N	0.06[b]	0.06[b]	0.06[b]
Arsenic	0.010[c]	0.005[b]	0.009[c]
Cadmium	0.0034[c]	0.0019[c]	0.00047[c]
Copper	0.004[b]	0.0039[c]	0.0169[c]
Lead	0.0448[c]	0.0185[c]	0.0183[c]
Nickel	0.15[b]	0.0959[b]	0.025[b]
Silver	0.00034[c]	0.00021[c]	0.00032[c]
Zinc	0.360[c]	0.208[c]	0.043[c]
Sulfate	429[d]	309[d]	218[d]
Selenium	0.005[e]	0.005[e]	0.005[e]

a) CCME guideline, is pH and temperature dependent
b) CCME guideline, harness of 50 mg/L used for KV-81, 100 mg/L for KV-7 and 250 mg/L for KV-6
c) Upper 95th percentile from 2008 to 2013 data set
d) BCMOE sulphate guideline
e) USEPA Threshold

2.4.7.2 Proposed Effluent Quality Standards for Mine Water Discharge

The original proposal included only one discharge point to Christal Creek from the Mill Pond at the current licenced discharge criteria for that site (KV-83). These criteria are outlined in Table 5 along with the assumed attenuation rate in percent reduction of loading and the predicted maximum concentrations for COCs not included in the licence criteria.

The original modelling provided by the Proponent included predictions for zinc and cadmium exclusively. The Proponent modelled their expected discharge concentrations for these two parameters, discussed further in Section 2.4.8 based the expected effluent quality from their proposed water treatment plant rather than discharge at the proposed effluent quality standards. Following information requests from the Mayo Designated Office regarding the supporting rationale for the derivation of the discharge criteria in Table 7, the Proponent modified their proposal by adding a separate discharge point (KV-104) and amended discharge criteria (Table 8).

[24] Table 16 from the Christal Creek and Lightning Creek Mass Load Model Report YOR 2013-0161-146-1.

Table 7: Proposed effluent quality standards for Mill Pond discharge at water quality station (KV-83).[25]

	Effluent Quality Standard (mg/L)	Attenuation Rate (%)	Predicted Maximum Concentrations for non-Effluent Quality Standard parameters (mg/L)
Ammonia	5	0	-
Nitrate	-	0	8
Nitrite	-	0	0.2
Arsenic	0.1	75.7	-
Cadmium	0.01	23	-
Copper	0.1	0	-
Lead	0.2	0	-
Nickel	0.5	73.2	-
Silver	0.02	0	-
Zinc	0.5	76.7	-
Sulphate	-	0	708
Selenium	-	0	0.004

Table 8: Proposed effluent quality standards, expected average discharge concentration and predicted maximum discharge concentrations for COCs at water quality station (KV-104).[26]

	Proposed Effluent Quality Standard for grab sample	Expected Average Discharge Concentration anticipated under normal operational conditions*	Predicted Maximum Concentrations for non-Effluent Quality Standard parameters
Ammonia-N	4	1.83	-
Nitrate-N	-	3.3	8
Nitrite-N	-	0.1	0.2
Arsenic	0.025	0.0051	-
Cadmium	0.004	0.00044	-
Copper	0.010	0.0020	-
Nickel	0.4	0.079	-
Lead	0.07	0.028	-
Silver	0.001	0.00031	-
Zinc	0.3	0.053	-
Sulfate	-	571	708
Selenium		0.0021	0.004

***average operational discharge based on average concentration from January 2011 to present from the Bellekeno water treatment plant discharge (KV-43)**

2.4.8 Mass Load Model and Water Quality Predictions

In support of the Proposal, the Proponent provided their mass load modelling results performed in the Goldsim modelling program. Following information requests and responses from the Proponent, the

[25] Table 13 from the Christal Creek and Lightning Creek Mass Load Model Report YOR 2013-0161-146-1
[26] Table 3 from the Christal Creek and Lightning Creek Mass Load Model Report YOR 2013-0161-146-1.

original model inputs and subsequent model predictions underwent significant changes from those originally proposed. These changes included modifications to the load sources because of more restrictive effluent discharge criteria and re-allocation of discharge water between Christal and Lightning Creeks. This summary is of the most recent iteration of the mass load model predictions[27] and is the basis of our effects assessment.

2.4.8.1 Mass Load Model Inputs

As the Flame and Moth Mine is proposed in a region that has experienced significant mining activity for over 100 years, numerous historic and modern contaminant sources exist that contribute to the cumulative degradation of surface water quality in the area. This is particularly true for the Christal Creek drainage. These historic loadings to Christal and Lightning Creeks were included in the inputs to the mass load model presented in the proposal.

An additional factor considered in the model inputs was the impending closure of the Keno Hill Silver District Type 2 Abandoned Mines. Many of the sources of contaminant loadings contributing to the degraded water quality in Christal and Lightning Creeks will likely be reduced as a result of reclamation of the historic liabilities in the area. Although these activities and associated reductions in loadings are proposed for some time in the future (expected by 2019), the exact nature and extent of the reclamation of historic liabilities remains unknown. As such, the Proponent included the results from five modelling scenarios that account for various closure options currently under consideration.

The model inputs included source loads from the Flame & Moth mine, current licenced contaminant sources and historic source loads from abandoned sites. These source terms include:

- N-AML waste rock (~137 000 tonnes) placed in the Christal Creek catchment and used for construction of roads, expanded coarse ore stockpile, mill yard expansion and toe berm for the DSTF;
- Treated Flame and Moth underground water from mine dewatering. Dewatering rates are assumed to be on the order of 35 L/s maximum, with most of the flow (23 L/s) reporting to the Christal Creek drainage and the remainder (12 L/s) reporting to the Lightning Creek drainage. Concentrations of contaminants in the treated discharge within the model are assumed to be at proposed effluent quality standards and at expected performance concentrations based on water treatment experience from Bellekeno;
- Groundwater discharge from mine pool or bioreactor at closure to Christal Creek;
- Groundwater discharge from mine pool to Lightning Creek (33 percent of flow or 1.86 L/s);
- Sensitivity analysis of portal discharge from bioreactor to Christal Creek at closure; and
- Licenced load sources from:
    - Lucky Queen adit discharge (QZ12-053-1 limits) that is discharged to ground and includes assumed peat/soil attenuation factors for ammonia, As, Cd, Ni and Zn (e.g. metal reduction along flow-path prior to entering Christal Creek). For example, concentrations of Zn in the Lucky Queen adit discharge are assumed to be at the QZ12-053-1 licence limit of 0.5 mg/L and are attenuated by 76.7 percent to concentrations of roughly 0.12 mg/L. These discharge rates are anticipated to be low and range from 0.2 L/s to 0.95 L/s under average conditions (i.e., 17 to 82 m^3/d).

[27] Christal Creek and Lightning Creek Mass Load Model Report YOR 2013-0161-146-1 to 150-1.

- Onek 990 mine groundwater seepage from underground workings. These flow rates are anticipated to be very low and range from roughly 0.02 L/s to a maximum of 0.06 L/s (i.e., 2 to 5 m^3/d). Loading concentrations based on shake flask extraction results using 90th percentile data from these tests.
- Lucky Queen and Onek 990 N-AML predicted waste rock leaching concentrations from shake flask tests (90th percentile results) that are attenuated for As, Cd, Ni and Zn;
- District Mill Pond Discharge. This loading source is very small and, in reality, has not discharged to date. The mass loading model has assumed a May discharge period only at a rate of less than 1 L/s. Concentrations are assumed at QZ12-053-1 limits and attenuated for ammonia, As, Cd, Ni and Zn; and
- Treated Bellekeno Mine discharge using average discharge rates and discharge concentrations calculated from operational data from 2012 to 2013 weekly sampling. The Bellekeno mine discharge is only considered in the Lightning Creek mass load model and water quality predictions.

2.4.8.2 Mass Load Model Outputs

As a result of information requests during the project evaluation, the Proponent provided several revisions to the input parameters in their mass load model affecting the water quality predictions. Most notably, the Proponent revised their proposed effluent quality standard and provided the model results based on those criteria. Because the criteria used in the derivation of the proposed effluent discharge criteria were not included in the Proposal, we asked the Proponent to model their expected average discharge concentrations for the various COCs based on their operational experience with their Bellekeno water treatment plant in addition to the updated effluent quality standards. Both model runs are provided for the five operational and district closure scenarios in the most recent model run, summarized in the update to the mass load model report.

The complete mass load model predictions are provided in the latest version of the mass load model report.[28] The results are summarized in Lorax Environmental Services Ltd.'s technical memorandum to YESAB.[29] The following is a summary from that report.

Christal Creek

Table 9 and Table 10 provide the mass load model results for the parameters modelled at water quality stations KV-6 and KV-7 respectively. The cells highlighted in beige note parameter concentrations in excess of the proposed objective at the respective water quality station.

[28] ibid
[29] Lorax Technical Memorandum YOR 2013-0161-169-1.

Table 9: Summary of Mass Load Model Results for Water Quality Predictions in Christal Creek at KV-6 during Operations.

Parameter List	Model Predicted Concentrations at KV-6			
	EQS[1] (max predicted)	Expected Performance (max predicted)	Baseline 95th	Proposed Objective
NH_3-N	1.4	0.68	0.133	**0.85 - 1.92**
Nitrate_N	2.7	1.3	0.29	**3**
Nitrite-N	0.07	0.038	0.025	**0.06**
As	0.013	0.0078	0.01	**0.01**
Cd	0.0033	0.0022	0.0034	**0.0034**
Cu	0.0042	0.0018	0.0029	**0.004**
Pb	0.027	0.016	0.0448	**0.0448**
Ni	0.14	0.03	0.0061	**0.15**
Ag	0.00038	0.00018	0.00034	**0.00034**
Zn	0.33	0.26	0.36	**0.36**
Se	0.0029	0.0022	0.0011	**0.005**
SO_4	562	562	394	**429**

1: Water treatment plant discharging at EQS

Table 10: Summary of Mass Load Model Results for Water Quality Predictions in Christal Creek at KV-7 During Operations.

Parameter List	Model Predicted Concentrations at KV-7			
	EQS (max predicted)	Expected Performance (max predicted)	Baseline 95th	Proposed Objective
NH_3-N	0.8	0.39	0.09	**0.4 - 1.92**
Nitrate_N	1.6	0.7	0.208	**3**
Nitrite-N	0.044	0.026	0.025	**0.06**
As	0.01	0.0048	0.005	**0.005**
Cd	0.0024	0.0017	0.00186	**0.0019**
Cu	0.0034	0.0018	0.00391	**0.0039**
Pb	0.019	0.011	0.0185	**0.0185**
Ni	0.081	0.02	0.0036	**0.0959**
Ag	0.00024	0.0001	0.00021	**0.00021**
Zn	0.217	0.165	0.208	**0.208**
Se	0.0022	0.0019	0.00106	**0.005**
SO_4	362	362	280	**309**

1: Water treatment plant discharging at EQS

The maximum COC concentrations are predicted during the low flow periods in the winter during the operational period when the mine is actively releasing water. As outlined in Table 7, when discharging at the proposed effluent quality standards, concentrations of nitrite, arsenic and sulphate are expected to exceed the water quality objectives at water quality station KV-6. Further downstream at KV-7, concentrations of arsenic and sulphate remain elevated compared to the objectives at that station (Table 8). When discharging at concentrations expected from the proposed water treatment plant (estimated from performance at the Bellekeno water treatment plant), sulphate is the only parameter that remains elevated compared to the proposed objective. The difference in predicted concentrations of arsenic when discharging at the proposed effluent quality standards compared to discharging at the expected water quality from the proposed water treatment plant is considerable.

The exceedances of water quality objectives noted in Table 9 and Table 10 are driven by the operational release of water as a result of the de-watering of the underground workings. This is apparent in the mass load model outputs. During the closure period, exceedances of the operational objectives for the various contaminants are not predicted. However, it should be noted that closure objectives have not been set at this time. Closure objectives will need to consider the larger closure plan for the historic liabilities in the district and the restoration goals for Christal Creek and the McQuesten River watershed as a whole.

Lightning Creek

As outlined in Table 11, COC concentrations in excess of the objectives are not predicted for any parameters modelled in Lightning Creek at water quality station KV-81. Contaminant release to Lightning Creek is expected primarily during the latter part of the operational period (during active release of mine water by way of the proposed water treatment plant). Limited movement of contaminants through groundwater from the underground workings to Lightning Creek may occur during closure. However, maximum concentrations of COCs in Lightning Creek as a result of the Flame and Moth Mine are predicted to occur during the operational period.

Table 11: Summary of Mass Load Model Results for Water Quality Predictions in Lightning Creek at KV-81 during Operations

Parameter List	Model Predicted Concentrations at KV-81		
	EQS[1] (max predicted)	Baseline 95th	Proposed Objective
NH_3-N	0.28	0.061	**0.85 - 1.92**
Nitrate_N	0.664	0.253	**3**
Nitrite-N	0.039	0.0012	**0.06**
As	0.004	0.009	**0.009**
Cd	0.00038	0.00047	**0.00047**
Cu	0.0021	0.0169	**0.0169**
Pb	0.0054	0.0183	**0.0183**
Ni	0.0235	0.0103	**0.025**
Ag	0.00009	0.00032	**0.00032**
Zn	0.034	0.043	**0.043**
Se	0.0009	0.00117	**0.005**
SO_4	90	67	**218**

1: Water treatment plant discharging at EQS

2.4.9 Transport and Access

Mine traffic associated with the Flame and Moth will use the Christal Lake Road and short haul road (~175 m) that would be constructed between the portal and the crusher pad. The existing Bellekeno Bypass Road North (~325 m) will be re-routed to allow expansion of the DSTF.

The Proponent noted that overall traffic with the addition of the Flame and Moth operations would not increase through Keno City, as operations at the Bellekeno mine would cease while Flame and Moth is active. Table 12 summarizes the volume of traffic in the Keno City area for the development phase of the Project.

During mine production, all heavy and light traffic will be routed along the Christal Lake Road and the proposed 175 m Flame and Moth haul road; Table 13, adapted from the project proposal, presents estimated traffic volumes during the operation phase of the Project. The Proponent noted that these values are considered typical for daily traffic based on 400 tpd production, however variations up to 50 percent are possible on any given day.

The Proponent provided a Traffic Management Plan,[30] which was developed and approved under QML-0009, and was updated to incorporate traffic associated with Flame and Moth. The Traffic Management Plan outlines procedures and protocols for site access, traffic routing and management, and the Proponent's policy with respect to vehicle and employee transportation. Of note, access to operational areas related to mining in the KHSD will be restricted to authorized site personnel through signage and gates where appropriate. The Traffic Management Plan also specifies speed limits, communication and notification protocols.

Table 3. Estimated Traffic During Development – Flame & Moth[31]

Vehicle Type	Average Traffic Volume (roundtrips/week)
Light truck	50
Water truck	2
Sewage truck	2
Semi-trailer loads (mining equipment, building supplies, construction equipment, etc.)	7
Grader	1
Total	**62**

[30] Appendix F – KHSD Traffic Management Plan, YOR 2013-0161-011-1
[31] Project Proposal, YOR 2013-0161-003-1

Table 43: Estimated Daily Traffic Count – Operations Phase Flame and Moth

Vehicle Type – One-way traffic count	Travel direction	Shift Change 6 am – 8 am	Day Shift 7 am – 7 pm	Shift Change 4 pm – 6 pm	Night Shift 7 am – 7 pm
Light trucks (<1 t) and autos	Elsa to Mine/Mill	4	8	4	6
Buses	Elsa to Mine/Mill	2		2	
Heavy trucks (>5 t) bulk materials	Elsa to Mine/Mill		3		
Ore trucks (>20 t) hauling ore	Mine to Crusher		14		
Ore trucks (>20 t) hauling tailings or empty	Crusher to Mine		14		
Total round trips/day		**6**	**44**	**6**	**6**

2.4.10 Fuel Storage

A 28 000 L Envirotank will be used for fuel containment at Flame and Moth; fuel will be used to power generators and mining equipment. The Proponent updated their existing Spill Contingency Plan and Hazardous Materials Management Plan to reflect activities proposed with the addition of Flame and Moth. The Spill Contingency Plan[32] outlines procedures and protocols for spill response, communication, and reporting, in addition to providing information regarding spill kits, emergency equipment, and employee training requirements. The Hazardous Materials Management Plan[33] provides information on the storage and types of hazardous materials on-site; employee training; health and safety; spills and emergencies; and signage and monitoring.

2.4.11 Waste Management

The Proponent provided a revised Waste Management Plan[34] to reflect activities proposed for Flame and Moth, outlining waste management practices. Domestic and construction/industrial wastes will be managed according to the Waste Management Plan, which describes existing facilities for use by KHSD mining operations. Facilities include a landfill, incinerator, land treatment facility, and permanent and portable sewage disposal facilities. The Waste Management Plan provides information about the use, permitting and procedures regarding these facilities and the management of their respective wastes.

[32] Appendix I – KHSD Spill Contingency Plan, YOR 2013-0161-014-1.
[33] Appendix J – KHSD Hazardous Materials Management Plan, YOR 2013-0161-015-1.
[34] Appendix H – KHSD Waste Management Plan, YOR 2013-0161-010-1.

2.4.12 Camp Facilities

The Proponent did not indicate that any changes to the existing camp facilities were proposed; the footprint and capacity of the existing camp are not proposed to expand with activities associated with the Project. Currently, the camp at Flat Creek has a capacity of 200 people.

2.4.13 Explosives Use and Storage

The use of explosives is proposed to develop the decline, for waste development and ore production. Explosives will be trucked to the site and stored in an approved magazine in accordance with applicable legislation, away from portals and other buildings. 15 000 kg of explosives will be stored on-site. The blasting reagent will be comprised of approximately two thirds ammonium nitrate and fuel oil (ANFO) and one third of explosives in stick form. Detonators will be non-electric and tied in with detonator cord.

Explosives and detonators will be conveyed to the working headings on an as-need basis, transported via approved day boxes. Unused explosives brought to the work-site will be returned to the magazine at the end of the shift. A log book will be maintained in the magazine as required by regulations.

2.4.14 Decommissioning

The Proponent has a Reclamation and Closure Plan (RCP) in place for the currently permitted Bellekeno, Lucky Queen and Onek mining operations, and noted that the RCP will be amended with the addition of the Flame and Moth deposit, in conjunction with ongoing engagement with the First Nation of Na-Cho Nyäk Dun (NND), regulatory agencies and stakeholders. The only mine components not already included in the existing RCP are the Flame and Moth mine portal and surface facilities (pond, office trailers, fuel storage, etc.), and the proposed DSTF expansion. The closure objectives in the approved RCP will be used to update the RCP with the additional mine components associated with Flame and Moth.

- The Reclamation and Closure Plan contains the following primary objectives:
- Protect public and worker health and safety
- Protect and restore the environment by:
    I. incorporating progressive reclamation where possible;
    II. providing slope stabilization and erosion control on linear and non-linear disturbances;
    III. ensuring long-term chemical stability of the N-AML waste rock disposal areas and components constructed from waste rock to minimize effects to downstream aquatic resources;
    IV. ensuring the long term chemical stability of materials placed into the dry stack tailings facility;
    V. ensuring the long-term physical stability of key structures such as the dry stack tailings facility, Bellekeno, 990 and Lucky Queen portals, P-AML waste rock storage facilities, and access roads; and
    VI. conducting post closure monitoring of the site and adaptive management to assess
- Ensure land use commensurate with surrounding lands
- Ensure meaningful participation of the First Nation of Na-Cho Nyäk Dun
- Ensure cost effectiveness

- Realizing a walk-away closure scenario

2.5 Project Scope

The proposed project involves the underground development and mining of the Flame and Moth silver/lead/zinc deposit, and milling of the ore at the existing Keno District Mill. The Project entails the use of existing mine facilities previously constructed in conjunction with the development of the Bellekeno Mine, as well as the development of new surface infrastructure, including expanding the Dry Stack Tailings Facility (DSTF) to accommodate storage of an additional 585 000 tonnes of mining tails. The proposed project represents an expansion of mining operations in the Keno Hill Silver District by Alexco Keno Hill Mining Corp (the Proponent), which is currently licenced to mine the Bellekeno, Lucky Queen and Onek deposits. The Flame and Moth deposit is located below the existing mill site, approximately 1 km from the townsite of Keno City. No change in the currently licenced and authorized daily milling rate of 400 tpd is proposed. However, an amendment to the Type A Water Use License (QZ12-053) and Quartz Mining License (QML-0009) will be required to support development of the new deposit. While the production schedule is proposed to conclude in 2021, the temporal scope of the Project is from summer 2014 to 2031 that will allow for closure activities.

Table 14: Summary of project activities part of assessment.

Project Activity	Description
Ore Tonnages and Mill Operation	• Extraction of up to 1 000 000 tonnes over the life of the Project (limited by a maximum mill rate of 400 tpd) • Milling of Flame and Moth ore at the Keno District Mill for an additional 7 years until 2021.
Mining Development and Operations	• Development of underground workings, including: development of portal on mill site and primary decline, ventilation raise, safety bays, loadout bays and sumps • Mining via overhand cut and fill and/or long hole stoping methods • Haulage to surface using 15 t trucks • Construction of the following surface infrastructure: laydown yard; expanded coarse ore storage pad; and mill yard expansion
Tailings Management	• Development of an expanded DSTF to accommodate up to a 585 000 tonnes of additional tailings with a footprint of 31 000 m^2 • Use of tailings to backfill Flame and Moth mine • Addition of composite tailings (mixture of Bellekeno, Onek and Lucky Queen tailings) to existing Dry Stack Tailings Facility (DSTF) and proposed expanded DSTF.
P-AML Waste Rock Storage	• Temporary storage on surface • Use as underground backfill • Maximum of 12 000 tonnes brought to surface
N-AML Waste Rock Disposal	• Use for general construction • Construction of portal pad and laydown area, expanded coarse ore stockpile, mill yard expansion, new haul road to crusher and construction of the toe berm and base layer for DSTF expansion • Use as underground backfill • Maximum of 125 000 tonnes brought to surface

Water use and management	• Water use of 141.1 m^3/day from underground workings and contingency sources (25% contingency), which include the Mill well and Christal Creek. • Development of a primary and secondary storage/settling pond, plus contingency in Mill Pond, for the onsite management of Total Suspended Solid. • Dewatering of underground workings at a monthly average rate of up to 3 024 m^3/day • Discharge of effluent to Christal Creek and Lightning Creek, and water treatment (as required) to achieve effluent quality standards. • Deposition of filtered sludge (generated via water treatment processes) into DSTF.
Access/Ore Transport	• Construction of a 175 m haul road from Flame and Moth portal to ore stock pad. • Re-routing/re-alignment of ~325 m of the Bellekeno haul road to accommodate expanded DSTF.
Power	• Use of grid power (estimated 6 570 MWh/yr)
Fuel Storage	• Up to 30 100 L of fuel storage
Auxiliary Facilities	• Operation of portal facilities (plant services, miners' dry area, offices, trailers, portal, water treatment plant, settling ponds, fuel and explosives storage) • Explosives storage (up to 15 000 kg) and use • Development of borrow sources on claims for up to 15 000 m^3
Closure	• Closure and reclamation activities associated with the mine, waste rock, road closures and expanded dry stack tailings facility.

3.0 ENVIRONMENTAL AND SOCIO-ECONOMIC SETTING

3.1 Physical Environment

3.1.1 Geology

3.1.1.1 Keno Hill District Geology

Keno Hill is underlain by Yukon Group metasedimentary rocks, three formations: Upper Schist, Central Quartzite (Keno Hill Quartzite) and Lower Schist. The mineralized Flame and Moth hydrothermal vein system occurs within the upper part of the Keno Hill Quartzite. Quartzite is comprised mainly of quartz (SiO_2) but also mica, carbonate minerals and sulphides. Schist and greenstone are also found within the ore body. Greenstone will occur in sills within the more ductile schist units.[35]

[35] YOR 2013-0161-006-1; 016-1

3.1.1.2 Flame and Moth Ore Body Mineralization

Economic mineralization occurs within the more brittle quartzite and greenstone units. There are two types of mineralization veins within the ore body. An early phase is dominated by quartz containing sulphides, mainly pyrite (FeS_2), sphalerite (ZnS) and arsenopyrite (FeAsS). A later phase is dominated by siderite ($FeCO_3$) containing sphalerite, pyrite and galena (PbS). Other minerals found in this phase include pyrrhotite (FeS) and chalcopyrite ($CuFeS_2$; YOR 2013-0161-016-1).

3.1.2 Watercourses and Water bodies

Watercourses and waterbodies in the project area include Christal Creek, Christal Lake, Lightning Creek (Duncan Creek) and the South McQuesten River. Christal Lake drains into Christal Creek and into the South McQuesten Watershed. Lightning Creek drains into the Mayo River. Both placer gold mining and the historic and current hard rock mining in the region affect the watercourses and waterbodies in this area. Many historic sources of contamination exist in the region and are contributing to cumulative metal contamination in these systems.

As outlined in Minnow (2014)[36], the South McQuesten River and its tributaries are dominated by erosional habitat with substrates consisting of cobble, gravel and some boulders with small sand sized particles in between. Deposition of sediment in these systems is predominately along stream margins where it settles out behind boulders, fallen logs, etc. Sediment samples from these watercourses consisted predominately of sand and silt with a small component of clay.

The following sections summarize additional information regarding the physical characteristics of Christal and Lightning Creeks as these systems are most affected by the Project.

3.1.2.1 Christal Creek

Christal Creek begins at Christal Lake and flows northwest approximately 22 km to the confluence with the South McQuesten River. Flows vary considerable between water monitoring stations KV-6 and KV-7 as the watershed area increases. The difference in flows between KV-6 and KV-7 are quite variable, but are typically substantially higher (two to eight times higher) at KV-7 compared to KV-6. This has implications for the overall flow volumes, contaminant loadings and assimilative capacity for Christal Creek at these two stations.[37]

Although complete hydrometric data was not available for the entire year, two low flow periods are apparent, one during the summer (June – mid August) and one during the winter (December - April) with the lowest flows assumed during the winter period.

Water Quality

Water quality in Christal Creek is affected by inputs from numerous sources including:

- Galkeno 900 adit
- Galkeno 300 adit
- Seepages from west face of Keno Hill
- Metals from Mackeno Mill area and tailings (by way of Christal Lake)

[36] 2012 Long-Term Aquatic Monitoring Program (Minnow 2014) YOR 2013-0161-118-1 to 121-1.
[37] Additional details are provided in Section 8.1.1 of the project proposal YOR 2013-0161-004-1.

Median concentrations of total and dissolved zinc and cadmium are elevated above Canadian Water Quality Guidelines (CWQG) at station KV-6 and KV-7. In addition, median concentrations of arsenic, lead and zinc are more than double water quality guidelines (WQG) or toxicity reference values (TRV) at KV-6 with median zinc concentrations greater than ten times the background. Although median total arsenic concentrations were observed above the guideline at KV-6, median concentrations of dissolved arsenic at this station remained below CWQG.[38] Median sulphate concentrations are also elevated in Christal Creek relative to background.[39]

At station KV-7, median concentrations of aluminum, arsenic, copper, iron, silver, lead and zinc are all at greater than twice the WQG or TRV with silver, lead and zinc more than ten times background concentration.

Contaminant concentrations are highest in the headwaters of Christal Creek (KV-6) and decrease downstream toward the South McQuesten River. This trend is correlated with the proximity to mine affected areas with most contaminant releases located in the headwaters of Christal Creek.

Median zinc and cadmium concentrations have decreased following the treatment of discharge from the Galkeno 900 and Galkeno 300 adits.

Sediment Quality

Concentrations of arsenic, cadmium, lead and zinc in sediments in Christal Creek are higher than the Canadian Sediment Quality Guidelines (CSQG) and probable effects level (PEL). Concentrations are the highest at KV-6 and KV-9A due to the proximity to contaminant sources. Toxicity testing of the sediment noted no reduction in survival or growth of *Hyalella azteca* when exposed to sediments from any of the stations on Christal Creek, suggesting that contaminants are in a form that is not biologically available.[40]

3.1.2.2 Lightning Creek

Lightning Creek begins in steep mountainous terrain and flows through Duncan Creek to the Mayo River. Lightning Creek has an extensive history of placer gold mining that pre-dates silver mining in the region. Extensive placer mining continues today on Lightning Creek and many of its tributaries upstream of the KHSD. In addition, water quality in Lightning Creek is affected by historic and modern hard rock mine inputs from Bellekeno 625 adit discharge, Keno 700 adit discharge and the Bellekeno Mine that was re-opened in 2011.[41]

The hydrograph for Lightning Creek shows high flows during the freshet period (May – June) and decreasing flows through the summer and fall with the low flow period during the winter (December – April).[42] The sustained relatively high flows through the summer are likely indicative of the mountainous headwaters of this system whereby snowmelt continues at high elevations into the late summer.

Water Quality

Lower Lightning Creek shows a general trend of higher total metals during the spring and summer with a decreasing trend into the fall and winter. Increases in total metals concentrations during the summer are attributed to high total suspended solids from placer mining in the system. Dissolved metals in this system are at times an order of magnitude lower than the total concentrations as was noted for arsenic, cadmium

[38] 2012 Long-Term Aquatic Monitoring Program (Minnow 2014) YOR 2013-0161-118-1.
[39] Lorax technical memorandum to YESAB YOR 2013-0161-169-1.
[40] 2012 Long-Term Aquatic Monitoring Program (Minnow 2014) YOR 2013-0161-118-1.
[41] Section 8.1.1.2 of Project Proposal YOR 2013-0161-004-1.
[42] Appendix N of Project Proposal YOR 2013-0161-019-1.

and zinc in 2013. The dissolved concentrations of cadmium and zinc below the hard rock mining influence (KV-41 and KV-81) have been decreasing over recent years while the totals for cadmium remain in excess of the CCME–PAL guideline and the concentration of total zinc exceeds the CCME–PAL periodically. In addition, aluminum, chromium, copper, iron, lead, selenium and silver also exceed the CCME–PAL on a regular basis (i.e. greater than or equal to 15 percent of the time).[43] Generally, water quality in Lightning Creek is considered better than in Christal Creek.

Sediment Quality

Concentrations of arsenic and lead exceed the PEL and the concentrations are higher in the upstream sampling sites (KV-37; above the UKHM influence) than downstream of the UKHM influence (KV-41). This suggests that the UKHM sites have limited impact on the sediment quality in the system. Toxicity testing of the sediment noted slight reductions in growth of *Hyalella azteca* when exposed to sediments at KV-41. Notwithstanding the reduced growth at KV-41, Minnow (2014) concludes that contaminants in the sediments are likely not biologically available.[44]

3.1.3 Climate

Mean annual temperatures in this ecoregion (Yukon Plateau – North) are near -5ºC, but there is a strong seasonal variability accentuated by difference of elevation. Mean January temperatures range from below -30ºC in the lower valleys to above -20ºC over the higher terrain. This gradient is dramatically reversed by July as mean temperatures in the lower valley floors of 15ºC drop to near 8ºC over the higher terrain. Extreme temperatures in the lower valley floors have ranged from -62ºC to 36ºC. Over higher terrain the extremes are more moderate. Frost can occur at any time of the year but is less likely from mid-June to late July.

A weather monitoring station is located on the Project site from which the Proponent has determined that the dominant winds blow from the north and southeast. The average wind speed is 1.19 m/s and winds are calm 23.2% of the time. [45]

3.2 Biological Environment

3.2.1 Aquatic Resources

As noted previously, Christal Creek is in the McQuesten River watershed while Lightning Creek is in the Mayo River watershed. The focus of this section is on the two streams potentially affected by the Project to provide a baseline for the effects characterization and significance determination. Additional details are provided in the project proposal and supporting documents.

3.2.1.1 Christal Creek

Benthic Invertebrates

Conclusions of benthic invertebrate sampling performed in accordance with the Canadian Aquatic Biomonitoring Network (CABIN) protocols note that Christal Creek is potentially stressed and not in

[43] Section 8.1.1.2 of Project Proposal YOR 2013-0161-004-1.
[44] 2012 Long-Term Aquatic Monitoring Program (Minnow 2014) YOR 2013-0161-118-1.
[45] Air Quality Data Summary Memo, June 2014, YOR 2013-0161-128-1.

reference condition.[46] These findings are not surprizing considering the significant contaminant loadings to this system.

Fish Community

Northern pike, Arctic grayling and slimy sculpin have all been documented within Christal Creek. Arctic grayling and Slimy sculpin are the species most encountered during fish surveys on Christal creek. Arctic grayling have not been documented above station KV-7, likely due to a fish barrier above KV-7. Relatively high densities of Slimy sculpin were recorded at station KV-6.

3.2.1.2 Lightning Creek

Benthic Invertebrates

The benthic community analysis for Lightning Creek noted significantly lower organism density at the hard rock mine effluent exposed (EXP) site compared to the reference stations exposed only to placer mining.[47] Minnow (2014) noted that station KV-41 shows moderate effects indicative of mining activities due to a potentially greater proportion of chironomidae and lower proportion of EPT taxa. Minnow (2014) does note however, that the historical and current placer mining upstream of KV-41 confounds the determination of causality.[48]

Fish Community

Arctic grayling, slimy sculpin and round whitefish are the only three species of fish documented in Lightning Creek above Duncan Creek. Arctic grayling and slimy sculpin are encountered most frequently in this system. It appears the Arctic grayling will used the upper reaches of Lightning Creek during the summer and the lower reaches during the winter.[49]

3.2.2 Wildlife

The Keno Hill Silver District supports a variety of wildlife including ungulates, fur-bearers, small mammals, upland game birds and waterfowl. However, there are no key wildlife areas in the district.

Moose are considered one of the ecoregion's most important subsistence animals, and are prevalent in the Keno Hill Silver District. Repeated survey work over the last 15 years indicates a healthy, stable moose population that has in recent years reached a maximum level of harvest.[50]

Woodland caribou are not presently found in the Keno Hill Silver District with the exception of the appearance, in summer, of less than 10-12 caribou scattered in very small groups in the Mt. Hinton and Bunker Hill areas. Occasional caribou have been sighted within the reaches of Mayo Lake and Fraser Falls.[51]

Sheep are not known to inhabit the Keno Hill area.[52] Grizzly and black bears are common in the KHSD. Collared pika are present in the area, occupying scattered small boulder fields in alpine meadows of mountainous regions.

[46] Attachment 8 of Response to Information Request, January 2014, YOR 2013-0161-051-1.
[47] *ibid*
[48] 2012 Long-Term Aquatic Monitoring Program (Minnow 2014) YOR 2013-0161-119-1 p 22.
[49] Attachment 8 of Response to Information Request January 2014 YOR 2013-0161-051-1.
[50] YOR 2011-0315-130-1
[51] YOR 2011-0315-130-1
[52] YOR 2013-0161-003-1

The KHSD is the seasonal home to numerous migratory birds during the migration and breeding season. While the Canada goose and trumpeter swan are abundant within the area, several species including the tundra swan, the greater white-fronted goose, the snow goose and brant pass through the area on their way north to Arctic breeding grounds.[53] Common nighthawk, bank swallow and barn swallow are migratory bird species at risk protected under the *Migratory Birds Convention Act* (MBCA) which may also be found in the area.[54] Other bird species at risk potentially present in the area include rusty blackbird, olive-sided flycatcher, and peregrine falcon.[55]

In addition to migratory birds protected under the MBCA, woodland caribou, grizzly bears, collared pika, rusty blackbird, and olive-sided flycatcher have all been granted special status under federal legislation. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) identifies the above species as species of 'Special Concern.' This definition is understood to encompass wildlife species that may become threatened or endangered due to a combination of biological characteristics and identified threats.[56] Wolverine and little brown myotis, also identified as species at risk under COSEWIC, may also be found in the district.[57]

The project area itself, however, is unlikely to support wildlife or provide wildlife habitat, as the site is adjacent to and surrounded by previously disturbed areas, infrastructure, and an active milling operation.

3.3 Socio-economic Environment

The Flame and Moth deposits lie within the traditional territory of the First Nation of Nacho Nyäk Dun, and in the community of Keno City, and Mayo. The area has been affected äby mineral development over the past hundred years. Silver and lead ore deposits were discovered on Keno Hill in the early 1900s and the area has since seen fluctuating levels of ongoing quartz and placer mining and exploration. Today, the area supports not only mineral development, but also tourism, recreation, and traditional pursuits.

Comprehensive Cooperation and Benefits Agreement with the First Nation of Na Cho Nyäk DunThe proposed project occurs within the traditional territory of the self-governing FNNND. The FNNND have held a Final Agreement since May 29, 1993. The proponent has a signed Comprehensive Cooperation and Benefits Agreement with FNNND that "recognizes both Alexco's mineral rights as well as FNNND's aboriginal rights and sets out rights, obligations and opportunities for both parties".52 The two parties have established a framework within which implementation of the Agreement occurs. Environmental matters are discussed earlier and in-depth, allowing comprehensive discussions between the two parties regarding any proposed amendments or new undertakings by the proponent.

3.3.1 Keno City

Of greatest relevance to this assessment is the socio-economic environment of Keno City. Keno City is a small community situated at the end of the Silver Trail Highway with a population of roughly 20 permanent year-round residents, with a small increase during the summer season. Through much of the 20th century, Keno City, though not the center of mining activities, was largely supported by mining activities in the region, particularly due to its proximity to the company town of Elsa. Whereas Elsa's population was

[53] YOR 2011-0315-130-1
[54] YOR 2013-0161-0105-1
[55] YOR 2011-0315-130-1; 2013-0161-003-1
[56] YOR 2011-0315-130-1
[57] YOR 2013-0161-105-1

approximately 600 in the late 1970's, Keno City's population was approximately 60. Anecdotal information from long-time residents suggests that Keno City was fundamentally different from Elsa due to its size and distance from intensive mining activity, as well as its culture, as its character was not derived from being a "company town" as was the case in Elsa. Workers in Elsa would frequent Keno City's bars and other services. Some residents of Keno City today who worked in Elsa during that time indicated that one of the reasons they had moved to Keno City was for its peaceful, remote, "end-of-the-road" setting.

In 1986 Keno City residents developed a Community Plan with a focus on developing a tourism economy in the region. Four years prior to this plan in1982, the Keno City Mining Museum opened, which has become a significant tourist attraction in the region. In the early 1990's Yukon Government made significant investments into the Mining Museum, with the Community Development Fund contributing $217,260 for the development of the museum, and Tourism and Culture contributing $80,000 for exhibits.[58] Since 2001, the Department of Tourism and Culture has invested over $440,300 in the Museum. Visitor information from the Keno City Mining Museum serves as a good indicator of visitation to the community, which typically exceeds visitation numbers at Mayo's Binnet House museum. The comment submission from Yukon Government, Department of Tourism and Culture, provides the following description of Keno City's tourism industry:

"In addition to community-based attractions, Keno is close to numerous hiking and biking trails, wildlife viewing opportunities and lakes and rivers that offer fishing, boating and canoeing. Year-round accommodation supports summer, shoulder and winter activities, and positions Keno as a base for exploring the surrounding area.

Keno has been successfully marketed as a tranquil Yukon community with an interesting mining history and easy access to scenic wilderness and outdoor activities – features particularly attractive to Yukon's key tourism markets."[59]

History and current status of conflicts relating to AKHM Projects and Keno City residentsThe development of Bellekeno Mine and the Keno District Mill by the Proponent marked the return of silver, lead and zinc mining in the Keno Hill Silver District since operations in Elsa ceased in 1989. For Keno City, it was also the first time significant mining infrastructure had been located in Keno City since the Mackeno Mill, which operated for two years from 1952 to 1954.

Residents indicate that the e recent mining development within the proximity of Keno City over the past five years has changed its character as described above, as well as other components of the socio-economic environment. In particular, the development of the Bellekeno Mines, Lucky Queen and Onek mines, and the siting of related infrastructure, has resulted in a relatively high level of social conflict and community upset. The assessment records for these previous developments, as well as numerous news articles over the past five years, document this conflict. The following description outlines the chronology of events and processes contributing to this conflict.

The Bellekeno Mine Development proposal submitted in early 2009 proposed to locate the ore processing and tailings facility (referred to as the "the mill site") at Christal Lake. Residents who were concerned with the location of the mill site indicated a level of concern and frustration that the location was determined and a proposal developed without consultation with residents to inform the selection of a site. The Proponent's summary of consultation submitted to the assessment of Bellekeno indicates that discussions with the community regarding their concerns with the Christal Lake site were initiated on January 28, 2009, two weeks before the proposal was submitted to the Mayo Designated

[58] Comment Submission, Yukon Government, Tourism and Culture, YOR 2013-0161-090-1
[59] *Ibid*

Office.[60]Comments on the YOR for the Bellekeno assessment articulated the sense that this failure to consult community members before developing the site plans was indicative that community concerns were unimportant to the Proponent's decision-making.

During this assessment, many residents suggested that facilities should be located at a greater distance from Keno City, frequently referencing Elsa as a preferred location due to its historical use as a mill facility and company town. Section 2.2.13 of the proponents project proposal for the Bellekeno Mine indicated that nine possible sites had been identified for the mill site, including: Elsa, Christal Lake, Bellekeno Power Line Road 1 and Road 2; Thunder Gulch; Onek NE; Onek SE; Onek Pit; and Onek 400 adit site. The proponent stated that these nine potential sites had been identified based on the following criteria:

- Proximity to hydro power;
- Haul distance from mine to portal; location suitability for future mines;
- **Community/NNDFN impacts; (emphasis added)**
- Environmental impact/footprint;
- Dry stack tailings location suitability;
- Availability of reliable water source; and,
- Geotechnical suitability.

The proposal went on to state that the three sites deemed best rated in the above criteria were Onek pit, Thunder Gulch and Christal Lake. However, no other information was included in terms of how these ratings were weighted for consideration. A "Location Trade-off Summary" was also provided to the Designated Office prepared by a Wardrop Consultants that evaluated the merits of the three possible sites, and which recommended the Christal Lake site based on consideration of the following criteria:

- Capital cost
- Operating cost (haulage)
- Civil (earthworks and site road quantities)
- Power supply distribution
- Geotechnical/ structural

The above criteria were not based on socio-economic impacts to the community of Keno City. Comments from many residents suggested that it was not clear how the proponent had evaluated effects to their interests, citing the apparent emphasis on economic considerations, such as haul costs, in the above study.

However, the Proponent continued to discuss the community's concerns and eventually proposed to move the mill site from Christal Lake to its current location at the Flame and Moth site in an effort to find a suitable alternative, a site suggested as a possibility by several community members during a January 29th meeting.[61] Information regarding the alternative location was submitted to the YESAB Online Registry on May 6th, but the site was not formally proposed until May 22nd, five days before the Seeking Views and Information period closed on May 27th. Several residents expressed the view that there was insufficient time to comment on the specific Flame and Moth mill site in the assessment process, and questioned the fairness of the YESAB process in this regard.

[60]Bellekeno Mine Development, Revised Volume One Sections 4 to 10, Table 4-2 AlexcoBellekeno Consultation Summary Table. YOR 2009-0030-015-1.

[61] AKHM Supplemental Information in Response to Stakeholder Concerns, AKHM, Bellekeno Mine Development, YOR Document 2009-0030-084-1

Many residents and the Yukon Government Department of Tourism and Culture emphasized their concern that the mill site would be a long-term development, beyond the proposed 5-year operational period for Bellekeno. These residents took the position that the level of community consultation, consideration of impacts to the community, and the time to review and evaluate the effects, should be commensurate with the long-term potential of the facility. The Proponents description of the long-term mineral potential of the area and statements made in the project proposal indicating that the mill site would function as a district mill receiving ore from deposits other than Bellekeno in the future were seen by some to be evidence of the intended lifespan of the mill site. However, the scope of the YESAB assessment considered the mill site and tailings as a five-year operational window, and made significance determinations partly on the basis that the duration of effects was short, limited to a 5-year operational period.

Subsequently, in late 2011 when the proposal to amend the Bellekeno Mine QML and WUL to develop ore deposits at Lucky Queen and Onek was submitted that referred to the mill as the "Keno District Mill," many community members voiced frustration and anger, asserting that their prediction that the mill site would become a long-term fixture was accurate. However, as no amendments to the ore processing facilities, tailings facility, or the operational period of the QML were proposed, residents were advised by YESAB that the scope of the assessment did not include consideration of these activities, (other than the potential effects of co-mingling ore and tailings from the Lucky Queen and Onek deposits). The assessment record of comments submitted with respect to Lucky Queen and Onek, including the transcript of a 4-hour meeting organized by YESAB and held in Keno City, documents a mistrust of the proponent and a lack of faith in the assessment and regulatory processes.

During the Engagement Forum for the current Project proposal, residents indicated that the Proponent met with them in December to give a presentation regarding the Flame and Moth proposal, after the proposal had been submitted to the Mayo Designated Office. Many residents viewed this communication effort by the Proponent as exemplifying a lack of meaningful engagement with the community around project plans, due to both the approach (a presentation rather than consultation), and the timing.

A common theme in the assessment record for Bellekeno, Lucky Queen and Onek, and the proposed Project is the view that the impacts of the project, and specifically those resulting from the location of the mill site and tailings, are borne exclusively by the residents of Keno City.[62] In other words, that there has been an inequitable distribution of effects from the proponents activities to the community of Keno City relative to other people, communities and stakeholders with an interest and an economic stake in the project (e.g. employees of the mine, community of Mayo, FNNND).. Residents have noted that, when it comes to values such as quality of life, public safety, or health that the potential adverse effects are to their community alone. Indeed, this view was shared by the majority of the 14 people present at the Keno City Engagement Forum, as well as in numerous comment submissions for all Bellekeno Mine and Lucky Queen and Onek.

Many residents have indicated that the selection of possible alternatives for the mill site was based primarily on economic factors affecting the company, and that this approach resulted in an unfair outcome that was, in their view, avoidable by placing the mill site away from their community. Many residents now point to the proposed Project as an outcome of the Bellekeno Mine Development assessment, which did not consider the long-term potential and/or likelihood of the mill site.

[62] E.g. Comment submission, Dirk and Tracey Rentmeister, YOR 2013-0161-097-1; Summary of Keno Community Engagement Forum, April 15, 2014, YOR 2013-0161-094-1; Comment submission, Blackburn and Bindig, YOR 2013-0161-100-1.

3.3.1.1 Social conflict and lack of trust

The residents present at the Keno City Engagement Forum indicated that the previous projects had resulted in considerable social upheaval and conflicts in the community, as well as between communities. For example during the Bellekeno assessment a petition was submitted in support of that project signed by a number of Mayo residents and four Keno residents, while in 2012, a petition was entered into the Yukon Legislature signed by nine Keno residents requesting assistance for relocation and compensation. Social divides between Mayo residents and Keno residents have also been noted in the assessment record, particularly in the assessment of the Bellekeno Mine.

Views submitted on the YOR for these past assessments indicate a profound lack of trust in the Proponent and Government, with a belief that community interests are unimportant to these parties. Some of this relates to their views regarding the fairness of the process and its outcomes (e.g. consultation, consideration of alternatives, etc.). During the Seeking Views and formation period for the current assessment, there was also significant concern respecting enforcement of mitigation, and a perceived lack of respect for Keno residents, as described in the Keno City Engagement Forum summary. These examples, point to a negative relationship between the Proponent and the majority of fulltime residents in Keno City .Many of the examples provided related to communications, (e.g. when consultation occurred, timing of notifications, presence of follow-up, etc.), which the residents identified as being fundamental to a respectful relationship. As well, perceived and/or actual failures to implement certain commitments, mitigation, and informal understandings (e.g. covering the crusher, the development of a new trail along Christal Lake Road, etc.), has undermined many resident's trust in the Proponent, the regulators, and the assessment body.

4.0 SCOPE OF THE ASSESSMENT

4.1 Views and Information Submitted

The Mayo Designated Office sought views and information throughout the assessment. Due to the large and complex nature of the Project, comments were solicited during the Adequacy Review (AR) period in addition to two Seeking Views and Information (SV&I) periods. These comments provided valuable information for both the AR stage of the assessment and the evaluation stage of the assessment. These comments are referenced throughout Part B of this report as they pertain to the effects assessment for each valued component.

During the Adequacy Review (AR) period, the Mayo Designated Office invited departments from Yukon Government, Government of Canada and the First Nation of Na-Cho Nyäk Dun government to submit comments regarding the adequacy of the information provided in the Project proposal. These comments were considered during the AR prior to moving the Project into the SV&I period.

During the SV&I period, the Mayo Designated Office held engagement forums in both Keno City and Mayo to provide an opportunity for community members to submit comments about the Project. Fourteen people, of which twelve were residents of Keno, attended the forum in Keno and provided comprehensive comments on the Project. No members of the public attended the forum in Mayo. A complete summary of the comments received at the forum in Keno is provided in Appendix C.

4.2 Consideration of Significance

In order to mitigate a potential adverse effect, the Designated Office must first find significance. In addressing what may constitute a "significant" adverse effect, the Designated Office considered the following factors:

Magnitude: This refers to the magnitude of the effect. Low magnitude effects may have no impact, while high magnitude effects do have an impact.

Probability: The likelihood that an adverse effect will occur.

Geographic Extent: This refers to the extent of change over the geographic area of a project. The geographic extent of effects can be local or regional. Local effects may have a lower impact than regional effects.

Duration and Frequency: This refers to the length of time the effect lasts and how often the effect occurs. The duration of an effect can be short term or long term. The frequency of an effect can befrequent or infrequent. Short term and/or infrequent effects may have a lower impact than long term and/or frequent effects.

Reversibility: This refers to the degree to which the effect is reversible. Effects can be reversible or permanent. Reversible effects may have lower impact than irreversible or permanent effects.

Context: This refers to the ability of the environment to accept change. For example, the effects of a project may have an impact if they occur in areas that are ecologically sensitive, with little resilience to imposed stresses.

4.3 Consideration of Cumulative Effects

With regards to cumulative effects, subsection 42(1)(d) of the *Yukon Environmental and Socio-economic Assessment Act* (YESAA) instructs Designated Offices to consider:

42(1)(d) the significance of any adverse cumulative environmental or socio-economic effects that have occurred or might occur in connection with the project or existing project in combination with the effects of:

I. Other existing projects for which proposals have been submitted under subsection 50(1), or

II. Other existing or proposed activities in or outside Yukon that are known to the Designated Office, Executive Committee or panel of the Board from information provided to it or obtained by it under the Act.

In the situation where the Designated Office determined that there would be no residual effects of the proposed Project on a specific value then a cumulative effects assessment for that value was not necessary.

4.4 Consideration of Cumulative Effects for Socio-economic Valued Components

The Designated Office determined that the proposed Project would result in adverse effects to socio-economic values to Keno City residents only (i.e. socio-economic values important to FNNND and Mayo residents considered in past assessments would not be impacted by the current proposal).

The proposed Project includes an amendment to an existing Quartz Mining License to allow the development of the Flame and Moth ore deposit and expand the DSTF, as well as to process ore at the Keno District Mill for an additional 7 years. The existing activities form part of the baseline conditions,

which include ore processing and tailings facilities, and mining activities at Bellekeno, Lucky Queen and Onek. Residual effects of these projects are reflected in the baseline conditions for the socio-economic values described in this Evaluation Report. As such, the effects assessment considers the effects of the Project in connection with the residual effects of past projects and activities because the residual effects form the current baseline conditions in Keno City.

4.4.1 Other projects and activities summary

Several existing activities in the area have influenced the socio-economic environment of Keno City. In particular, and most relevant to this assessment, are those activities associated with the operations of the Bellekeno Mine development, the construction and operation of the mill and crusher facilities at the Flame and Moth site (Keno District Mill), and the preliminary development of Lucky Queen and Onek mines. Additionally, there have been residual effects to community wellbeing resulting from, and because of, the governance structures and processes under which these projects have been facilitated (e.g. community consultation measures, assessment process considerations, regulatory oversight), partly described in Section 3.3 Socio-economic Environment.

Projects assessed by the Mayo Designated Office within a 5 km radius of Keno City were considered for their potential socio-economic effects (e.g. effects to visual and auditory amenity). These projects include the following:

- 2008-0254 – Keno City Solid Waste Disposal
- 2008-0291 Aurex Property
- 2008-0039 Bellekeno Advanced Exploration and Development
- 2009-0048 Eagle Project
- 2010-0146 Closure Plan for Keno Hill: Physical Reduction of Hazard Buildings
- 2011-0299 Solid Waste Disposal Facility
- 2011-0310 Erikson Gulch Placer
- 2012-0141 Water Use License Renewal for Care and Maintenance, Keno Hill District
- 2012-0143 Placer Mine on Lightning Creek
- 2013-0077 Class III Quartz Exploration – Galena Hill
- 2013-0083 Quartz Exploration and High Grade Mining near Keno
- 2013-0153 Placer Mining Thunder Gulch and Lightning Creek
- 2014-0055 Road Upgrade Granite Creek
- 2014-0128 Placer Mining Duncan Creek

These projects consist primarily of placer and quartz projects, indicative of the active mining industry in the vicinity of Keno City. However, no comments indicating a concern for adverse residual effects to socio-economic values (or any other valued component) were submitted during the assessment of the above activities. Based on information about Keno's economy and various resident's support for mining activities[63] the community appears to consider some of the residual effects of specific projects as part of

[63]Comments from Keno residents located on the YOR for Project 2009-0030, 2011-0315, and 2013-0161.

the baseline socio-economic conditions. In other words, many of the above projects did not result in significant changes to the socio-economic of Keno City, and therefore, were consistent with general baseline conditions. As well, most placer and quartz exploration and mining projects above are located greater than 2 km from Keno City, so residual effects to Keno City have been few. Similarly, activities that generally do not trigger assessments, such as those related to private use, (e.g. residential use), recreation and hunting, and non-consumptive business activity such as tourism ventures, (e.g. visitor amenities, art gallery), are also appropriately considered part of the baseline socio-economic conditions on which effects to values have been considered.

The current assessment provides the opportunity to evaluate some of the residual effects from the mining development to date to socio-economic values based on both data collected (e.g. from noise and dust monitoring and/or modelling) as well as the experiences documented in comment submissions and expressed during the Keno Community Engagement Forum. This information can then be used to predict the cumulative effects of the proposed Project to this valued component and evaluate possible mitigation. To reduce redundancy, the evaluation of effects to socio-economic valued components is presented as a cumulative effects assessment, in consideration of residual effects from the Proponents existing and proposed activities within the local area of Keno City.

4.5 Consideration of Alternatives

The Proponent chose not to propose any alternatives in the context of the Flame and Moth assessment for the Mill site or the location or method of tailings storage/disposal. The Proponent indicated that alternative locations for the mill site and location of the DSTF were previously investigated during the assessment of the Bellekeno Mine (2009-0030), and that the Flame and Moth site was determined to be the most appropriate site. The Proponent further indicated that given the location of the Flame and Moth deposit under the existing mill site, the current location for the mill and expanded DSTF continues to be the most appropriate site.

Therefore, the Designated Office has not considered alternative locations for the DSTF and/or the mill site as they were not presented. The assessment therefore considers the Flame and Moth site exclusively.

4.6 Consideration of Wildlife and Wildlife Habitat

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) identifies a number of species of concern which are or may be present in the Keno Hill Silver District, as discussed in Section 3. In a comment to the Designated Office, Environment Canada noted activities are to be managed in compliance with the *Migratory Birds Convention Act*, the *Migratory Bird Regulations*, and the *Species at Risk Act*.[64] The First Nation of Na-Cho Nyäk Dun also submitted comments to the Designated Office regarding the Project. NND raised concerns regarding habitat loss and fragmentation, wildlife injury and/or mortality, and cumulative impacts given other mine sites in the area. NND also requested any wildlife encounters or incidents be reported to the NND Fish and Wildlife Officer at (867) 996-2265 (extension 143).[65]

However, as noted in Section 3.2.2 – Biological Environment, the project area itself is unlikely to support wildlife or provide wildlife habitat, and does not spatially overlap with any key wildlife areas. The proposed expansion of the existing footprint is small, at approximately three hectares. Beyond the Project footprint the site is disturbed, with project activities occurring immediately adjacent to or overlapping with existing

[64] YOR 2013-0161-105-1
[65] YOR 2013-0161-163-1

footprint, particularly to the north and south, as well as west of the district mill, wildlife habitat is relatively undisturbed.

In their Waste Management Plan,[66] the Proponent commits to a number of measures to prevent wildlife attraction to the Project area. At closure, the Proponent commits to blocking the mine portal entrances to prevent wildlife access.

The proposal states: "As the mine operations at Flame and Moth begin, traffic from other deposits is expected to decrease, and the net level of traffic for the district should remain the same."[67] Project related traffic will remain at the same level, thus posing no increased risk to wildlife.

There is limited to no loss of wildlife habitat in the project area. Further, beyond the project area lie large areas of undisturbed habitat. The noise produced will occur from a relatively small point source surrounded by wilderness. The overall increase is not significant given the surrounding area.

These factors, combined with the Proponent's commitments and relevant legislation, lead the Designated Office to conclude that potential effects of project activities on wildlife and wildlife habitat are minimal and are not significant. Therefore, wildlife and wildlife habitat is not considered further in this report.

4.7 Valued Environmental and Socio-economic Components (VESEC)

The following valued environmental and socio-economic components (VESEC) are the specific values that have been identified by the Mayo Designated Office as being adversely affected by the Project:

- Aquatic Resources (Section 5.0)
- Human Health (Section 6.0)
- Visual and Auditory Amenity (Section 7.0)
- Community Wellbeing (Quality of Life) (Section 8.0)

[66] YOR 2013-0161-013-1
[67] YOR 2013-0161-003-1

PART B. ASSESSMENT AND REASONS FOR RECOMMENDATION

Part B of this evaluation report presents the effects assessment of the Project on valued components identified in Section 4.0. For each valued component, an overview of the value is provided followed by the effects characterization analysis. Where relevant, measures to reduce significant adverse effects of the Project on the valued component are identified. The effects characterization ends with a conclusion on the key findings of the assessment.

5.0 AQUATIC RESOURCES

5.1 Overview

The Flame and Moth mine will contribute contaminant loadings to streams located in the McQuesten and Mayo River watersheds. Water quality in these watersheds is affected by current and historic mining in the region. Mining activities have contributed to elevated concentrations of many contaminants in these two watersheds with the most significant degradation of water quality in tributaries to the McQuesten River.

The Flame and Moth mine development activities are summarized in Section 2.4 and detailed in the Proposal and supporting documents on the YOR.[68] This information is necessary to the understanding of potential effects and is not reproduced in detail in this section. In general, the following project activities were considered most relevant to the evaluation of effects to aquatic resources:

- De-watering of underground mine workings during operations (~35 L/s discharge at peak);
- Mining, segregation, storage and disposal of P-AML rock; and
- Ore processing and disposal of tailings.

Effects of the Flame and Moth mine to aquatic resources will occur primarily from the release contaminants to surface and groundwater. The effects of the Flame and Moth mine to aquatic resources will vary with the phase of mine development and will be most prominent in Christal Creek during the operational period.

The development of the Flame and Moth mine is predicted to produce significant adverse effects to aquatic resources that require additional mitigation. The rationale used to arrive at the determination of significant adverse effects is outlined in the proceeding sections.

5.2 Project Effects – Release of contaminants through effluent discharge to surface and groundwater

The Flame and Moth ore deposits contain sulphide minerals that can produce metal leaching (ML) and acid rock drainage (ARD). The product of ML/ARD can be concentrated dissolved metals and adversely affected water quality (e.g. reduced pH) that can result in significant adverse effects to aquatic resources.

The effects of contaminants (mostly dissolved metals) to aquatic resources vary by the type of contaminant and the concentration in the receiving environment. In addition, toxicity of some contaminants is dependent on a number of factors including background water chemistry and food web cycles.

[68] YOR 2013-0161

This section begins with a background discussion of ML/ARD as the source of contaminants to the receiving environment. The predicted COCs from the Flame and Moth mine are discussed in relation to appropriate water quality objectives. Finally, the mass load model predictions are discussed as they pertain to effects to aquatic resources.

5.2.1 ML/ARD Potential of Mine Wastes and Implications for Metal Release

5.2.1.1 Background to ML/ARD

As noted in Section 3.1.1 (Geology), the Flame and Moth deposits consist of sulphide mineralization. Drainage waters from sulphidic deposits can contain elevated concentrations of metals and other elements at any pH. Problematic drainage occurs primarily from the exposure of sulphidic deposits to oxygen and water that results in oxidation. Oxidation changes the chemical species from a relatively insoluble form into free ionic species that are easily dissolved. Once dissolved, these metals are readily transported by water.

The oxidation of some sulphide minerals produces acid. In the absence of neutralizing minerals, the lower drainage pH can increase the:

- Rate of sulphide oxidation;
- Solubility of many products of sulphide oxidation; and
- Rate of weathering of other minerals.

In addition to leaching of metals, non-metals such as selenium can be readily leached from sulphidic rock at near-neutral or alkaline pH. Depending on the exposure of sulphidic rock to oxidation and weathering processes, contaminant loadings[69] of metals and non-metals from a mine site can readily exceed water quality objectives (Price 2009).

Understanding the ratio of neutralization potential[70] to acid potential[71] of the minerals present is a critical factor in Acid Base Accounting (ABA). Understanding ABA for the mine site allows for more informed predictions of potential weathering rates and release of metals to the environment.

5.2.1.2 ML/ARD Predictions for Flame & Moth

Appendix K of the project proposal details the geochemical analysis performed on the Flame and Moth waste rock and tailings.[72] Total sulphur was used to calculate the maximum acid potential of the material. The total sulphur ranged between 0.02% and 2.56% in all rock lithologies. For neutralizing potential, the carbonate minerals provide the primary neutralizing potential for the material. Specifically, calcium carbonate is the primary source of neutralizing potential and % Ca can be used reliably and accurately to estimate NP within all non-mineralized lithologies except greenstone at Flame and Moth.

The Proponent notes that their past experience with the district provides them confidence that a neutralizing potential ratio (NPR) of >2:1(2NP:1AP) for designation of geologic materials as being unlikely to produce net acidity is sufficiently conservative.

[69] Loading is the concentration multiplied by flow, providing a mass per unit of time flowing from a mine or mine component (MEND 2009).
[70] Acid Neutralization Potential – The total acid a material is capable of neutralizing (MEND 2009).
[71] Acid Potential – The total acid a material is capable of generating, including acid that dissolves, is neutralized and forms acid salts (MEND 2009).
[72] Appendix K, YOR 2013-0161-016-1.

As part of their proposal, the Proponent provided results from Shake Flask Tests and the first 20 weeks of Humidity Cell (HC) Test results to provide an understanding of the ARD/ML potential of the Flame & Moth geologic material. These tests indicated that As, Sb, Cd, Pb, Ni, Se, Ag, and Zn were all COCs. Of these, further testing of leachability showed that only maximum values of Ag, As, Cd and Se exceeded CCME guidelines and only Se exceeded CCME guidelines at average concentrations. It is also noted that Se appeared to be stabilizing below the CCME guidelines at weeks 18-19 of the HC results.[73] The most recent HC results to week 45 confirm this declining trend of Se concentration with a concentration of 0.00038, well below the CCME guidelines.[74] However, these static and kinetic tests results do not provide predictions of loadings on their own and will need to be scaled up to represent actual site exposure to provide an estimate of loadings.

From the ABA analysis, the Proponent predicts that the Flame & Moth Mine will produce approximately 12 000 tonnes of P-AML waste rock and approximately 125 000 tonnes of N-AML waste rock. In addition, the Project includes the production of up to 585 000 tonnes of tailings predicted to be non-acid producing[75] and the disposal of tailings in an expanded DSTF.

5.2.2 Contaminant Sources from Flame & Moth Mine and Model Inputs

The primary potential contaminant sources from the Project include:

- Contact water from underground mine workings discharged to surface during operations (~35 L/s);
- Contact water from P-AML rock temporarily stored on surface during operations;
- Contact water from misclassified rock used for surface infrastructure;
- Discharge water from the Flame & Moth adit at closure (not expected but possible due to incomplete groundwater data);
- Groundwater flow to surface through underground workings and backfilled P-AML waste rock during closure (~5.6 L/s);
- Potential seepage from DSTF; and
- Geochemical or geotechnical failure of the DSTF (discussed in Section 5.3).

Many of these sources were included in the latest mass load model provided by the Proponent. Some, such as seepage from the DSTF and failure of the DSTF, are considered very unlikely and were not included. These potential sources will be managed adaptively if they arise and the Proponent has provided plans to prevent adverse environmental effects from these potential sources. A summary of the inputs and the latest mass load model is provided in Section 2.4.8.

Due to the poor water quality predicted from some of the contaminant sources, the Proponent has committed to treatment of some of these during operations and closure. These sources and proposed treatment include:

- Treatment of mine de-watering discharge before release to the environment;
- In-situ treatment of mine pool water post closure to reduce loadings from groundwater flows; and

[73] Appendix K YOR 2013-0161-016-1.

[74] Response to IR June 12, 2014 YOR 2013-0161-116-1.

[75] DSTF Operations and Maintenance Schedule YOR 2013-0161-067-1.

- A bioreactor at closure to treat any adit seepage or seepage from the DSTF.

The inputs to the mass load model were adjusted to account for treatment prior to release to the receiving environment. Proposed water treatment is summarized in Section 2.4.6.

In addition to active and passive treatment, the Proponent is predicting attenuation factors for Arsenic, Cadmium, Nickel and Zinc before the effluent reaches surface waters in the receiving environment.[76] These reduced loadings were then input to the model to provide water quality predictions in the receiving environment.

The primary contaminant loadings to Christal and Lightning Creeks will occur during operations as a result of discharge water from the underground workings through the water treatment plant (see Section 2.4.6) to these two drainages. The actual loadings during operations will depend on the performance of the proposed water treatment plant and the proposed EQS for discharge from the treatment plant as the upper limit of release. These loadings constitute the primary effects expected from the Project to aquatic resources.

5.2.3 Proposed Water Quality Objectives and Predictions of Effects

Water quality objectives (WQOs) are a critical component of understanding and predicting effects to aquatic resources. In the case of Christal and Lightning Creeks, aquatic life is the valued component and WQOs should be developed based on the protection of aquatic life. In Canada, the Canadian Council of Ministers of the Environment (CCME) sets generic water quality guidelines for, among other things, the protection of aquatic life. These guidelines are often referred to as the Canadian Water Quality Guidelines for the Protection of Aquatic Life (CWQG – PAL). These guidelines include guidance on the development of Site Specific Water Quality Objectives (SSWQOs) for contaminants where toxicity is modified by site-specific water parameters such as pH and hardness. In addition, CCME provides guidance on the development of SSWQOs where contaminant concentrations are naturally elevated in background waters (CCME 2003).

As outlined in Section 3.1.2, the background water quality in both Christal and Lightning Creeks has been degraded by contaminant loadings from active and historic mines in the area. Concentrations of many contaminants are elevated above the CWQG – PAL. The effects of these elevated contaminant loadings are the likely reason that aquatic resources in Christal Creek are stressed and not in reference condition.[77] Although Lightning Creek is currently found to be in reference condition, concentrations of many contaminants in this system are elevated compared to CWQG – PAL, and additional loadings will likely lead to adverse effects to aquatic life in this system. In short, there is no remaining assimilative capacity[78] in Christal or Lightning Creek to accept additional loads[79] of some contaminants.

The Proponent has developed WQOs for both Christal and Lightning Creeks (Table 6). The development of these WQOs is described in Attachment F of Attachment 12 of the response to the IR on July 8, 2014.[80] Water quality objectives for Christal Creek and Lightning Creek were developed using water

[76] Christal Creek and Lightning Creek Mass Load Model Report YOR 2013-0161-146-1 to 150-1
[77] 2012 Long-Term Aquatic Monitoring Program (Minnow 2014) YOR 2013-0161-118-1.
[78] "Assimilative capacity" in this case refers to the capacity of the watercourse to dilute contaminant loadings to concentrations that are below predicted effects levels for aquatic life.
[79] Contaminant loadings are a product of concentration and volume (e.g. high concentrations of contaminants in low volumes may produce significant loadings of a particular contaminants to a receiving watercourse).
[80] Attachment F of Attachment 12 of IR Response YOR 2013-0161-137-1.

quality monitoring data for the period of 2008 to 2013 for stations KV-6 and KV-7 (Christal Creek) and KV-81 (Lightning Creek) for all parameters except Selenium (Se). Recognizing that several parameters are elevated in concentration above regulatory guidelines, water quality objectives were set at the 95th percentile of baseline data (2008-2013) for that station. When baseline concentrations did not exceed referenced CCME guidelines or British Columbia Ministry of Environment (BCMOE) guidelines, the guideline was selected as the water quality objective. For Se, the 95th percentile background concentrations throughout Christal and Lightning Creeks essentially meet or exceed the current CCME guideline. However, the Proponent chose a SSWQO for Se that is roughly five times the current CCME guideline. No supporting rationale was provided.

For As, Cd, Pb, Ag and Zn water quality objectives for upper Christal Creek (KV-6) were set on the 95th percentile of background concentrations. For lower Christal Creek (KV-7), Cd, Cu, Pb, Ag and Zn were set at the 95th percentile of background concentrations. For Lightning Creek, Cd, Cu, Pb Ag and Zn were set at the 95th percentile of background concentrations. The proposed objectives for sulphate in both receivers followed the most recent scientific data as published in the BCMOE guidelines (BCMOE 2013). Increased water hardness has been shown to decrease the toxicity of sulphate to sensitive species, therefore the BC guideline is dependent on the hardness of the water.

In their comment submission,[81] the First Nation of Na-Cho Nyäk Dun noted their desire to see the aquatic resources of Christal and Lightning Creek preserved and restored to the extent practicable through the prevention of the release of additional contaminant loads to the system and future reclamation of pollution sources from historic mine workings in the region. The principles of use protection, as outlined in CCME (2003), should guide the development of SSWQOs that protect this end use (aquatic life). The SSWQOs based on the 95th percentile of a limited data set for heavily impacted streams does not provide for the principles of use protection or the development of SSWQOs. Additional loadings up to the 95th percentile of the background data set for the specific monitoring stations will result in further degradation of the water quality of the stream. The reduction of contaminant loadings to these systems from historical sources is outside the Proponent's direct control and largely dependent on the larger future reclamation efforts in the region. However, the release of additional contaminant loadings above the typical (e.g. mean + two standard deviations [CCME 2003]) water quality will further degrade the system and may impede restoration of aquatic resources in these systems. In addition, as noted in Minnow (2014), the degraded water quality of Christal Creek may already be affecting aquatic resources in the South McQuesten River.[82] Additional contaminant loadings to Christal Creek will further reduce water quality in the South McQuesten River and may contribute to adverse effects to aquatic resources there.

The development of the SSWQO for Selenium was not outlined in the Proposal, but appears to be based on the draft guidelines released by the United States Environmental Protection Agency (USEPA) guidelines from May of this year (2014). This value is approximately five times the current CWQG – PAL.

The 95th percentile of the background dataset is essentially at the CWQG – PAL (0.001 mg/L) for Se. However, the Proponent has proposed a SSWQO of 0.005 mg/L with no supporting rationale provided. This is presumably set based on operational needs as Se is difficult to treat and concentrations in effluent will significantly exceed background concentrations. In the absence of this rationale, Lorax Environmental Inc. (Lorax; retained by YESAB for technical support) provided a discussion of the appropriateness of the SSWQO proposed for Se.[83] In that report, Lorax argued that the CCME guideline, based on Se concentration in the water column is not an accurate gauge of potential effects to aquatic life because Se

[81] NND comment submission May 9, 2014 YOR 2013-0161-106-2.
[82] 2012 Long-Term Aquatic Monitoring Program (Minnow 2014) YOR 2013-0161-118-1 p. 23.
[83] Lorax Environmental Services Ltd. Memo to YESAB YOR 2013-0161-169-1.

toxicity is dependent on bioavailability through food web processes. In addition, toxic effects are primarily to eggs of egg laying vertebrates with aquatic diets and are not directly related to concentrations of Se in the water column. In light of this recent research, BCMOE has developed tissue criteria for Se. Se tissue concentrations are not easily monitored and so a relationship between Se concentrations in water and reproductive tissues can be developed using a bioaccumulation model and has been done in many northern streams. Lorax notes several streams in Northern BC where bioaccumulation models have produced SSWQOs for Se as high as 0.01 mg/L. Lorax concludes that a SSWQO of 0.005 mg/L is unlikely to result in significant adverse effects in Christal and Lightning Creeks.

The conclusions of Lorax regarding the proposed SSWQO of 0.005 mg/L for Se may be true for Christal and Lightning Creeks. However, the Proponent has not provided site specific testing or modelling to support their proposed SSWQO for Se in either Christal or Lightning Creek. We do not have the benefit of tissue samples to compare to the BC guidelines as a gauge as to where the systems currently are in terms of Se loadings. In addition, the Proponent provided no supporting rationale as to the applicability of the USEPA draft guidelines for Se in Christal and Lightning Creeks. The Mayo Designated Office is of the opinion that there is not sufficient site-specific information to determine that a SSWQO for Se of 0.005 mg/L is appropriate. However, we recognize the recent study on Se and the difficulty with treatment of this contaminant and consider these when evaluating potential effects from predicted Se loadings.

5.2.4 Proposed Effluent Quality Standards (EQS)

Water quality objectives based on chronic toxicity values are the values that in the receiving environment should not be exceeded during normal operations. To ensure this principle is achieved, EQS should be set to ensure that concentrations of contaminants do not exceed the objectives in the receiving environment. Predictive modelling should be used to assist in the development of EQS and to demonstrate that EQS will produce contaminant concentrations in the receiving environment below the water quality objectives during normal operations.

The Proponent's proposed EQS are discussed in Section 2.4.7 and outlined in Table 7 and Table 8. Table 7 outlines the EQS for the station KV-83 at the Mill Pond and Table 8 outlines the EQS at station KV-104. The Mill Pond has not discharged to date and is not expected to discharge throughout the duration of the Flame & Moth Mine. However, the Proponent modelled approximately 1 L/s flow from this point at the proposed EQS during the freshet in May.

The primary discharge of the Flame & Moth Mine and associated effects on water quality will occur from discharge of water through the proposed water treatment plant of approximately 35 L/s. This water will be discharged at concentrations not exceeding the proposed EQS for station KV-104.

The Proponent did not provide supporting rationale for the derivation of their proposed EQS. The standards proposed for KV-104 are substantially reduced from those originally proposed and include many additional contaminants than originally proposed. The EQS do not appear to be calculated from the SSWQOs for all constituents as discussed in Section 5.2.5 below.

5.2.5 Model Predictions and Discussion of Potential Effects

The Proponent's original model run was based on the expected performance of their water treatment plant rather than their original objectives. Following questions from our office the Proponent revised their model along with their EQS. Finally, we asked the Proponent to model discharge at both the expected water quality from their proposed water treatment plant and at discharge at their revised EQS. The intent behind this request was to provide reviewers with the expected discharge compared with discharge at the EQS, considered the maximum potential concentrations of COCs. We also asked the Proponent to

provide the monthly time steps in the model run to demonstrate the maximum concentrations of contaminants at the various stations during the low flow periods when the effluent would have the most influence on receiving environment waters. The predicted contaminant concentrations at the water quality stations in both Christal and Lightning Creeks are provided in Table 9, Table 10 and Table 11.

5.2.5.1 Christal Creek

For water quality stations KV-6 and KV-7 on Christal Creek, exceedances of the SSWQOs were noted when discharging at the proposed EQS for sulphate, arsenic and nitrite at KV-6; and sulphate and arsenic at station KV-7. Sulphate concentrations exceeded the SSWQOs at stations KV-6 and KV-7 when discharging at the predicted performance of the proposed water treatment plant. Maximum concentrations are predicted to occur in year 2020 for all contaminants modelled except cadmium with predicted maximums in year 2018. De-watering of the underground during the operational period is the driving factor in elevated contaminant concentrations in the receiving environment.

In their technical memo to YESAB, Lorax concluded that exceedances of SSWQOs cannot be characterized as temporary or short-lived and could persist for up to six months of the year.[84] Lorax noted the most troublesome exceedances are for sulphate that is elevated well above the SSWQOs when discharging at the proposed EQS and remains elevated during discharge at the expected concentrations from the proposed water treatment plant. Lorax noted potential cumulative effects of multiple contaminants elevated above the SSWQOs in combination. In response to this memo,[85] the Proponent provided a follow up statement that highlighted their disagreement with these conclusions. In particular, the Proponent reiterated that the CCME guidelines for arsenic are inappropriate due to the use of safety factors and that the more recent USEPA guideline for chronic effects is approximately three times the concentration of the CCME guideline and is a better evaluation of potential effects. For sulphate, the Proponent noted that they do not expect to be discharging at the proposed EQS, but that this should be viewed as the maximum discharge occurring infrequently and that the expected performance of the proposed water treatment plant is a better prediction of potential effects. In addition, the Proponent contended the conclusion that elevated contaminant concentrations in the receiving environment may interact to form adverse cumulative effects to aquatic resources. The Proponent noted that guidelines across the mining industry in Canada evaluate substance by substance toxicity and noted that requirements under the *Metal Mining Effluent Regulations* for toxicity testing of the mine effluent along with environmental effects monitoring (EEM) are sufficient to capture any potential contaminant interactions and associated effects.

Although few contaminants are predicted to exceed SSWQOs at discharge at the EQS, many of the contaminants are predicted to be at or slightly below the proposed SSWQOs in Christal Creek. As noted in Section 5.2.3, the SSWQOs for many contaminants were set at the 95th percentile of background concentrations. Even at the expected performance, concentrations of some of the contaminants are predicted to be at or near the SSWQOs or, in the case of many contaminants, the upper limits of the background concentrations. As background concentrations of many contaminants are already substantially elevated above CWQG-PAL due to ongoing contamination, discharge of effluent even at the predicted performance of the proposed water treatment plant will contribute additional contaminant loads that may push contaminant concentrations beyond the typical background (e.g. mean + two standard deviations). These concerns were noted by NND in their comment submission along with the desire to

[84] Lorax Environmental Services Ltd. Memo to YESAB YOR 2013-0161-169-1.
[85] Proponent response to Lorax memo YOR 2013-0161-170-1.

restore the water quality in the system.[86] It is possible that the expected performance from the proposed water treatment plant will produce contaminant concentrations for some contaminants that fall within the typical range of background concentrations. However, until the SSWQOs for contaminants that are elevated above water quality guidelines for protection of aquatic life are adjusted to reflect the objective of maintaining water quality in the system (not contributing additional mass loads of some contaminants), this determination cannot be made.

Another important factor to consider when evaluating the potential effects of the Project to aquatic life is the issue of uncertainty in the model inputs. Environment Canada (EC) concluded that the groundwater monitoring wells installed by the Proponent were inadequate to develop an understanding of depth discrete groundwater quality or hydraulic parameters and that most of the groundwater data should be considered suspect and is not sufficient for further licensing.[87] EC noted that because there is no understanding of the potentiometric surface of groundwater, it is possible that the Flame & Moth adit will discharge at closure. In addition, EC noted that the data seem to suggest a groundwater divide between Christal and Lightning Creeks and noted that the flooded mine workings may affect both drainages during the post closure period.

In response to EC's concerns, the Proponent provided additional modelling runs to simulate adit discharge following closure and contaminant movements of approximately 33% to Lightning Creek at closure. These model runs provided reviewers the ability to evaluate the sensitivity of the model to these additional loads. As predicted in previous model runs, the water quality predictions appear to be most sensitive to active de-watering during the operational period. Therefore, predictions of groundwater inflows and quality during the active mining period are likely the most important factor to determining potential effects to aquatic resources.

EC noted that the inflow and outflow values in the water balance remain the same for each month of the year and that the Proponent did not provide a sensitivity analysis for their water balance to predict effects based on wet and dry years. EC noted that this is essential to predict the amount of water to be discharged.[88]

During closure, exceedances of the operational SSWQOs are not predicted based on in-situ mine pool treatment. However, water quality objectives during closure will likely reflect improved water quality in the system as a result of district wide closure efforts. Predictions of effects will necessarily need to be based on these future water quality goals and updated water quality objectives. In addition, the uncertainties in the potentiometric groundwater surface, as highlighted in EC's comments,[89] are particularly critical, as adit discharge may become an issue in the future. Effectiveness of the proposed bioreactor will depend on many factors including actual input flows.

As discussed in Section 5.2.3, the Proponent has chosen a draft USEPA guideline as their water quality objective for selenium. Unfortunately, supporting rationale for the use of this guideline in Christal and Lightning Creeks was not provided. The current CWQG-PAL is 0.001 mg/L. The upper limit (95 percentile) of background concentration meets the CWQG-PAL objective. While the Mayo Designated Office recognizes that this objective is outdated and may be overly conservative, the Proponent has provided no site-specific evidence (e.g. reproductive tissue analysis) to provide an understanding of the background selenium concentrations in reproductive tissues of fish in this system.

[86] NND comment submission May 9, 2014 YOR 2013-0161-106-2.
[87] Environment Canada comment submission YOR 2013-0161-105-1.
[88] Christal Creek and Lightning Creek Mass Load Model Report YOR 2013-0161-146-1 to 150-1.
[89] Environment Canada comment submission YOR 2013-0161-105-1

The selenium concentration of 0.001 mg/L adopted by the CCME was originally introduced by the International Joint Commission (IJC) in 1981 to protect aquatic life in the Great Lakes of Canada and the United States. The CCME guideline is based on field studies at Belews Lake, North Carolina, where waterborne selenium concentrations from 0.005 to 0.01 mg/L were associated with food web contamination causing acute lethality to predatory fish (IJC 1981; as cited in CCREM 1987). Recent literature suggests that fish accumulation rates of selenium in river systems are less than those found in lake systems (Orr et al., 2006, 2012). The selenium concentration in reproductive tissue (egg/ovary) provides the most direct way of measuring the potential for adverse effects of selenium. Without an understanding of the baseline concentrations of selenium in reproductive tissues of fish in Christal Creek and a supporting bioaccumulation model, the potential effects of selenium in the system cannot be accurately predicted. However, the Project is predicted to result in selenium concentrations in the water column of around 0.002 mg/L. At these concentrations, adverse effects are not expected in the near term, but additional baseline sampling is necessary to predict the long-term effects.

5.2.5.2 Lightning Creek

Predicted contaminant concentrations at water quality station KV-81 in Lightning Creek are expected to remain below the SSWQOs in that system during discharge at both the EQS and the expected performance of the proposed water treatment plant for all contaminants except cadmium. The maximum concentrations of cadmium are predicted to slightly exceed the 95th percentile of background in two out of the four scenarios modelled (exceedances are likely within margins of error). Concentrations remain below the CWQG–PAL acute toxicity threshold.

The same concerns apply to Lightning Creek as Christal Creek regarding the derivation of SSWQOs for contaminants elevated above CWQG-PAL. However, water quality in Lightning Creek is considerably better than that in Christal Creek and discharge to this system is also lower. Derivation of SSWQOs for contaminants elevated in background based on the principle of maintaining the typical water quality would allow for a better understanding of the potential effects. It appears that zinc and cadmium are the only contaminants that are predicted to approach the 95th percentile of background concentrations when modelled at discharge concentrations at the proposed EQS.

As with Christal Creek, uncertainty exists with predictions of groundwater flows in the area. This is particularly important during the closure period as the groundwater divide, as suggested by EC,[90] is not well defined or understood. In terms of effects, the highest predicted concentrations of contaminants occur in 2020 during peak de-watering of the mine workings. Therefore, contaminant loadings from groundwater flows during closure are predicted to be less than during the operational period. However, water quality objectives during closure will likely reflect improved water quality in the system as a result of district wide closure efforts. Predictions of effects will necessarily need to be based on these future water quality goals and updated water quality objectives.

5.2.6 Relevant Proponent Commitments

These identified commitments mitigate specific adverse effects of the Project and are instrumental in the Designated Office's significance determination. These commitments demonstrate the Proponent's efforts under Section 42(1) of YESAA to consider adverse project effects and mitigation measures.

- Installation and operation of a water treatment plant
- In-situ treatment of flooded underground at closure

[90] Environment Canada comment submission YOR 2013-0161-105-1.

- Installation of a bioreactor at closure to treat seepage and adit discharge
- Compliance monitoring of effluent discharge
- Monitoring of contaminant concentrations in the receiving environment
- Environmental effects monitoring to detect changes in aquatic resources in the receiving environment
- Regular toxicity testing of mine effluent

5.2.7 Relevant Legislation

The Mayo Designated Office considered the following legislative requirements because of the direct relevance of this legislation to aquatic life.

- *Waters Act*
- *Quartz Mining Act*
- *Fisheries Act*
    - *Metal Mining Effluent Regulations*

5.2.8 Significance Determination

When evaluating the significance of adverse effects to aquatic resources, the Mayo Designated Office considered the project design and Proponent's commitments, non-discretionary legislation and comments received during the assessment. The Project is likely to result in significant adverse effects to aquatic resources and additional mitigations are necessary to reduce, eliminate or control those effects.

When evaluating effects of the Project to aquatic resources, the Mayo Designated Office considered whether predicted effluent quality was likely to add additional contaminant loads where no assimilative capacity exits in the receiving environment. Considering the desire to protect and restore water quality in the streams in this system, the SSWQOs proposed by the Proponent for As, Cd, Pb, Ag, Se and Zn at station KV-6, and Cd, Pb, Ag, Se and Zn at station KV-7, are not considered appropriate to gauge effects. This is also true for As, Cd, Cu, Pb, Ag, Se and Zn at station KV-81 in Lightning Creek.

The use of the 95th percentile of background concentration as the objective for contaminants that are elevated above water quality guidelines for the protection of aquatic life in background waters is inappropriate. As discussed in Section 5.2.3, many contaminants are already elevated above water quality guidelines for the protection of aquatic life in Christal and Lightning Creeks. Any additional loadings of contaminants will result in significant adverse effects to aquatic resources. The use of the 95th percentile of background concentrations is an inappropriate gauge of effects because release of effluent can result in water quality that is reduced to the upper end of contaminant loadings in an already polluted system with no corrective action required. Although the Proponent cannot directly control the loadings from historic liabilities, they are in control of the additional loadings from the Flame and Moth Mine.

A comprehensive closure plan is currently under development for the Keno Hill Silver District. The water quality in both Christal and Lightning Creeks is expected to improve as a result of closure activities. As noted by NND, one of the primary goals of the district wide closure plan is to restore water quality to the extent possible in affected watercourses including Christal and Lightning Creeks. Although improvements to water quality are not expected as a result of closure activities until roughly 2019, near the end of the operational period of the Flame and Moth Mine, the potential additional mass loads of contaminants from

the Flame and Moth Mine would further impair the aquatic resources of Christal Creek in particular, making restoration more difficult.

5.2.8.1 Christal Creek

The spatial extent of the current effects to aquatic resources is thought to potentially extend to the South McQuesten River as a result of loadings from the Christal Creek drainage.[91] Therefore, the effects of additional contaminant loadings to Christal Creek may also affect the South McQuesten River to some extent. The temporal scope of these effects varies by contaminant. For most contaminants, additional loadings are primarily an issue during the operational period. For selenium, concentrations will remain elevated above historic background levels for the entire duration of modelling (~2030) in Christal Creek.

5.2.8.2 Lightning Creek

The elevated contaminant concentrations in background waters in Lightning Creek have not produced measurable effects to aquatic resources in that system to date. However, the addition of contaminant loadings to this system above water quality guidelines for protection of aquatic life or typical concentrations in background is considered to result in significant adverse effects to aquatic resources. The Flame and Moth Mine will have far less of an impact on Lightning Creek than on Christal Creek. However, the Project may result in the release of additional loadings of Zinc and Cadmium in excess of the typical background concentrations. These loadings and associated effects cannot be managed effectively in the absence of appropriate SSWQOs for these contaminants.

5.2.8.3 Consideration of the Proponent's Adaptive Management Plan (AMP)

As a means of dealing with the inherent uncertainty with mine development, the Proponent has developed an Adaptive Management Plan[92] to manage and mitigate, among other things, risks to aquatic resources. The Proponent's Adaptive Management Plan relies on exceedance of water quality objectives in the receiving environment as a trigger for further investigation. Therefore, additional excess mass loads of many contaminants can be released to the receiving environment with no corrective action taken by the Proponent as long as they remain at or below the 95th percentile of background concentrations. In addition, the wording of the narrative trigger under event 12 of the AMP is ambiguous:

"Receiving environment water quality objectives are exceeded, and do not have a history of exceedance."

The qualifying statement, "*and do not have a history of exceedance*" seems to preclude corrective action for those contaminants that may most require corrective action. Event 12 of the AMP also includes a limiting statement in that the only indicators are licenced discharge parameters. This would exclude corrective action for sulphate, the nitrate species and selenium. The thresholds for corrective actions also include ambiguous wording:

"Exceedance of water quality objective at a receiving environment monitoring station, no previous trend of exceedance"

It is unclear what is meant by "*no previous trend of exceedance*" and how this would guide corrective action. As currently written, the AMP is inadequate to reduce, eliminate or control the significant adverse effects of the Project to aquatic resources. The AMP is currently based on inappropriate SSWQOs for some contaminants and does not include trigger points for some COPCs in the receiving environment.

[91] 2012 Long-Term Aquatic Monitoring Program (Minnow 2014) YOR 2013-0161-118-1 p. 23.
[92] Adaptive Management Plan AKHM YOR 2013-0161-041-1.

5.2.8.4 Proposed Effluent Quality Standards (EQS)

The proposed EQS will result in excessive contaminant loads to Christal Creek and lightning creeks and significant adverse effects to aquatic resources are expected. EQS should be set at concentrations that will not exceed appropriate SSWQOs in the receiving environment under the most conservative circumstances (i.e. low flow conditions). Currently, discharge at the proposed EQS would result in contaminant loads to Christal Creek that are near the 95th percentile of background. Some contingency should be built into EQS to allow for reasonable operational flexibility as long as it does not result in exceedance of appropriate SSWQOs. However, it is clear that the current EQS are not based on appropriate SSWQOs in the receiving environment.

5.2.8.5 Conclusions

The proposed EQS will result in the release of excess contaminant loadings to the receiving environment for many contaminants during the operational period of the Project. The proposed SSWQOs for As, Cd, Pb, Ag, Se and Zn at station KV-6, and Cd, Pb, Ag, Se and Zn at station KV-7, are not considered appropriate to gauge effects. This is also true of the SSWQOs for As, Cd, Cu, Pb, Ag, Se and Zn at station KV-81 in Lightning Creek. Finally, uncertainty in the baseline groundwater conditions makes predictions of conditions at closure and effectiveness of closure mitigations (i.e. bioreactor) uncertain.

The Mayo Designated Office has determined that the Project will have significant adverse environmental project effects on aquatic resources. These effects can be eliminated, reduced or controlled by the application of the following terms and conditions:

1. The Proponent shall revise their site specific water quality objectives (SSWQOs) for As, Cd, Pb, Ag and Zn at station KV-6; for Cd, Pb, Ag and Zn at station KV-7; and for As, Cd, Cu, Pb, Ag and Zn at KV-81 to reflect the typical background concentration (e.g. mean + two standard deviations) at those stations rather than the upper limit of background. The Proponent shall employ the Canadian Council of Ministers of the Environment (CCME 2003) guidelines for the derivation of site specific water quality objectives in the development of SSWQOs with the intent of reducing, to the extent practicable, the release of contaminants at concentrations in excess of the typical water quality for those stations (i.e. non-degradation).
2. The Proponent shall revise their proposed Effluent Quality Standards (EQS) for water quality station KV-104 to reflect the revised SSWQOs developed in mitigation number one (1). The Proponent shall demonstrate to regulators, by way of updated modelling, that the revised EQS will not produce exceedances of the updated SSWQOs in the receiving environment. In addition, the revised EQS shall include standards for ammonia, nitrate, nitrite and selenium.
3. The Proponent shall provide regulators with supporting rationale for the use of the draft United States Environmental Protection Agency water quality guideline for selenium as opposed to the current Canadian Water Quality Guidelines for the Protection of Aquatic Life. The supporting rationale should include a site-specific discussion of selenium concentrations in reproductive tissues of fish in Christal and Lightning Creeks and how these concentrations are related to selenium concentrations in the water.
4. All water discharged from mine de-watering shall be treated through the proposed water treatment plant prior to discharge to the receiving environment at station KV-104.
5. Any future discharge from the Mill Pond shall be treated through the proposed water treatment plant prior to release.

Rationale: Additional contaminant loadings to Christal Creek in excess of water quality guidelines and/or typical background concentrations are not protective of aquatic life and should not be permitted. It seems inappropriate for the Proponent to be permitted to discharge effluent from the Mill Pond with much higher contaminant concentrations than necessary if a treatment plant exists at the site.

6. In support of the licencing process, the Proponent shall provide regulators with the results of a sensitivity analysis of metal attenuation rates that are lower than predicted by column tests. This analysis shall include a model run assuming no attenuation of metals.
7. In support of the licencing process, the Proponent shall provide regulators with the results of additional depth discrete groundwater monitoring at depths equal to the proposed mine workings to allow for an understanding of the potentiometric groundwater surface to confirm groundwater inflows to the underground workings and the potential for adit discharge at closure. If adit discharge is predicted or cannot be ruled out post closure, the Proponent shall maintain active water treatment on site until the effectiveness of the passive bioreactor can be demonstrated to achieve necessary protection of aquatic life.
8. In support of the licencing process, the Proponent shall provide regulators with the results of additional depth discrete groundwater monitoring with sufficient coverage to determine the groundwater flow in the area of the Flame and Moth Mine and define any groundwater divides that exist.
9. In support of the licencing process, the Proponent shall provide regulators with the results of a sensitivity analysis of their water balance illustrating the effects of estimated maximum and minimum flows (dry and wet years) for all inflows and outflows of the water balance model.
10. In support of the licencing process, the Proponent shall provide regulators with updated geochemical analysis comparing both non-mineralized and mineralized zones to provide certainty that all of potential contaminants of concern have been identified.
11. The Proponent shall update their Adaptive Management Plan to include reference to the Flame and Moth Mine and corrective actions specific to the Flame and Moth Mine where applicable.
12. The Proponent shall update events 12 and 13 of their Adaptive Management Plan to trigger investigations of sources of contaminants that show trends of increasing contaminant loads before they exceed the water quality objectives to reduce the potential of exceedances and associated significant adverse effects.
13. In support of the licencing process, the Proponent shall provide regulators with an updated Adaptive Management Plan outlining actions to be taken in the event that potentially acid producing or metal leaching waste rock is left on surface during such events as a temporary shutdown of operations.

5.3 Project Effects – Contaminant release from Dry Stacked Tailings Storage Facility (DSTF)

To accommodate the production of additional tailings from the Flame and Moth Mine mixed with tailings from the other licenced mines in the district including contingency for unexpected storage requirements, the Proponent is proposing an expansion to their existing DSTF located beside the existing Mill. Details of

the DSTF are summarized in Section 2.4.5, and detailed in the project proposal and responses to information requests.[93]

The existing and proposed DSTF exist within the Christal Creek drainage and effects from these facilities if they occur are expected primarily to Christal Creek and downstream aquatic resources. The primary concern from this facility to aquatic resources is from both a geotechnical and geochemical perspective. A geotechnical failure of the facility, particularly during closure, may cause the release of tailings and contaminated run-off to the receiving environment. In addition, a geochemical failure, a failure of the DSTF to meet performance thresholds, may result in such things as surface water infiltration and the release of contaminated seepage.

Additional mitigation measures are required to ensure geotechnical and geochemical integrity of the DSTF and prevent significant adverse effects to aquatic resources throughout the design life of the facility. The rationale supporting this conclusion is provided in the following sections.

5.3.1 Geotechnical Integrity

The primary concern raised by all parties during the review of the proposed DSTF was the lack of foundation characterization work to support the assumptions in the engineering analysis provided in support of the proposal. The design of the current facility was based on foundation conditions characterized during the development of the existing DSTF. Some shallow test-pitting work was completed in the footprint of the proposed DSTF expansion area, but this did not allow for a thorough material characterization at depth or an understanding of issues for stability such as ground temperature and groundwater depth. In addition, the bedrock contact points from exploration drilling confirmed greater overburden depths in the area of the proposed DSTF expansion than those under the existing facility. Although the Proponent had committed to completing confirmatory foundation characterization prior to construction, this uncertainty left reviewers with many unanswered questions.

As the Proponent would not provide additional foundation characterization within the footprint of the expanded DSTF, they provided some additional information that was satisfactory, but not preferred, to allow for the assessment of this component of the Project to proceed. The Mayo Designated Office was of the opinion that qualified geotechnical engineers informed by adequate foundation investigation and materials characterization could design an appropriate and stable DSTF at the site if provided with adequate baseline characterization. The Proponent, throughout the Adequacy Review process, emphasized this point. However, this approach could lead to substantive changes to the design parameters of the proposed DSTF and result in unanticipated effects as a result. In response to this concern, the Proponent provided some maximum parameters around the design criteria to allow for better understanding of potential effects.

During the review, the Mayo Designated Office retained Terraprobe Inc. to review the geotechnical aspects of the Proposal.[94]Terraprobe raised concern throughout the review regarding the lack of baseline data and requested supporting evidence and justification for assumptions in the preliminary design and geotechnical analysis of the expanded DSTF. Most of these concerns could have been addressed through adequate baseline sampling and materials analysis and so became the root of information requests to the Proponent. Following several meetings with the Proponent, it was clear that they were not

[93] Appendix D Project proposal YOR 2013-0161-008-1;
Response to Information Request Adequacy Review YOR 2013-0161-040-1; and
Response to Information Request #2 Adequacy Review YOR 2013-0161-062-1 to 070-1.
[94] Terraprobe Inc. Memo to YESAB YOR 2013-0161-055-1; 079-1.

willing to provide the preliminary borehole analysis suggested by Terraprobe and other reviewers, but noted that the work would be done prior to the final design and development of the facility. Terraprobe concluded that as long as foundation conditions prove to be as predicted, the stability analysis of the facility and factors of safety used are appropriate.

There are numerous potential failure modes that could affect the proposed DSTF including differential settlement, deep-seated instability in the foundation materials, increased pore water pressure, etc. The results of these failures could vary considerably in magnitude and extent of potential effects. At worst, a complete loss of stability of the DSTF could expose considerable area of tailings to erosion and surface run off depositing tailings and metals in the receiving environment. Containment and cleanup of the tailings would be an expensive and time-consuming matter.

5.3.2 Geochemical Integrity

Dry stacked tailings disposal relies on the long-term storage of filtered tailings (to reduce moisture content) under conditions that prevent significant water infiltration and subsequent contaminant mobilization to the receiving environment. The geochemical integrity of a DSTF is dependent on the prevention or near complete reduction of infiltration from surface water through design parameters including material compaction, covers, diversion ditches and drains. As with any permanent tailings storage facility, DSTFs require maintenance and monitoring in perpetuity to confirm adequate performance (Davies 2011).

As part of the preliminary design, presented in Appendix D[95] of the project proposal, the Proponent did not include a geosynthetic liner as a design mitigation to contain and direct any future seepage water from the facility to a collection point for treatment. The Proponent noted that a liner was not required based on their operational experience from the existing facility and the lack of seepage over the past three years from this facility. The Proponent did include a 'drainage blanket' to reduce potential pore water pressure build up and direct water away from the base of the facility for reasons of geotechnical stability.

During the assessment, several reviewers expressed concern with the lack of a liner under the proposed facility. In their comment submission, EC noted that the absence of a geosynthetic liner would preclude the Proponent from demonstrating compliance with the provisions of the *Fisheries Act.* [96] Following these concerns, the Proponent modified their proposal to include a geosynthetic liner, seepage collection and treatment as contingency measures.

The combination of a cover on the DSTF, diversion ditches around the DSTF, and seepage collection and treatment will reduce the effects of the DSTF to aquatic resources by limiting movement of contaminants from the DSTF to the receiving environment. This facility is designed in perpetuity and will require regular monitoring, inspection and maintenance forever to ensure that the facility is functioning as designed.

5.3.3 Relevant Proponent Commitments

The Proponent has proposed numerous design criteria aimed at reducing the probability of a geotechnical and/or geochemical failure of the DSTF. These design criteria are detailed in the Proposal and numerous supporting documents referenced previously and are not re-produced here as they are considered Project design features rather than specific Proponent mitigations. The one clear commitment from the Proponent

[95] Appendix D Project proposal YOR 2013-0161-008-1.
[96] Environment Canada comment submission YOR 2013-0161-105-1.

was for the construction of a geosynthetic liner under the proposed facility to contain and direct seepage for treatment before release.

5.3.4 Relevant Legislation

The Mayo Designated Office considered the following legislative requirements because of the direct relevance of this legislation to aquatic life.

- *Waters Act*
- *Quartz Mining Act*
- *Fisheries Act*
    - *Metal Mining Effluent Regulations*

5.3.5 Significance Determination

When evaluating the significance of adverse effects to aquatic resources, the Mayo Designated Office considered the project design and Proponent commitments, non-discretionary legislation and comments received during the assessment. The Project is likely to result in significant adverse effects to aquatic resources and additional mitigations are necessary to reduce, eliminate or control those effects.

The effects of a geotechnical or geochemical failure of the DSTF are considered significant as they would result in the release of contaminants to the receiving environment. Release of contaminated seepage to Christal Creek may contribute additional contaminants for which the assimilative capacity has been exhausted by previous activities. The focus of this significance determination is on the Proponent's ability to demonstrate geotechnical and geochemical integrity of the facility in perpetuity as a means of adequately reducing the probability of future failure as the risk of failure cannot be eliminated.

5.3.5.1 Geotechnical Stability

As noted previously, third party review of the Proponent's preliminary DSTF design was hampered by a lack of baseline data regarding the foundation conditions under the proposed facility. This lack of supporting baseline information left reviewers to focus on the adequacy of analysis based on assumptions of foundation conditions alone. Many of the questions posed by reviewers during the assessment required confirmation of foundation conditions to be answered effectively. The Proponent did not provide this information.

Although this assessment took the approach of asking the Proponent for some additional analysis in an attempt to define the level of uncertainty inherent with the absence of baseline data, this approach is not considered appropriate for future assessments as numerous uncertainties remain. We feel that third party review of preliminary analysis of foundation conditions extrapolated from actual subsurface characterization is invaluable for ensuring appropriate design considerations are incorporated for long-term stability. Results of preliminary subsurface sampling must form part of the Proponent's submission to regulators to ensure adequate third party review occurs.

5.3.5.2 Geochemical Stability

The DSTF contains numerous design features that will reduce exposure of tailings to water. The final performance of the facility is predicted to be adequate to reduce contamination from the facility. However, considerable uncertainty remains regarding the actual effectiveness of the final cover and diversion drains at preventing infiltration of surface waters to the DSTF and associated seepage. This was a point raised by reviewers throughout the assessment of this facility. Following concern from reviewers, the Proponent

committed to the installation of a geosynthetic liner to contain any future seepage that may occur and to address some of the inherent uncertainty. An important step to ensuring long-term performance of the DSTF is adequate monitoring including monitoring for potential pore-water and future seepage.

5.3.5.3 Consideration of Monitoring and Maintenance and Adaptive Management Plans

Mitigations cannot eliminate the risk of a failure of the DSTF, but can significantly reduce that risk. In support of their proposal, the Proponent provided their "Operation, Maintenance and Surveillance Manual Dry Stack Tailings Facility" and their "Adaptive Management Plan Keno Hill Silver District Mining Operation".[97] These plans detail both the operational procedures for the development of the DSTF and the ongoing maintenance and monitoring to ensure integrity of the facility. This plan includes numerous measures aimed at reducing the probability of a geotechnical or geochemical failure of the facility and the AMP provides some general guidelines for corrective action if necessary.

Overall, these plans are considered adequate to reduce the risks of a future failure as long as they are informed by adequate monitoring. Some of the procedures within this document are of particular importance to informing future decision making, including ongoing monitoring of stability indicators and monitoring wells located within the DSTF.

5.3.5.4 Conclusions

Additional mitigations are necessary to ensure the installation of key monitoring equipment to inform the AMP and future maintenance works, along with the implementation of key mitigations as contingency measures to deal with uncertainty. These mitigations will further reduce the probability of significant adverse effects from the DSTF to aquatic resources.

The Mayo Designated Office has determined that the Project will have significant adverse environmental project effects on aquatic resources. These effects can be eliminated, reduced or controlled by the application of the following terms and conditions:

14. In support of the licencing process, the Proponent shall provide regulators with the results of borehole logs from subsurface investigations in the footprint of the proposed dry stacked tailings storage (DSTF) expansion area. These subsurface investigations should be sufficient in number to provide representative sampling from across the footprint of the proposed DSTF expansion to support the conclusions of the DSTF design and stability analysis. This subsurface monitoring shall include the installation of stability monitoring equipment, ground temperature cables and groundwater monitoring wells to build adequate baseline data prior to construction. These monitoring systems shall be monitored throughout the design life of the facility.
15. In the event that water is observed in monitoring well BH39 in the existing dry stacked tailing storage facility, this water shall be collected and sent for full metals analysis to confirm its origin. The results of this analysis shall be reported to regulators in a timely manner.

    Rationale: This mitigation is intended to inform the ongoing expansion of the DSTF to ensure that all pertinent information is available throughout the development of the new facility.

[97] DSTF OM&S Manual YOR 2013-0161-067-1.

16. The Proponent shall install a geosynthetic liner beneath the expanded DSTF to contain and capture any seepage that may occur from the facility in future and allow for treatment prior to release to the receiving environment.
17. In support of the licencing process, the Proponent shall provide regulators with a discussion and analysis of the potential effects of blasting at the Flame and Moth Mine to the integrity of long-term monitoring wells and instrumentation in the area of the Mill and DSTF.

5.4 Residual Effects

Residual effects of the Project to aquatic resources will include the release of water to Christal and Lightning Creeks contaminated with dissolved metals. As discussed throughout this report, additional loadings continue to enter these watercourses as a result of contaminant sources from historical mining and milling operations in the district. Licences are in place for the release of metal contaminants from the Bellekeno, Lucky Queen and Onek mines as well. In addition, placer gold mining on Lightning Creek and its tributaries is contributing to reduced water quality through stream alterations and the release of sediments. Sediment loads from placer mining on Lightning Creek may be driving total metal concentrations in the system.

5.5 Cumulative Effects

The Proponent's mass load model included inputs from other licenced sources and consideration of historic liabilities and the future district closure plan. This modelling was a cumulative effects assessment in that the project effects were evaluated in combination with other contaminant sources in the area.

Cumulatively the loadings from historic mining contamination along with existing licenced loads are producing significant adverse effects to aquatic resources in both Christal and Lightning Creeks as water quality guidelines for the protection of aquatic life have been exceeded in both systems. Mitigations to deal with these historic loadings are coming in the form of a district-wide closure plan currently in the final stages of development. Implementation of this final closure plan for the district is expected to produce significant improvements for aquatic resources over time as contaminant loads are reduced.

The Flame and Moth Mine will contribute cumulative loadings to both Christal and Lightning Creek. The re-development of SSWQOs based on non-degradation as prescribed by mitigations in Section 5.2.8 will effectively prevent the Flame and Moth Mine from contributing to significant cumulative effects to aquatic resources. The mitigations prescribed in Section 5.3.5 in combination with the project design will effectively reduce the probability of a geochemical or geotechnical failure of the DSTF and associated significant adverse effects. This will effectively prevent the Project from contributing to additional cumulative effects.

6.0 HUMAN HEALTH

6.1 Overview

This Section describes effects to employee and public health pertaining to mine operations at Flame and Moth, as well as use and expansion of the Dry Stack Tailings Facility and mill site infrastructure. The Designated Office has considered the following project activities to have potential to affect human health:

- Mine operations, including ore extraction and storage, transportation, water management and treatment, and storage of explosives; and

- Ore processing and tailings facilities, including operation of an expanded DSTF, mill and crusher, materials handling.

The Designated Office has determined that the key potential effects to human health are from effects to air quality and domestic water supply.

6.2 Project effect – Effects to air quality

Air quality is a value of importance to human health, to aesthetic quality of the region, and to environmental quality, (e.g. potential for bioaccumulation due to settling of toxic dust). The following discussion outlines how air quality may be adversely affected by project activities generally, but the determination of significance in this section is limited to effects to human health and environmental health only. Effects to visual amenity are assessed in Section 7.0 Visual and Auditory Amenity.

6.2.1 Overview

The proposed project will generate atmospheric emissions via several pathways that will adversely affect air quality, and subsequently, human health. Sources of atmospheric emissions include fossil fuel combustion to a smaller extent, as well as both fugitive and point sources of airborne particles from mine development and production activities. Sources of airborne particles, measured as TSP, include but are not limited to: blasting; stripping; crushing, processing, and screening ore; stockpiling materials (waste rock, overburden, ore, tailings, etc.), the operation of a Dry Stack Tailings Facility; transportation (e.g. use of unpaved haul roads, increased traffic); and materials handling generally (e.g. loading and unloading trucks).

The Designated Office has evaluated the cumulative effects from current and proposed activities to Air Quality. Of particular importance to this cumulative effect is the ongoing milling of ore at the District Mill and the expansion of the DSTF.

Initially, the Proponent provided a qualitative effects assessment of the potential for air quality to be impacted, based on TSP data collected from August 2012 to April 2014. However, their analysis was limited to the potential for the Flame and Moth activities to contribute to increased sources of fugitive dust emissions from those generated by currently permitted activities, and whether these sources would result in exceedances of the Yukon Ambient Air Quality Standard of 120 µg/m^3 TSP. To date, the TSP data collected from 2012 to August 2013 during a period of active milling indicates that the TSP levels have not exceeded the 120 µg/m^3 limit at the monitoring stations (Figure 8). Similarly, data collected in conjunction with a Health Impact Assessment over a period of 7 days in Keno City, a sensitive receptor site, indicated that TSP levels also did not exceed the threshold of 120 µg/m3. These values are typically measured as a 24-hour average, as this is the period over which TSP concentrations become meaningful to assessing the potential health risks. Many of the comments during the Keno Engagement Forum and/or submitted to the YOR during the SVI period indicated a concern for air quality based on observations of visible dust. Therefore, the Designated Office would like to highlight for the benefit of those individuals the relevance of the 24-hour sampling period. There may be occasions when there is significant visible dust in the atmosphere, but which is reduced to very low levels within the 24-hour sampling period, resulting in a 24-hour average is still below the relevant threshold.

Regardless of the measured TSP levels to date, the currently permitted DSTF has not reached operational capacity, so the full extent of potential effects from this activity may not be realized. YG Environment[98] noted that initial modelling completed in 2010 related only to dust blowing off the DSTF,

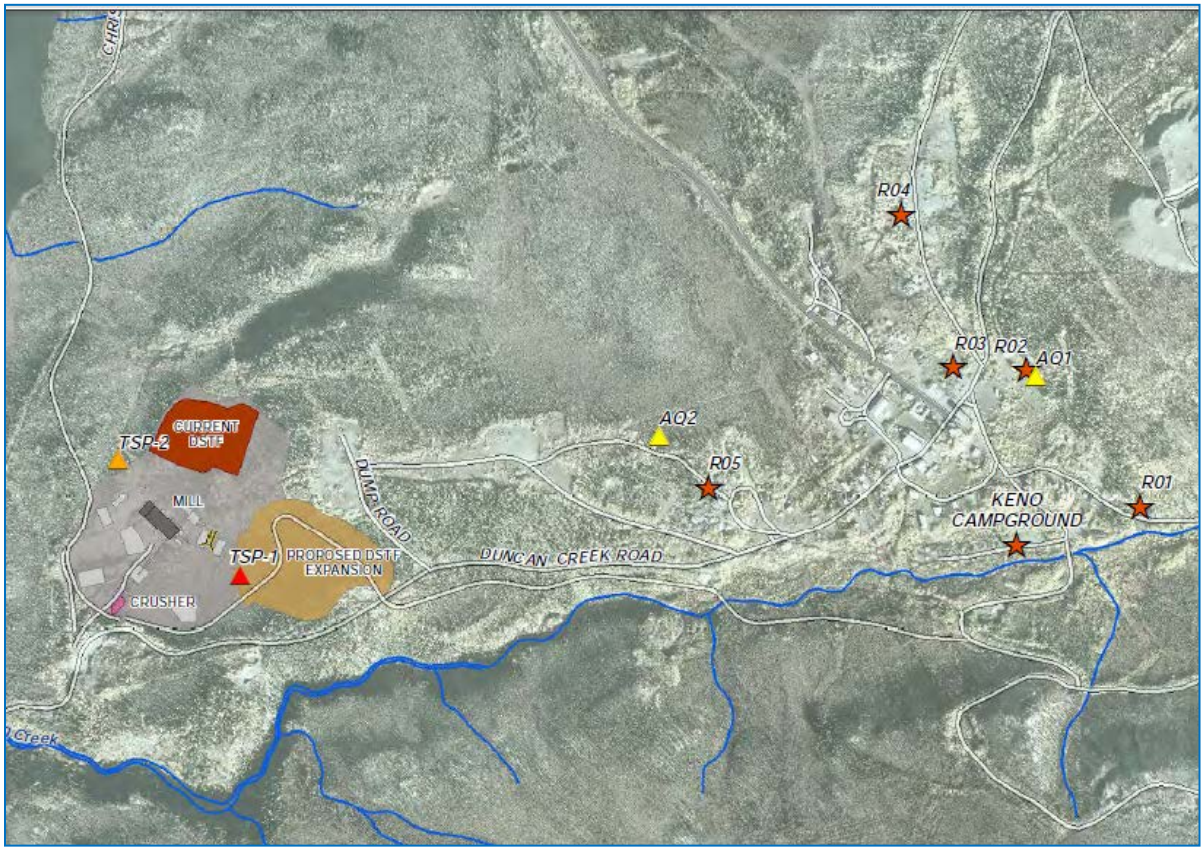
[98]Government of Yukon - Environment, Comment Submission; YOR 2013-0161-090-1

and for the exposed source area of the dust to be 5000 square meters, which has not been maintained. As such, Environment Yukon identified a number of reasons why the dust modelling to date was inadequate and required new modeling to provide a better basis for understanding potential effects of the project (and existing/current impacts). Similarly, YG Health and Social Services echoed Environment's concerns, and suggested that the composition of the TSP that is comprised of PM10 and PM2.5 is more important to the understanding of potential effects related to TSP. As well the chemical composition of the TSP needs to be assessed, for which exceedances to cadmium, lead and manganese based on the Ontario guidelines, had been observed in 3 – 8% of all samples. These concerns prompted the Designated Office to request an updated dust model from the Proponent, particularly given the DSTF expansion, and retained a technical consultant to assist in the review of this data.[99]

The proceeding assessment considers the potential for the Project to affect human health via the following:

- Increases to Total Suspended Particulate (TSP); and,
- Exceedances of air quality criteria for metal concentrations.

The Designated Office has determined that the Project, upon the implementation of the Proponents commitments, will result in significant adverse effects to human health, specifically to the health of workers on-site, but that these effects can be mitigated.



[99]EcoMetrix Dust Modelling YOR 2013-0161-166-1.

Figure 7: TSP-1 and TSP-2 Air Quality Monitoring Stations (existing and proposed).[100]

6.2.2 Effects Characterization

6.2.2.1 Total Suspended Particulate (TSP)

Total Suspended Particulate (TSP) and fine particulate matter (PM10 and PM2.5) are typically measured for the purpose of compliance monitoring in terms of mass and over a 24-hour sampling period. These criterion are used to determine the acceptability of emissions from proposed and existing development. Particulate matter is unique among atmospheric constituents in that it is not defined on the basis of its chemical composition. Therefore, it may include a broad range of chemical species (discussed below). The air quality standards for particulate matter are based on studies demonstrating adverse effects on cardio-respiratory health from inhalation, rather than effects related to chemical toxicity. Health effects from inhalation of TSP generally include a range of adverse health effects from general irritation of tissues to illness, disease and premature mortality.[101] The level of and/or composition of TSP that is PM10 and PM2.5 is of greater concern, as these constituents can penetrate more deeply into the lung tissue and therefore result in more damage.

The Proponent modeled three scenarios to estimate the potential adverse effects to air quality from mine operations. Scenario 1 included current operations of Bellekeno, with the additional mitigation that the crusher be enclosed, while Scenarios 2 and 3 represented future conditions. Scenario 2 involved concurrent operations of Flame and Moth Mine and Bellekeno Mine, while Scenario 3 involved concurrent operations of Flame and Moth Mine with Lucky Queen and Onek Mines. (The Proponent did not model all three mines operating concurrently, as this was not proposed.)

The results of the model suggest that in either of Scenario 2 or 3, the TSP, PM10 and PM2.5 concentrations will exceed the YAAQC on the Keno District Mill site in proximity to the DSTF and crusher, but not at the fence-line and/or at sensitive receptors in Keno City. Further, the spatial extent of the exceedances are expected to be less for the Flame and Moth operations than the current operations. The Designated Office agrees with the review and conclusion EcoMetrix Inc. that the Proponent's model assumptions and results do not under-predict the potential future concentrations of TSP, PM10 and PM2.5 at off-site receptor locations. However, while the YAAQC values off-site may be less than 120 µg/m^3 threshold, exceedances are noted on-site, which present a risk to workers' cardio-pulmonary health.

[100] AKHM Corp Dust Abatement and Monitoring Plan, June 2014. Attachment 9.YOR 2013-0161-130-1.
[101] Kampa, M., E. Castanas. 2007. Human Health Effects of Air Pollution. *Environmental Pollution* 151 (2008): 362-67.

6.2.2.2 Metal concentrations in TSP

The chemical composition of the TSP has implications for human health. The Project may contribute to increased metals in the TSP at the site and potentially beyond, via the increased volume of material processed at the site and the expansion of the DSTF. Further, the tailings associated with Flame and Moth ore are expected to be higher in manganese than those currently processed for Bellekeno, which could increase the potential for manganese to exceed thresholds derived in consideration of human health.

Air quality criteria for metals are not available in Yukon. However, the Proponent has collected metal speciation data for the Keno District Mill site, with a total of 39 samples from TSP-1 and 40 samples from TSP-2 during period of active milling from August 23, 2012 to October 27, 2013 (milling ceased August 28, 2013), and has analyzed these exceedances in comparison to the Ontario Ministry of Environment (OMOE) standards. Like TSP, exceedances of metal concentrations are also measured in $\mu g/m^3$. Short-term exceedances for three metals, cadmium (TSP-1 and TSP-2), lead (TSP-1 and TSP-2), and manganese (TSP-2), have been observed in connection with current activities.

Given the similarities in the Flame and Moth ore with Bellekeno Mine ore, contaminants of concern for TSP are likely to include cadmium, lead and manganese. While the lead and cadmium content will be lower in the Flame and Moth tailings, manganese content will increase in comparison to Bellekeno tailings (4.28% to 3.22% respectively). Therefore, as elevated concentrations of manganese have already been detected, this metal is likely to continue to present a risk for exceedances in the Ontario MOE air quality standards, with impacts to health. Flame and Moth tailings will contain a higher concentration of nickel and chromium than Bellekeno tailings.

The Ontario MOE air quality standards for cadmium, lead and manganeseare derived from studies of health effects for long-term exposure rates, and then converted to 24-hour average exposure values. For cadmium, the 24-hour exposure rate is 0.025µm/m3, with non-cancer kidney damage being the toxicological endpoint. For lead, increased blood lead levels in children forms the basis for the criteria (0.5 $\mu g/m^{3)}$, as children are the most sensitive to the neurotoxic effects of lead exposure (e.g. impacts to normal brain development). The most important health effects from manganese exposure include impacts to the human central nervous system, such as hand-eye coordination, as well as evidence of developmental neurotoxicity and concern that short-term exposures at critical early life stages could potentially result in subtle yet significant adverse neurological deficits with life-long implications (Jugloff, 2013). However, there is considerable variability in the criteria for manganese, for which a 24-average criteria is uncommon. The Ontario 24-hour AAQC of $0.4\mu g/m^3$is based on a long-term exposure rate of $0.1\mu g/m^3$. While this is higher than Health Canada's reference concentration of $0.05\mu g/m^3$, the reference concentration "*reflects a concentration to which the general population, including sensitive subgroups, can be exposed for a lifetime without appreciable harm*."[102] Health effects from nickel and chromium are similar to those of for lead and cadmium.

6.2.3 Relevant Proponent Commitments

In the Project Proposal, AKHM committed to:

- Not operating the expanded DSTF simultaneously with the operation of the current DSTF;
- Having completed the final reclamation of the current DSTF when the expanded DSTF becomes operational

[102]Health Canada, 2010.

In the Revised Dust Abatement and Monitoring Plan:

- Progressive reclamation of the current and expanded DSTF (such as placement of cover and revegetation);
- Enclosing the crusher and ventilated building (also a term and condition of their current license that has not yet been implemented);
- Regularly applying dust suppressant agents (such as calcium chloride or similar) to unpaved roads;
- Applying a dust suppressant agent (tackifier product) to exposed tailings surfaces prior to progressive reclamation;
- Implementing monitoring for PM10 in addition to TSP, at a frequency of 4 times per month, sampling events at least 4 days apart;
- Relocating air quality monitoring station TSP-1 from its location south-east of the current DSTF to the western limit of Keno City (near receptor R05);
- Implementing an additional air quality monitoring station at the eastern end of Keno City (near receptor R02);
- Continuing air quality monitoring at station TSP-2 which is the historic monitoring station located at the north-west fence line, west of the current DSTF and north of the crusher; and,
- Revising component 17 of the Adaptive Management Plan (AMP) to incorporate TSP data collected in Keno City as well as PM10 data collected at the three sampling sites, and evaluating monitoring results against triggers and thresholds determined during licensing process to identify requirements for additional mitigation.[103]

6.2.4 Significance determination

6.2.4.1 Total Suspended Particulate

In terms of TSP, the determination of significance is dependent upon the implementation of the above Proponent commitment. The Designated Office is of the view that the proposed Project will not result in significant adverse effects to human health if the above mitigations committed to by the Proponent are implemented. The model results indicate that the Flame and Moth Project can be undertaken in such a way that the TSP will be below the YAAQC at the fence-line. While there may be some short-term exceedances on-site and/or at specific locations, these exceedances are limited in both duration and spatial extent, and do not pose a significant health risk for the relevant measures of long-term exposure. Additional monitoring locations and specific monitoring for PM10 and PM2.5 will improve the understanding of this effect and, in conjunction with the Adaptive Management Plan, will mitigate the potential for significant adverse effects.

6.2.4.2 Metal concentrations in TSP

To understand the potential significance for effects from chemical toxicity associated with the Project, it is helpful to understand the existing effects, environmental correlations, and the uncertainties associated

[103]Component 17 of the AMP is currently initiated when there is an increasing trend of fugitive dust from the DSTF, based on three consecutive results of measured TSP above three standard deviations of the historical average.

with current monitoring for metals. First, the cadmium detection limit is higher than the standard for human health, making it not possible to know whether cadmium may have exceeded the Ontario MOE standards on more than the one documented occasion. Given the toxicity of cadmium and its presence in the environment of the Keno District, it will be important for the Proponent to continue monitoring this contaminant. Notwithstanding the uncertainty associated with cadmium concentrations, exceedances in lead and manganese are helpful for understanding the potential extent of the issue and correlating factors.

The exceedances in lead and manganese appear to correlate with windy conditions where maximum wind speeds were greater than 10 m/s.[104] In the case of lead, these events occurred in August, October, and June from 2012 to 2013, and therefore, appear to be short-term exceedances with no trend. In contrast, 4 out of 5 sampling events from March 23rd to April 7th, 2013 showed elevated concentrations of manganese, potentially representing a sustained increase, albeit for a relatively short period (~2 weeks). As well, the observed manganese exceedances were from samples taken only from TSP-2, adjacent to the DSTF, indicating that the DSTF was the most likely source of the metal, and that the spatial extent of this effect was limited (i.e. because it was not detected at TSP-1 during the same event). Based on the dust dispersion modeling, it is likely that future exceedances will be of short duration and limited extent.

Notwithstanding the above, in all exceedances to date, the corresponding TSP measured was below the YAAQC of 120 µm/m^3. This indicates that TSP cannot be used to predict or identify metal exceedances of air quality standards. Component 17 of the Adaptive Management Plan indicates that the Adaptive Management Plan will be implemented (to reduce TSP concentrations) where/if the TSP concentration exceeds three standard deviation from the historical average on three consecutive occasions. However, if this "historical average" is based on the long-term average including periods of active milling, two of the three events where the Ontario MOE standards were exceeded for lead would not have been identified, or the period where manganese was elevated. Therefore, it is possible that where/if manganese exceeds the Ontario MOE routinely, it would not be identified under Component 17 of the AMP, and thus, that the corrective action would not occur.

The following excerpt is taken from the EcoMetrix Inc. review, summarizing the effectiveness of the AMP trigger value to identify elevated metals in the air:

"Table 2 presents the average, the standard deviation and the average plus three standard deviations for TSP for the full dataset from August 23, 2012 to April 15, 2014. In addition, the same summary statistics are provided for the period of active milling at the site, August 23, 2012 to August 31, 2013, and the period where no milling was occurring at the site, September 21, 2013 to April 15, 2014. These three periods show similar average TSP concentrations, 9 µg/m^3, 11µg/$m^3$and 8 µg/m^3respectively. However, variability in the measured TSP data is greater during periods of active milling on the site. The higher variability is attributable to the occurrence of short-term events characterized by elevated TSP concentrations. The more recent period of inactivity has a standard deviation for TSP data of 3 µg/m^3,whereas the averaging periods that include active milling operations have standard deviations varying from 8 to 11 µg/m^3.

The average 24-hour TSP concentration plus 3 standard deviations at TSP-2 is 18 µg/m^3 for the recent period of inactivity between August 31, 2013 and April 4, 2014, when no milling or mining was occurring at the site. A threshold set at this level would have identified all but oneof the events (August 23, 2012) when TSP was below the YAAQC and either lead or manganese were above their Ontario AAQC. A

[104]EcoMetrix Inc. 2014.Review of AKHMs Effects Characterization for Dust for the Flame and Moth Project. YOR 2013-0161-166-1.

trigger value based on TSP concentrations during periods when active milling is not occurring would be more indicative of an excursion from background air quality and more predictive of on-site events that may have a potential to affect human health if they are not mitigated."

The Designated Office notes that the Proponent proposes to "revise component 17 of the Adaptive Management Plan (AMP) to incorporate TSP data collected in Keno City as well as PM10 data collected at the three sampling sites, and [evaluate] monitoring results against triggers and thresholds determined during licensing process to identify requirements for additional mitigation."[105] The Designated Office is of the view that this revision should include evaluating monitoring results against triggers and thresholds that include exceedances to metals, and that the AMP be initiated if metal concentrations are exceeded and demonstrate an increasing trend as such. Given the potential toxicity of the TSP and the magnitude of potential effects to human health if metal concentrations are routinely elevated and/or demonstrate sustained elevations, it may be important to define the "historical average" as the period without active milling, in order to initiate the AMP in respect of metals. Otherwise, an additional threshold or trigger in the AMP should be identified that addresses the potential for deteriorating air quality due to increasing and/or sustained exceedances of metal concentrations in the air.

Given the above, the Designated Office has determined that the Project will result in significant adverse effects to human health resulting from elevated metal concentrations in TSP, but that these effects can be mitigated with the addition of the following terms and conditions:

18. The Proponent shall implement the revised Dust Abatement and Monitoring Plan, which shall be reflected in an updated Monitoring and Surveillance Plan and Adaptive Management Plan.
19. The Proponent shall monitor levels of TSP, PM10, PM2.5 and metals speciation of TSP.
20. The Proponent shall revise the trigger values for initiating the Adaptive Management Plan to include consideration of the ability to identify events when metal levels in TSP on the site are elevated above health-based criteria. Use of a long-term historical average that is derived from periods without active milling may be an appropriate revision/method for the trigger value.

6.3 Project Effect – Affects to Drinking Water

6.3.1 Effects characterization

Keno City obtains its drinking water from the Firehall well, located near the centre of Keno. The proposed underground mining activities have the potential to contaminate groundwater resources that could include existing or future drinking water sources. A hydrogeological assessment completed by Interralogic Inc. inferred that groundwater in the Flame and Moth area generally moved in a northwest direction away from Keno City,[106] which suggests that groundwater from Flame and Moth will not likely affect the community's water supply and therefore, poses a low risk to health in this regard. The following is a summary of their interpretation of the groundwater elevation contours:

[105] Component 17 of the AMP is currently initiated when there is an increasing trend of fugitive dust from the DSTF, based on 3 consecutive results of measured TSP above 3 standard deviations of the historical average.

[106] Interralogic Inc. (2013). Appendix C - Flame and Moth Groundwater Evaluation YOR 2013-0161-007-1.

- Lightning Creek is a perennial stream that is in hydraulic communication with the groundwater system;
- South and west of Keno City, Lightning Creek is a losing stream that recharge groundwater;
- In the F&M area, it is uncertain if Lightning Creek is a gaining or losing stream;
- In the F&M area, groundwater flow is generally to the northwest towards Christal Lake or west towards Christal Creek: and
- Natural groundwater flow does not occur from the F&M area to the Keno City area.

However, comments from Environment Canada regarding the adequacy of the groundwater investigation provided in support of the Flame and Moth proposal indicate a significant concern with the groundwater wells and the information obtained and inferred from them. For example, Environment Canada states that because the monitoring wells were not completed, they are essentially "open bore holes" from which "depth discrete groundwater samples or hyrdraulic parameters are not available." [107]Further, EC notes that since none of the wells were completed to the proposed depth of mining activities, there is a lack of groundwater investigation from which to infer groundwater movement. Subsequently, there remains considerable uncertainty regarding likelihood or extent of potential effects to drinking water resources; effects cannot be confirmed or refuted based on the information to date.

6.3.2 Relevant Proponent Commitments:

- Groundwater Monitoring Plan (further characterization of the groundwater hydrology)
- Component 14 of the Adaptive Management Plan (AMP):
    - Event: A significant increasing trend is observed in groundwater near Keno City trends due to the Onek 990 mine.
    - Narrative Trigger: Total zinc, arsenic or cadmium significantly exceeds baseline measurements for a given monitoring well, or parameters listed in the Canadian Drinking Water Quality Guidelines are exceeded.
    - Indicators: Total zinc, arsenic, cadmium and parameters listed in the Canadian Drinking Water guidelines.
    - Thresholds: Total zinc, arsenic or cadmium exceeds the highest baseline measurement, and exceeds Canadian drinking water quality guidelines.
    - Monitoring locations: Groundwater monitoring wells (ON-MW-02, ON-MW-03, KC-MW-4, KV-84Nd).
    - Response:
        - Notification to the Water Inspector that the trigger has been triggered within three working days.
        - Increased sampling frequency may be required around the area of the exceedence, and will be implemented to help determine potential causes.
        - Quarterly results of the monitoring program will be communicated to the Yukon Government, Keno residents and the First Nation of Nacho Nyäk Dun. Any mitigation measures identified through the meetings with the stakeholders will inform the responses.
        - Investigation of the root cause of the exceedance.
        - If a root cause of exceedence can be readily identified and remedied, the remedy will be implemented in a timely manner, and the water inspector

[107] Environment Canada Comment Submission, YOR 2013-0161-105-1

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.

6.3.2 Significance Determination

The likelihood for effects to drinking water has not been determined due to imperfect groundwater data. The magnitude of the impact if it occurred is high given the potential for significant adverse effects to human health from a variety of contaminants. Depending on the cause of contamination and/or whether a cause can be determined, impacts to groundwater may be persistent and/or irreversible.

The above AMP event indicates that the source of the contamination must be known to be Onek 990, though the response to the event and triggers includes identifying the cause. Further, the narrative trigger indicates that exceedances to parameters other than zinc, arsenic and cadmium must have occurred to initiate a response. The Designated Office recognizes that the AMP event was generated in respect of the potential risk posed by Onek 990, and is aware that the Proponent had committed to treating water from the Onek 400 adit prior to commencing mining operations at Onek 990, which may be part of the rationale for the wording in the AMP. Regardless, the AMP event, trigger and responses have not been revised in respect of Flame and Moth, and the Designated Office is not confident that the current AMP triggers adequately mitigate this potential health risk, for which Flame and Moth would represent a cumulative effect.

Given the above, the Mayo Designated Office has determined that the Project will have significant adverse environmental and socio-economic project effects on human health resulting from impacts to drinking water. These effects can be eliminated, reduced or controlled by the application of the following terms and conditions:

21. The mitigations with respect to groundwater wells and monitoring identified in Section 5.0 Aquatic Resources must be implemented.
22. The AMP event shall be revised to include the potential for groundwater contamination from Flame and Moth, in addition to Onek 990, until such time as the groundwater flow can be adequately characterized to rule out this possibility. The wording of the AMP event shall be revised to allow for the AMP response to be initiated when there is uncertainty regarding the source of the contamination.
23. The narrative trigger in the AMP should capture increasing trends in concentrations of a wider range of contaminants that proactively mitigates for exceedances to the Canadian Drinking Water Quality guidelines before they occur.
24. In addition to notifying the Water Inspector, residents shall be immediately notified if there are exceedances to any parameters listed in the Canadian Drinking Water Quality Guidelines. Notification shall also include instructions on where to obtain water, if necessary, (e.g. identified back up well), and other information on health-related risks, measures, and actions being taken.
25. A suitable back up well shall be identified and monitored, in addition to other groundwater wells.

7.0 VISUAL AND AUDITORY AMENITY

7.1 Overview

Visual and auditory amenity, or aesthetics, is defined in this assessment as the aesthetic aspect of the viewscape and soundscape of Keno City. Effects to this valued component are evaluated as cumulative effects of the existing activities in the area with the addition of the Flame and Moth Mine and the ongoing milling and expanded tailings disposal at the District Mill. Our conclusions are based on both analytical predictions and comment submissions describing the experience and perception of effects from Keno City residents.

Effects to visual and auditory amenity that may result from the proposed Project include:

- Denuded viewscape, including from dust, traffic and mine infrastructure; and
- Increased noise.

The Designated Office has determined that the Project will result in significant adverse effects to auditory amenity that can be mitigated. The rationale for this determination is presented below.

7.2 Project Effect – Visual amenity impacts

7.2.1 Effects Characterization

7.2.1.1 Visible dust

The Project will result in the creation of visible dust, the component of particulate matter larger than 10 microns. Concerns about amenity from mine site dust often relate to the visibility of dust plumes and dust sources. Visible dust is a significant factor affecting the public perception of air quality and associated health risks.[108][109]Common and significant sources of visible dust often stem from blasting, materials handling (e.g. loading and unloading trucks at surface), and use of unpaved roads. Blasting, for example, often has a limited contribution to total dust emissions, (when measured over a 24-hour average), but produces a highly visible dust cloud that may be negatively perceived by neighbours. Similarly, unpaved haul roads create highly visible dust that may be relatively short-term and not contribute significantly to the 24-hour average or total emissions, but which is viewed unfavourably by the public.[110]Therefore, even though visible dust has a small overall contribution to dust emissions, visible dust has a significant impact on visual amenity making it an important consideration for managing dust emissions.[111]

Visual amenity effects can be subjective and are difficult to measure objectively.[112]However, the record of residents' concerns submitted during the assessment of Lucky Queen and Onek (2011-0315), which was

[108] Best Practice Environmental Management in Mining: Dust Control.(1998) Environment Australia; Department of Environment. Commonwealth of Australia. ISBN 0642 54570 7

[109]Ministry of Environment, New Zealand.2001. Good practice guide for assessing and managing environmental effects of dust emissions. Retrieved from: http://www.mfe.govt.nz/publications/air/dust-guide-sep01.pdf

[110] Best Practice Environmental Management in Mining: Dust Control.(1998) Environment Australia; Department of Environment. Commonwealth of Australia. ISBN 0642 54570 7

[111]Ministry of Environment, New Zealand.2001. Good practice guide for assessing and managing environmental effects of dust emissions. Retrieved from: http://www.mfe.govt.nz/publications/air/dust-guide-sep01.pdf

[112]Best Practice Environmental Management in Mining: Dust Control.(1998) Environment Australia; Department of Environment. Commonwealth of Australia. ISBN 0642 54570 7

informed by three years of experience with adjacent mining activity at Bellekeno and the Flame and Moth mill site (Keno District Mill), and during the SVI period for the proposed Project indicate a concern for air quality with frequent reference to dust. During the Keno City Engagement Forum, impacts to quality of life were the most cited concern by residents, including numerous references to air quality and dust."[113]Photos shared during the Engagement Forum showed visible dust in the atmosphere, as well as a clearly identifiable dust cloud over the region of the mill site taken from the town dump on one occasion. For Keno City, effects to the visual amenity of the area generally include reduced individual and community quality of life by affecting sense of place, undermining the use and enjoyment of the area for non-mining uses, and contributing to a perception of adverse air quality. (These effects are also discussed in Section 8.0 Community Wellbeing.)

Mitigation measures for reducing the effects to visual amenity from mining activities generally involve preventing the conditions that result in excessive dust, such as applying adequate moisture to dust sources during dry or windy conditions. Other mitigations emphasize the need for managing public expectations and perceptions by providing effective and timely information about activities that might generate more visible dust than usual.[114] For example, adequate public notice of specific events or increased activity can alert residents to the potential for more visible dust and its source, reducing residents' fears of the potential sources (i.e. tailings facility) and the negative impacts associated with unexpected events. Finally, other jurisdictions cite clear mechanisms for reporting and follow-up of conflicts as key mitigations necessary for reducing the effects of, or increasing social tolerance for, visible dust and its impacts to visual amenity.[115][116]

7.2.1.2 Traffic and mine infrastructure

Increases in traffic or visibility of mining infrastructure and activity may affect the visual amenity of Keno City for many of its residents and potentially for the general tourist populace. Although the mill site is not visible from the town, residents have indicated that there is still a strong visual presence from the Proponent's activities due to traffic, unsightly deterioration of roads, and viewscapes from other locales outside the main town site (e.g. from higher elevations). Residents have described some of the visual (as well as auditory) effects of mining traffic and infrastructure as contributing to the sense of living in a "mine site."[117]

An amendment to the existing Quartz Mining License is necessary for Flame and Moth to operate until 2021, with a mandatory 10-year post-operation period for reclamation and closure (ending in 2031). This amendment will also allow for an extension to the operational period of all four mines until 2021, thus increasing the duration of effects to visual amenity from traffic and mine infrastructure assessed for the Bellekeno and Lucky Queen and Onek mines.

The Proponent has indicated that their plans do not include operation of all four mines (Bellekeno, Lucky Queen, Onek, and Flame and Moth) concurrently. Instead, concurrent operations will include mining of the proposed Flame and Moth and Bellekeno Mine, or the proposed Flame and Moth mine and Lucky

[113]Keno City Engagement Forum Summary, YOR Document 2013-0161-094-1

[114] Best Practice Environmental Management in Mining: Dust Control.(1998) Environment Australia; Department of Environment. Commonwealth of Australia. ISBN 0642 54570 7

[115]*Ibid;*

[116]Ministry of Environment, New Zealand.2001. Good practice guide for assessing and managing environmental effects of dust emissions. Retrieved from: http://www.mfe.govt.nz/publications/air/dust-guide-sep01.pdf

[117]Keno City Engagement Forum, YOR 2013-0161-094-3

Queen and Onek mines. Traffic associated with Lucky Queen and Onek includes up to 27 roundtrips (6 light trucks and 21 heavy trucks, including ore trucks, buses, and heavy trucks) to the Keno District Mill along the Wernecke Road and planned north by-pass road. Traffic from Bellekeno Mine includes 62 total roundtrips between the Bellekeno Mine and the mill (22 light trucks and 40 heavy trucks, including buses, heavy trucks and ore trucks). To date, only operations at Bellekeno Mine have occurred. The proposed Project would result in the addition of approximately 28 roundtrips of 15-ton haul trucks along the 175 m haul road from the Flame and Moth portal to the mill site, and therefore, will not be readily visible from the town site of Keno City.

In addition to traffic, other potential impacts to visual amenity include mine infrastructure, such as mill and crusher and the expanded Dry Stack Tailings Facility. As the Project site is not directly visible to residents from the townsite of Keno City, this impact is more limited in extent. However, as noted above, viewscapes from higher elevations are impacted. As Keno City is surrounded by mountainous topography and is relatively close to treeline, recreational activities and tourist traffic often occurs at these higher elevations. For that reason, several residents have expressed concern that the proximity of the mill and tailings facility when viewed from higher elevations detracts from the viewscape of Keno City and also impacts the tourism value and potential of the region. This potential impact is best described and discussed in terms of impacts to community character or sense of place, and so further analysis is provided in Section 8.0, Community Wellbeing.

Finally, the proposed Project involves 24-hour operations at the site, including ore hauling, which would result in increased light pollution emanating from the site during darkness. For summer tourist traffic, this potential impact will not be significant due to the daylight, but may be experienced more negatively by the resident population during the rest of the year.

7.2.2 Relevant Proponent Commitments

Dust:

- Not operating the expanded DSTF simultaneously with the operation of the current DSTF;
- Having completed the final reclamation of the current DSTF when the expanded DSTF becomes operational
- Progressive reclamation of the current and expanded DSTF (such as placement of cover and revegetation);
- Enclosing the crusher and ventilated building (also a term and condition of their current license that has not yet been implemented);
- Regularly applying dust suppressant agents (such as calcium chloride or similar) to unpaved roads;
- Applying a dust suppressant agent (tackifier product) to exposed tailings surfaces prior to progressive reclamation;
- Relocating air quality monitoring station TSP-1 from its location south-east of the current DSTF to the western limit of Keno City (near receptor R05);
- Implementing an additional air quality monitoring station at the eastern end of Keno City (near receptor R02);
- Continuing air quality monitoring at station TSP-2 which is the historic monitoring station located at the north-west fence line, west of the current DSTF and north of the crusher.

- If Keno residents raise concerns about dust from Flame and Moth, Alexco will work with the stakeholders toidentify additional mitigation options.

Traffic and mine infrastructure

- To the extent possible employees will use project bussing and pool transportation from Mayo/Elsa to themine and mill site, thereby reducing overall vehicle traffic. Fleet vehicles will be utilized by staff as necessary;
- Alexco will continue to work with tourism and heritage representatives and the community to develop signage to be installed along the Silver Trail Highway to Keno and within Keno that shows a road/trail map of the area indicating the roads that are in active mining use, identifies key tourist features, and lists generalsafety precautions and traffic management procedures for active roads.
- Progressive reclamation and revegetation pursuant to sections 6.1 (Progressive Reclamation) and 6.2 (Revegetation) of the Preliminary Reclamation and Closure Plan
- Reclamation of the mill area and ancillary facilities, and the DSTF, "to an aesthetically acceptable level,"[118] as per Section 7.6 and 7.7 of the Preliminary Reclamation and Closure Plan.

7.2.3 Relevant Legislation

- Accepted terms and conditions of Decision Document 2011-0315, pursuant to section XXX of *YESAA*

7.2.4 Significance Determination

There is no legislation or standards specific to mitigating adverse effects of activities to the visual amenity of communities. Generally, visual amenity impacts are addressed at the local or regional level, such as through by-laws or land use planning processes, and community visioning exercises. In terms of visible dust, although standards for air quality exist in Yukon, these standards are based on TSP, PM10 and PM2.5 measurements that relate to health effects rather than visual considerations. The significance of adverse effects to visual amenity largely depends on the community in question and their values, as their values become the litmus against which to measure effects to visual amenity.

No comprehensive planning exercises or studies have been undertaken to specifically assess the visual amenity preferences of Keno City residents. However, due to the small population size, comments submitted during the past several assessments for related and proposed activities provide a good indication of visual amenity values. For example, tourism potential was frequently cited as a key consideration during the assessments of Bellekeno, Lucky Queen and Onek, and the current Project, based on the promotion of Keno City as a tranquil, rustic, colourful, mountain community with interesting mining history surrounded by wilderness and mining relics.[119] Other descriptions of Keno City relate to the perception of Keno City as a quiet, "off the beaten path" place to retire. These comments relate to Keno City directly, as residents have acknowledged the presence of mining in the surrounding area. Although not directly related to the visual attributes, the image created by these descriptions of Keno City is an image consistent with rural, rustic, and natural amenity values. As such, visual amenity impacts are considered in this context.

[118]Alexco Keno Hill Mining Corp., Preliminary Reclamation and Closure Plan, Section 7.6, page 45, YOR Document 2013-0161-045-1

[119]

The Designated Office concludes that the direct impact of traffic to visual amenity specifically is not a significant adverse effect because, although increased in duration and volume, the type of visual disturbance (generally light duty trucks) is more or less consistent with the viewscape of the town. Keno City has supported mining and exploration activity to some extent since 1989 when the UKHM operations closed in Elsa. For example, numerous exploration projects, placer mining, and care and maintenance activities have occurred, in addition to tourist traffic, that all result in the presence of increased traffic. As well, residents have not identified visual amenity impacts of traffic for areas outside of Keno City as being a key concern, as concerns focus on noise and public safety.

Visible dust was frequently identified as the main concern in respect of visual amenity, and to a lesser extent traffic, which contributed to the general feeling of living "in a mine site,"[120] rather than being a town within a mining region.[121][122][123]The contribution of visible dust to create an industrial aesthetic is significant for both tourism and resident quality of life. Given the number of references to this effect from community members, (including the past assessments and Keno City Engagement Forum, as well as supporting literature on this effect), the Designated Office considers the magnitude of effects from visual dust to be high. Though the dust dispersion modelling and references indicate that the duration of effects are generally caused by short-term events, the Project results in the duration of effects potential to extend for an additional 7 years.

However, several factors reduce the likelihood for effects to visual amenity. First, the predominant direction of wind is away from the community, which reduces the impact of visible dust generated at the Flame and Moth mine and mill site to sites within Keno City. Second, the Proponent has committed to a number of relevant dust abatement measures that, with effective and timely implementation, will reduce the likelihood, extent and magnitude of dust generation associated with Project activities. The dust dispersion modelling completed provides the Proponent with a better understanding to effectively target those areas predicted to have more dust-generating potential. As such, the Designated Office is confident that the information is available to manage the impacts of visible dust to visual amenity values.

Notwithstanding the above, due to the resident's opposition to the proximity of the Project to Keno City, residents are likely to be highly sensitive to visible dust and its impact to visual amenity. This social context is important for understanding the significance of potential effects from the residents' point of view. Twelve out of the 13 Keno City residents present at the Keno City Engagement Forum expressed opposition to the mining activity and mill infrastructure in close proximity to the community. Additionally, two seasonal residents and business owners also submitted comments that expressed opposition to the location of the Keno District Mill and mining development there, as did two former residents and business owners that moved away ostensibly in direct response to the development activities and processes in the Keno City area.[124]

Therefore, the Designated Office is of the view that there is sufficient evidence to determine that the Project will result in significant adverse effects to visual amenity, due to the social context, the identified community values with respect to visual amenity resulting in a high magnitude of potential effects. The significance of these effects can be mitigated with a focused effort on reducing the likelihood, extent and potential duration and frequency of all potential dust events, as well as by making significant effort to manage and improve resident's perception of these impacts (i.e. improve the social context). Given the

[120] Summary of Keno City Engagement Forum, YOR 2013-0161-093-1
[121] *Ibid*
[122] Comment Submission, Mike Mancini, YOR 2013-0161-103-1
[123] Comment Submission, Blackburn and Bindig, YOR 2013-0161-100-1
[124] Comment Submission, Insa Schultenkotter YOR 2013-0161-101-1.

above, the Designated Office has determined that the proposed Project will result in significant adverse effects to visual amenity, but that these effects can be mitigated.

During the assessment of Lucky Queen and Onek, several mitigations related to visual amenity were accepted by the Decision Body and included in the Decision Document. These mitigations are reproduced below to provide an understanding of residual effects and requirements for additional mitigation.

34. Any substantive change to traffic volumes, patterns or routing for the project shall be discussed prior to changes with the community of Keno City and FNNND in addition to regulators. The proponent shall make best efforts to create a mutually beneficial co-existence of mining, tourism and traditional lifestyles (emphasis added).

53. The proponent shall ensure new clearings for and around industrial infrastructure are limited to ensure visual disturbance in minimal, and the affected footprint, including berms, ditches, ponds and portal pads will be re-vegetated with seed mixture to promote re-growth in disturbed areas.

54. The proponent shall work with the residents of Keno City to ensure that aesthetic factors, which are a key part of Keno's image and appeal, are maintained.

Term and condition #34 has some reporting basis as the Proponent supplies information regarding implementation of the Traffic Management in the Annual Reporting. Similarly, #53 appears to be worked into relevant mitigation as well as the Preliminary Reclamation and Closure Plan. However, the 2012 and 2013 Annual Reports do not describe any implementation of Decision Document term and condition #54, so it is not clear how this term and condition may have contributed to improving aesthetic factors in the area.

Given the above, the Designated Office recommends the following additional mitigation measures:

26. Blasting shall not be undertaken during unfavourable weather conditions (e.g. westerly winds, lower than average humidity) to avoid deposition of dust on neighbours and the delayed dissipation of visible dust from the atmosphere. The conditions under which blasting shall not be undertaken shall be explicitly identified for the residents of Keno City.
27. In addition to notifications regarding traffic increases, the Proponent shall post and/or notify their operation schedules and potential dust-generating events in a manner that is approved by Keno City residents and that allows sufficient time to plan (e.g. regular meetings, approved posting locations, approved frequency of posting and meetings, etc.)
28. The Proponent shall include a section in their Annual Report for Social Impacts Monitoring, in consideration of monitoring and implementation of mitigation for valued components identified in the Socio-economic Mitigation Plan, including visual aesthetic factors.
29. The DSTF shall be reclaimed in consideration of improving the visual amenity of the site in addition to long-term stability. Visual amenity objectives shall be identified by the community of Keno City.

7.3 Project Effects – Auditory Disturbance

Auditory disturbance, (i.e. noise), can affect the auditory aesthetics, or soundscape, of Keno City and the surrounding region. Adverse effects to the soundscape vary, and are dependent largely on an individual or group's perception of what an acceptable level of disturbance and/or change to the soundscape is or

should be. In turn, this perception or tolerance to noise is based on several other factors, including but not limited to:

- Perception or understanding of the character of one's environment (e.g. wilderness, rural, urban);
- The source or type of noise (e.g. people may be more tolerant to sound generated from wind in the trees than to heavy equipment, despite similar db readings).
- The compatibility of the noise with everyday activities and/or lifestyle, including business activities;
- The duration and/or frequency of the noise (repetitiveness, constant, sporadic), and the timing (e.g. noise at night is more disruptive);

Although not exhaustive, the above list highlights some of the subjective elements of effects to auditory aesthetics. Effects to Keno City and the immediate area are best considered as effects to an aspect of the community's environmental character (i.e. soundscape), but which also has health implications (e.g. sleep disturbance, stress). The effects to the soundscape may in turn result in adverse effects to community character as well as the tourism potential for the community. Although this value has a subjective component, the quantitative analysis and research on noise levels and associated impacts is helpful for understanding the extent and scope of the effect resulting from the Project. The acceptability (i.e. significance) of the effect is another matter.

The following sections describe the effects of noise from the Project in combination with the residual effects of noise from the existing and licensed activities to the residents of Keno City. This section is in essence a cumulative effects assessment that evaluates the combination of existing and proposed activities and associated noise effects to residents of Keno City. Current activities appear to result in significant adverse effect to residents in Keno City. The continued operation of the Mill and the expansion of the DSTF are the single largest contributors to noise production from the Project. The largest contributing factors to the significance of that noise to residents in Keno City are the low frequency components of the noise produced and the heightened sensitivity of community members to that noise as a result of the strained relations between the Proponent and the residents of Keno City. Additional mitigations are required to both reduce the noise production and improve relations between the Proponent and residents of Keno City. Mitigations prescribed in this section, in combination with mitigations prescribed in Section 8.0 are expected to effectively reduce the significant adverse effects of cumulative noise impacts from the Project.

7.3.1 Effects Characterization

As part of the assessment, the Mayo Designated Office retained Patching Associates Acoustical Engineering Ltd. (PAAE) to evaluate the quality and accuracy of predictive noise modelling done during the Bellekeno assessment, the Proponent's noise monitoring and reporting procedures and to update predictive modelling work they completed for the Lucky Queen and Onek assessment in 2012.[125] The results of this work are provided in two separate reports from PAAE and assist in understanding the appropriateness of the current "effects" threshold (i.e. 50-90 dBA), the effectiveness of the existing noise monitoring, and the levels of additional noise expected from the Flame and Moth Mine.[126]

During the Bellekeno assessment, YESAB's analysis included a statement that noise levels of 50-90 dBA are acceptable and are not expected to result in significant adverse effects. PAAE disagreed with this

[125] Lucky Queen and Onek Noise Impact Assessment YOR 2011-0315-127-1.
[126] PAAE Noise Assessments YOR 2013-0161-168-1 and 171-1.

determination and noted that 50-90 dBA L_{eq} is representative of a daytime construction site in an urban area and is unacceptable for rural settings like that in the Keno City area. PAAE noted that in rural areas in Alberta, the Alberta Energy Regulator has set guidelines of 40 dBA L_{eq} (nighttime) as the standard and even at this level receives sporadic complaints. To remedy this, PAAE recommended that the "acceptable" range of noise be revised to match levels in other jurisdictions for similar sites rather than levels representative of an abnormally loud construction site in an urban area.

In regards to the Proponent's noise monitoring, PAAE concluded that the monitoring is insufficient for the purpose of gauging effects. PAAE noted that it is unclear what the Proponent's readings represent, but that it is assumed to be the 10 minute L_{eq} level. In the absence of longer-term measurements and isolating analysis to separate noise contamination from other sources, PAAE was unable to determine what levels were representative of the mine operations and what were the result of background conditions. In addition, PAAE noted that no noise readings were taken during the night when effects are most critical. PAAE concluded that the current noise monitoring is insufficient to provide accurate noise readings and an understanding of potential effects. PAAE recommended taking longer noise readings (3-7 days) including readings at night with noise isolation to remove extraneous noise sources not from the operations. As such, the update from PAAE to their previous noise predictions did not include the use of the Proponent's data.

In 2012, PAAE obtained sound power levels from field measurements of equipment at the mine and mill sites. For planned and proposed facilities, PAAE obtained sound power levels from both manufacturer's data and theoretical calculations. In the most recent update, PAAE added the sound power levels of facilities proposed as part of the Flame and Moth development. With the sound power levels, PAAE used the CadnaA noise-modelling package to develop cumulative sound level predictions at five sensitive receptors around Keno City. The predictions are based on the assumption that all AKHM operations are operating simultaneously and at full power. For each sensitive receptor, the total predicted sound levels for both daytime and nighttime noise were presented. In addition, the predicted increase in sound for both daytime and nighttime periods due to the Flame and Moth Mine was estimated for each sensitive receptor. PAAE concluded that the Flame and Moth Mine would produce negligible increases of A-weighted sound levels of the Keno City residences. However, residence R04 near the Onek portal site will experience sound level increases of approximately 3-4 dBA. In addition, the levels of low frequency sound from the combined operations are expected to be an ongoing source of annoyance. The modelling followed by PAAE follows the ISO 9613 standard with a published accuracy of plus or minus 3 dBA.

Appendix A of the PAAE noise reports provide important technical background to the difference between sound levels and noise levels. A summary of these details is presented below to provide context for a discussion of how the sound energy from the AKHM operations may affect Keno City residents' health.

Due to the wide range of energy in the form of pressure waves and vibration perceived by humans as sound, sound levels are most often measured on a logarithmic scale with levels measured in dB (proportional to ten times the common logarithm of sound energy). Human perception of sound energy (dB) is not linear across the frequency range of human hearing (~20 Hertz (Hz) to 20 000 Hz). At certain frequencies, the same sound energy is perceived differently. To account for these differences, several modifying curves or scales have been produced to more accurately predict human reactions to sound energy referred to as "noise". Most commonly, noise is measured using the A-weighting scale and is referred to as "noise level" referred to as dBA measurements. Although the most common measure of noise, A-weighted scale measurements are not the most appropriate for predictions of effects to humans for all frequencies. For low frequency sounds in the range of human hearing, the C-weighted scale, denoted dBC, is considered a more appropriate measure of noise levels.

The inadequacy of the A-weighted scale for predicting effects to humans from sound levels at different frequencies is summarized in the literature review by St. Pierre (2004). St. Pierre (2004) notes that A-weighted methods were developed more than 70 years ago and remain the predominant measure of noise in current evaluations despite the substantial body of research that concludes the effects of noise are not well represented using this scale for all frequencies of sound. The author notes that the "…*sharp roll-off at low frequencies minimizes their effect on the overall dBA reading…*", but highlights that low frequency noise has been established as an important factor assessment of loudness and annoyance. Low frequency components (below 400 Hz) have been shown to underestimate the subjective measure of "loudness" by as much as 14 dB (Kjellberg and Goldstein 1985; as cited in St. Pierre 2004). St. Pierre (2004) concludes that, "(s)*ince the A-weighting filter deemphasizes low frequency noise, it also has the effect of not considering physical and psychological effects caused by low frequency noise.*" If a component of the sound is comprised of low frequency tones, it is critical to adjust predictions by using and appropriate scale, and acknowledge the uncertainty when evaluating effects from low frequency noise.

Low frequency noise has been shown to result in both physical and psychological effects in humans and is the predominant cause of annoyance from sound. Physical effects include fatigue, reduced ability to sleep at night (Mirowska and Mroz 2000), reduced wakefulness during day, reduced concentration, impaired memory (Bengtsson *et al*., 2000; as cited in St. Pierre 2004), increased cortisol levels (a measure of stress), peripheral vasoconstriction, elevated blood pressure and greater risk of cardiovascular disease (Berglund *et al*., 1996; as cited in St. Pierre 2004) . Psychological effects include depression and other forms of mental illness (Mirowska and Mroz 2000; as cited in St. Pierre 2004).

In their updated noise assessment report[127], PAAE provided predictions of low frequency noise at the most sensitive receptor (R04) determined through the dBA analysis. PAAE used the C-weighted noise scale to more accurately quantify the low frequency noise. The results of this analysis are presented in tables 10-13 of PAAE's report. The total sound levels based on A-weighted scale range from ~27 dBA to ~35 dBA from operations evaluated for both day and night whereas the C-weighted measurements range from ~40 dBC to ~53 dBC. The lowest dBA and dBC predictions occurred at night when the mill, crusher and tailings equipment were not operating. PAAE notes the significant proportion of low frequency noise predicted and suggests that these levels are likely to cause annoyance.

In tables 10-13 of PAAE's report, each noise source is identified with a corresponding dBA and dBC measurement. What is most notable from these data is the significant difference between the dBA and dBC noise levels for much of the equipment, suggesting substantially greater noise will be produced as a result of low frequency sound than is predicted by the A-weighted measurements. The dominant sources of low frequency noise are from the Mill and associated equipment (crusher, DSTF packer, loaders, excavator etc.) and the ventilation fans for the underground workings. The most significant additional noise from the Flame and Moth Mine will result for the ventilation fans. However, due to the proximity of the Flame and Moth fans to the existing Mill and equipment, the fans are unlikely to play a dominant role in the perception of noise from at sensitive receptors.

As summarized in Appendix A of the PAAE report, sound is typically measured on a logarithmic scale and so a doubling of acoustic energy does not result in a doubling of the noise but an increase of

[127] PAAE Noise Assessment YOR 2013-0161-171-1.

approximately 3 dB or just perceptible to the human ear. A summary of research into human perception of changes in sound indicates the following[128]:

- A 3-dB change is just perceptible;
- A 5-dB change is clearly perceptible; and
- A 10-dB change is perceived as being twice or half as loud.

Unfortunately, from the PAAE report we cannot directly determine the change in low frequency noise between the AKHM operations and the background that existed prior to AKHM operations. However, it is clear from the PAAE analysis that the dominant sources of low frequency noise are from AKHM operations and particularly the operations associated with the Mill[129]. Therefore, it is likely that the ambient or background C-weighted levels would be similar to those presented in the PAAE report for A-weighted levels (although wind events can cause increases in low frequency noise and C-weighted readings), included in tables 6-9 of the PAAE report. Because we have C-weighted predictions for receptor R04, comparison of these numbers to the A-weighted ambient levels during the daytime (assuming ambient A-weighted and C-weighted are similar due to lack of low frequency sound sources) produces a difference of roughly 18 dB. This level of change would be perceived as a nearly fourfold increase in sound. During the nighttime, the difference in sound is over 10 dB or a perceived doubling of sound over the ambient conditions.

Because the primary source of noise, particularly low frequency noise, is from the Mill and associated equipment, the community has had a number of years living with the cumulative noise from the operation of the Bellekeno Mine and the Mill and associated equipment. The Flame & Moth mine is expected to contribute additional low frequency noise as a result of the large ventilations fans. However, due to the location of this equipment (relatively near the Mill), it appears that these fans will not be the driving sources of noise, but that the Mill and equipment in combination with either Lucky Queen, Onek or Bellekeno Mines will remain the dominant source.

Noise was one of the primary effects noted by the community from the project. Several community members described the sound as constant industrial noise and noted the significant change from the quiet community that Keno City was prior to mining and milling near the town. Community members attributed the noise to reduced quality of life and stress, noting that in combination with the other effects of the AKHM operations (dust, traffic etc.) these effects have caused some residents to consider moving away, and/or that desire has been expressed. One comment submission from a former resident cited these changes including noise as the reason for their decision to move. These same sentiments featured prominently in the assessment of the Lucky Queen and Onek mines in 2011 and were a common concern during the Bellekeno Mine assessment in 2009. During this assessment, the most significant difference in the comments from residents was the cohesion and consistency across the community, where the vast majority who commented noted the significant effects from noise as a result of the AKHM activities.

7.3.2 Relevant Proponent Commitments

- Blasting at the Flame and Moth surface portal will only be conducted during the dayshift period (7am to 7pm) until the portal reaches a distance of 20 m underground. At the point 24 hour

[128] Reproduce from PAAE Noise Assessment Report YOR 2013-0161-171-1 p. 1.

[129] The top three ranked sources of noise according to the C-weighted scale are the DSTF Track Excavator, the Mill Crusher and the Mill DSTF Packer. These activities are considered integral to the Mill operations and are therefore evaluated in combination.

blasting will occur. A community notification protocol will be developed and posted within Keno City outlining blasting schedules during the initial portal development.

- Noise silencer or enclosure will be part of the ventilation fan for Flame and Moth Portal.
- The use of existing bypass roads around Keno City will continue.
- Access to the Flame and Moth Mine will be routed through Christal Lake Road.
- The use of engine brakes will be avoided in the vicinity of Keno City.
- Flame and Moth Mine traffic management protocols have been incorporated in the revised draft Traffic Management Plan.

7.3.3 Significance Determination

Throughout this assessment the Designated Office considers potential effects in the context of Keno City and its residents. As such, the relevant spatial scope and sensitive receptors are the residents of Keno City, as the most directly affected by Project activities. Based on this population, the Designated Office has determined that the Project will result in significant adverse effects to Keno City residents due to auditory disturbance, and that these effects cannot be mitigated. The discussion below provides the rationale for this determination.

As noted by PAAE, a noise threshold of 50-90 dBA represents noise from a loud construction site in and urban setting and is not an appropriate gauge of effects in a rural setting such as Keno City. As noted by PAAE, the Alberta Energy Regulator mandates noise levels remain at or below 40 dBA during the nighttime period and at these levels complaints remain common. Although the A-weighted predictions remain below levels expected to produce significant effects (i.e. below 40 dBA) to the community, the C-weighted measurements predict effects that are clearly significant and may constitute an experience of up to a fourfold increase in noise above background at sensitive receptors. Although there are no regulatory guidelines for C-weighted noise noted by PAAE, this is likely a result of inadequate regulation and not due to a lack of effects as noted by St. Pierre (2004).

Noise measurements are an analytical tool used to make general predictions of effects of sound on humans, perceived as noise. These tools cannot account for other factors such as the sources of the sound and how that affects the perception of whether a sound is “noise” and is significant or not. For example, a strong wind storm may produce substantial A-weighted and C-weighted noise readings, but no adverse effects to people because the source is a natural phenomenon outside anyone’s control. The operation of heavy equipment at a construction site may produce the same A-weighted and C-weighted readings as those of the wind storm, but the interpretation of this sound would be perceived much differently. On that same note, if the sound is from construction an individual’s home, this individual may not perceive it as noise at all as they directly benefit from that sound. The same is likely not true for the neighbor of the person who’s house is under construction. In short, when evaluating the effects of sound to a population, it is important to consider the whole suite of contributing factors to truly understand the significance of effects to individuals.

An important factor to evaluating the significance of effects of noise to residents of Keno City are comments from the community members describing the effects to them as they are the people effected. The vast majority of community members in Keno City noted the significant effects from the noise of the AKHM operations to their wellbeing. Some individuals noted difficulty sleeping and annoyance as a result of the continuous noise from the mining and milling activities (when operating). Other members cited their fears of effects from the industrial noise to their tourism businesses and livelihoods. In addition, the

majority of community member who participated in the assessment described their strained relationship with AKHM. Community members noted that they live with the adverse effects of the mining operations with no direct benefit to them. This is very likely a contributing factor in how sounds from the AKHM operations are perceived negatively by Keno City residents. However, the apparent discrepancy between the measured and predicted sound levels and the significance of impacts described anecdotally by residents may be due, in part, to the use of the dBA scale to understand the noise levels, rather than the dBC.

Significant adverse effects will occur to residents of Keno City as a result of sound production from the Flame and Moth Mine and the ongoing operation of the Mill and associated equipment in combination with operations from the Bellekeno Mine or the Lucky Queen or Onek Mines. As mining and milling activities are the primary source of low frequency noise in the area, the C-weighted noise predictions are most appropriate for predicting effects. These readings are significant with predictions above 50 dBC during daytime and above 40 dBC during nighttime and are two to four times higher than the background noise (a natural reference for residents). Although these predictions are conservative as they assume all mines in operation simultaneously at full production, the dominant sources of low frequency sound are from the Mill and associated operations and the ventilation fans for the mines. Therefore, the total C-weighted noise predictions are not expected to change substantially based on the simultaneous operations of Flame and Moth with either Bellekeno, or Lucky Queen or Onek. Keno City residents have experienced more or less the extent of the noise that will continue out to 2021 and beyond as a result of this proposal. Keno City residents have noted significant adverse effects including trouble sleeping, stress and annoyance as a result of previous AKHM operations. If current trends continue with the community's apparent deteriorating relationship with AKHM, the perception of the noise from ongoing operations is likely to worsen.

7.3.3.1 Consideration of Proponent Commitments and Potential Mitigations

The following section outlines the Mayo Designated Office's consideration of potential mitigations, including Proponent commitments to reducing, eliminating or controlling the significant adverse effects form noise associated with the ongoing AKHM operations and the Flame and Moth Mine. The discussion is not exhaustive of all mitigations proposed or recommended previously, but focuses on those that are deemed relevant to achieving material reductions in overall noise from the project with particular attention to reductions in low frequency noise.

As noted by PAAE[130], several "best practices" exist to reduce sound and associated noise from industrial operations. The benefit of assessing mineral deposits separately (i.e. Bellekeno separately from Lucky Queen and Onek separately from Flame & Moth) is the ability for reviewers to look back at the effectiveness of past mitigation measures. This is particularly true for effects from noise. In the Bellekeno assessment (2009-0030), the Mayo Designated Office did not prescribe noise mitigations, but outlined numerous best practices for reduction of noise and associated effects. After reconsideration of the effectiveness of this approach, mitigations were prescribed in the Lucky Queen and Onek assessment, in addition to new commitments made by the Proponent, these mitigations collectively provided a wide range of actions intended to reduce the effects of noise from the operations. The mitigations in the Lucky Queen and Onek assessment were developed to mitigate residual effects following the implementation of Proponent commitments. It appears that the previous assessments underestimated the impacts of noise due to the reliance on the A-weighted scale, and the relative importance of low frequency noise to changes in baseline conditions.

[130] PAAE Noise Assessment YOR 2013-0161-171-1.

Restricting the operations of the Mill and associated equipment (as these are the dominant sources of low frequency sound) to daytime only was considered. This scenario was essentially modeled by PAAE and is presented in table 13 of their report. C-weighted noise levels remain above 40 dBC and would be perceived as a doubling of the sound compared to the ambient levels (presumed to approximate the dBA levels of 30). This same mitigation cannot be applied during the daytime as it would effectively shut down milling operations at that location. Therefore, daytime C-weighted levels will likely remain above 50 dBC as predicted by PAAE. These levels are expected to produce significant adverse effects to residents of Keno City as they represent an increase in total noise from levels that have already produced significant effects to residents.

The Mayo Designated Office is aware that the Proponent's commitment from the Lucky Queen and Onek assessment to cover the crusher at the mill site has not been implemented to date. If implemented, this mitigation would reduce the noise production from the site. However, the noise source from the crusher is measured at ~40 dBC compared to the DSTF excavator of ~51 dBC and the DSTF packer of ~48 dBC. Considering the substantial contributions of the DSTF excavator and packer to low frequency noise production and total noise production, covering of the crusher alone is unlikely to achieve material reductions in the total low frequency sound levels from the site. In addition, as outlined in table 13 of PAAE's report, the absence of all of the mill equipment still produced noise levels of over 40 dBC and so reductions of noise from the crusher alone would not produce noise levels much below the predicted ~50 dBC.

As the ventilation fans are a contributor of low frequency noise in general, the Proponent's commitment to installing noise reducing systems on the ventilation fans was considered. For the Flame and Moth Mine, the ventilation fans are predicted to produce ~20 dBC and ~19 dBC noise levels for the inlet and outlet discharge fans respectively.[131]Although these fans may be significant contributors of low frequency noise, as is apparent in their relative contributions to C-weighted noise, silencing equipment is likely more effective at reducing the high frequency noise and may actually contribute to a greater difference between A-weighted noise and C-weighted noise, exacerbating the effects of the low frequency component.

The Lucky Queen Mine and associated activities produces a disproportionately large amount of sound, particularly low frequency sound, compared to the other mines due largely to its location. As noted in the Proposal, the Flame and Moth Mine will be operated concurrently with one of the other three mines. The Flame and Moth Mine does not appear to contribute significant low frequency noise on its own and so limiting operations to Flame and Moth only and Lucky Queen only is not expected to achieve substantial reductions in cumulative noise relative to the operation of the Mill and DSTF. In addition, to date this mine has not operated and significant adverse effects were experienced by residents of Keno City during the operation of the Mill in combination with the Bellekeno Mine alone. The addition or removal of the Lucky Queen Mine is of little consequence to the determination of significance regarding the impacts to the residents of Keno City from noise.

The most significant reductions to low frequency noise would be achieved by moving the DSTF to an alternate location farther from the sensitive receptors (as the primary sources are from the DSTF packer and the DSTF track excavator) and to apply noise reductions at the mill site. This type of suggestion has profound implications for the overall project design and feasibility and is considered outside the realm of mitigation.

As noted previously, weighted measurements of sound energy (i.e. A-weighting and C-weighting) are imperfect analytical tools that attempt to quantify peoples subjective experience of sound energy. These

[131] Table 11 of the PAAE Noise Assessment YOR 2013-0161-171-1.

numbers are simply an estimate of effects and many other factors contribute to how an individual experiences sound. Nearly all residents of Keno City who attended the public forum last spring noted that sound from AKHM operations was significant to them. In addition, many residents noted that they feel subjected to noise from AKHM's operations with no benefits to them to compensate for having to live with that constant noise and associated stress. As one person put it, residents of Elsa during past mining operations there generally did not mind living with all of the noise and associated adverse effects that come with mining and milling operations because those people worked at that mine and received direct benefit from it. This sentiment featured prominently with the residents and affects how they view the sound from AKHM's operations.

In a similar line to the compensation residents' noted, many repeated their distrust of AKHM and noted numerous instances where they felt betrayed and deceived. In addition, residents' noted the numerous Proponent commitments and licence terms and conditions that they feel have not been implemented to date, including the covering of the Mill crusher as a signal that the company simply does not care about reducing their impact on the community. These sentiments outline the strained relationship between AKHM and the community of Keno City and the apparent lack of social licence from the community for AKHM to operate there.

The lack of direct benefit from AKHM operations to Keno City residents' and the strained relations between the company and the community may be the most important factors to evaluating the significance of noise effects to the community. It is unlikely that reductions in noise alone, in the absence of improved relations and commitment from the Proponent to compensate community members in some way for the effects of their operations, can achieve real reductions in the way noise from AKHM affects the residents of Keno City.

If the Proponent involved the community members in project planning for operations that directly affect the community, this would likely empower community members and improve community relations with the Proponent. Improved community and company relations and compensation to the community of Keno City would likely be the most effective mitigation at reducing the negative perceptions of the sound from AKHM operations by community members.

The following mitigations include past Proponent commitments and past mitigations that should be implemented to reduce the overall impacts from the noise of AKHM operations to the residents of Keno City. These mitigations in combination with a cooperative approach to developing a defensible noise monitoring and mitigation plan with appropriate noise thresholds and engaging in research to find and implement additional noise reduction measures that may exist should achieve substantial reductions to impacts from noise. In addition, the socio-economic mitigations in Section 8.0 will further reduce the residual effects of noise if implemented correctly as these mitigations should empower the community and improve company and community relations. If the mitigations in Section 8.0 are not implemented or are not implemented as designed, significant adverse effects to the community of Keno City from noise will likely remain and the relationship between AKHM and the residents of Keno City will likely worsen.

The Mayo Designated Office has determined that the Project will have significant adverse socio-economic project effects on visual and auditory amenity. These effects can be eliminated, reduced or controlled by the application of the following terms and conditions:

30. Prior to commencing operations, the Proponent shall install a noise reducing cover over the mill crusher.
31. To reduce impacts from low frequency noise, the Proponent shall not operate the crusher, DSTF track excavator or DSTF packer between the hours of 19:00 and 07:00.

32. The Proponent shall employ a neutral, third party mediator with proven education, training and experience in mediation and dispute resolution to administer engagement between the Proponent and the residents of Keno City to collaboratively develop the following:
    a. A comprehensive sound monitoring and mitigation plan that is administered by an independent third party noise specialist and reported on annually as part of the reporting requirements in the Proponent's quartz mining licence. The primary objectives of this plan shall include the development and implementation of a comprehensive and defensible sound monitoring program aimed at monitoring noise, including low frequency noise, at sensitive receptors in the community.
    b. Based on ongoing monitoring, the independent noise specialist shall provide the residents of Keno City and the Proponent with a comprehensive list of additional mitigations available to address concerns of noise from the Proponent's ongoing operations.
    c. To address any outstanding concerns of noise, the mediator shall administer discussions between the Proponent and the residents of Keno City to identify reasonable noise reducing mitigations. These mitigations shall include consideration of appropriate compensation as a possible mitigation. The Proponent shall implement noise mitigations including compensation as soon as practicable following identification of appropriate noise reducing measures.
    d. The Proponent and residents of Keno City through guidance from a mediator shall develop a noise compliant and resolution protocol to be administered by an independent third party to accept and investigate reasonable complaints of noise. Complaints and any corrective actions shall be documented and reported quarterly with reports distributed to the Proponent, the regulator and the residents of Keno City.

7.4 Residual Effects

As noted above, the Project will produce significant adverse residual effects to Keno City residents as a result of noise production. The AKHM mining operations are the dominant noise sources in the Keno City area and are the drivers of sound production (particularly low frequency sound) as noted by PAAE. Other AKHM activities such as exploration drilling are also contributing to the cumulative noise and were not accounted for in the PAAE study. Noise effects from these operations were referenced numerous times by Keno City residents during the community forum held there last spring. Noise from exploration drilling may be very acute to some residents depending on the location. These activities are hard to quantify, but are considered potentially significant based on comments from community members.

Other sources of noise include highways maintenance work, traffic and construction activity in Keno City. These other sources are discontinuous with noise levels going up and down as noise sources move through the community. These noise contributions are less significant in terms of effects largely due to their regular and transient nature.

7.5 Cumulative Effects

The Mayo Designated Office has determined that the Project will have significant adverse cumulative socio-economic effects on visual and auditory amenity in connection with the effects of other activities. These cumulative effects can be mitigated through the implementation of mitigations in Section 8.0.

8.0 COMMUNITY WELLBEING

8.1 Overview

Community wellbeing refers to the general quality of life of the community, based on consideration of values identified by residents as being important to their wellbeing. These include environmental, cultural, economic, and social values, for which effects to these values synergistically influence Community Wellbeing. The Designated Office uses it here to emphasize the collectiveness of impacts to the community of Keno City, rather than individual quality of life, as well as the place-based aspects particular to Keno City. In other words, Keno City has a particular character independent of its residents, but to which residents are attached and derive part of their sense of place.

During the assessments of projects related to AKHM development and production proposals, many residents have expressed concern for potential impacts to quality of life, including from impacts to the character of Keno City, increased noise, dust, potential impacts to environmental health (drinking water, tailings dust, etc.), and reduced viability of tourism operations. The assessment record for both the Bellekeno Mine and Lucky Queen and Onek mines show that while residents expressed support for the mining activities, the primary issue was the proximity of the proposed mill site, tailings, and crusher facility to residents in Keno City.[132] The table below demonstrates that the proximity of this infrastructure remains a key concern and source of adverse effects to community wellbeing. As well, the negative relationship between the residents and the Proponent, as well as their experience of powerless-ness throughout the project developments (e.g. consultation, complaint resolution, enforcement of mitigation), has increasingly become a flashpoint for the community.

Table15: Frequency of concerns articulated at Keno Community Engagement Forum, April 15, 2014

Comments/ concerns	Frequency of comment/concern
Quality of life: Increase in dust (from tailings and trucks)/ poor air quality/noise/truck traffic/town is now industrial mine site	24
Poor relationship between Alexco and community/ transparency/respect	21
Mill originally scoped as temporary/ Proximity of mill to town	19
Keno has no voice/ignored/lack of respect for residents	16
Risk of contamination/ health problems	12
Lack of reclamation activities/ monitoring	9
Alexco's activities have been detrimental to community's existence	7
DSTF (tailings)- Proximity to town/ increase in size	6
Lack of faith in YESAB/ YESAA	6
Lack of faith in Yukon Government	5

[132] Gross, Catherine. (2007). Community perspectives of wind energy in Australia: The application of justice and community fairness framework to increase social acceptance. *Energy Policy*.35:5 pages 2727 – 2736.

The Designated Office identified indicators of community wellbeing for Keno City residents based on the review of comment submissions and other external sources. Comment submissions included those from the previous assessment of Bellekeno Mine, Lucky Queen, and Onek Mines, (including the transcript of the meeting held in Keno City in respect of Lucky Queen and Onek Mines), as well as those comments submitted during the current assessment and the record of the Keno Community Engagement Forum. Finally, the Designated Office reviewed the Health Impact Assessment (HIA) of Mining Activities near Keno City, Yukon, to inform our understanding and selection of indicators, which are as follows:

- Local economic pursuits
- Noise and reduced visual amenity
- Stress, anxiety, mental wellbeing
- Community character and sense of place

The assessment considers the synergistic and additive impacts to community wellbeing resulting from the effects to auditory and visual aesthetics, health, and environmental health, described in preceding sections of this report. The Designated Office has considered effects to these indicators collectively, with a strong lens on how various governance structures and the perceived fairness of outcomes have contributed to adverse effects to community wellbeing, and the extent to which these are embedded in the experience and perception of effects. There are significant linkages and overlap between these indicators of community wellbeing. Therefore, the significance determination presented in Section 8.4 is based on effects to all of these components collectively. Further, as noted in Section 4.4, the assessment is a cumulative effects assessment in consideration of the residual effects of existing projects, specifically Bellekeno, and Lucky Queen and Onek. The Designated Office has determined that the Project will result in significant adverse cumulative effects to Community Wellbeing that can be likely be mitigated if all parties are willing to work towards improvement. The following sections present the rationale for this determination.

8.2 Project Effects – Local Economy

8.2.1 Overview

Economic pursuits in Keno City by residents are primarily tourist/visitor dependent, given the small population. Businesses/services include accommodation (hotel, bunkhouses), a snack bar, a café and bar, several outdoor guiding ventures, and government funded projects (e.g. development and maintenance of the Keno City museum), and a local campground maintained by the Keno Community Club. There are also several residents who are actively involved in the mining sector, and one commercial herb farm.

The tourism sector has been characterized as small but steady in the HIA. In contrast, the Yukon Government Tourism and Culture Branch has emphasized the fragility of the industry, noting the investments made by residents in this sector and their successes to date, while describing the potential impacts to tourism potential and growth from adjacent mining. The potential effects to this component of community wellbeing include:

- Reduced economic growth and potential for local businesses.
- Impacts to property values

Changes to the local economy would also affect the sense of place, and result in stress, anxiety and effects to mental wellbeing, described in other sections of this valued component.

8.2.2 Effects characterization and interactions

The description of impacts to this component is taken largely from the comment submission made by Yukon Government, Tourism and Culture Branch (TC),[133] TC identified the significance and importance of the tourism sector to Keno City. For example, visitation to the Keno City Mining Museum numbered over 1400 visitors each summer between 2006-2010, compared to the Binet House in Mayo (the local museum there), which received more variable visitation rates during this same period, from between 925 to 1700 visitors. This is a significant comparison when considering the relative size of these two communities as an indicator of the relative importance of this sector.

Potential effects resulting from the proposed Project in conjunction with the residual effects of other/existing projects include changes to the aesthetic and community character of Keno City that may reduce visitation and/or reduce/alter the tourism potential. For example, TC notes "*Keno has been successfully marketed as a tranquil Yukon community with an interesting mining history and easy access to scenic wilderness and outdoor activities – features particularly attractive to Yukon's key tourism markets*."[134] These changes are most likely to result of increases in noise, dust, traffic and road conditions, and the resulting general "industrial" character of the area due to the source of these disturbances (e.g. haul trucks, heavy equipment). The likelihood for future development and the proposed expansion of the DSTF and operation of the current mill site are particularly concerning for tourism in Keno City.

TC notes that in 2011 visitation dropped at the Keno City Mining Museum from 1434 to 1250, which was its lowest visitation in 10 years. Further, TC indicates that anecdotal information from that year suggests that road conditions may have been a factor. However, visitation rose to 1350 in 2012 and 2013, which could suggest a level of resilience, (defined as the ability to recover from some shock or disturbance), to effects that may have occurred because of mining activity to date. This resilience is alluded to in the following statement regarding residual effects of current activities:

"While the City itself may not be as quiet as it used to be, it remains a unique and interesting destination that appeals to Yukon visitor markets. It is a quaint, end-of-the-road town that has retained its historic character. Recent additions and improvements to tourism services support overnight and longer term stays in the community and a core of tourism businesses are interested in keeping Keno on the map as a tourism destination."

Further evidence of potential resilience to this sector is the comparison between the Binet House and the Keno City Mining Museum, as while visitation dropped in 2012 and 2013 at the Binet House, it rose slightly in Keno City's mining museum. As well, anecdotal information[135] points to several residents' continued commitment to making the tourism sector work, which will improve the resilience of this sector and the community overall. Residents quoted in the Yukon News indicated that 2014 had the highest visitation in years, credited to the efforts of residents to host events and the new businesses. While there may be some relationship between the temporary closure of the Proponents activity during the 2014 operating season and the increased business, it may also reflect the efforts of residents.

Notwithstanding the above, given that Yukon tourism's key market enjoys tranquil, historic, wilderness settings, the proposed Project, in combination with the residual effects of past/existing projects, will

[133] Comment Submission, Yukon Government Tourism and Culture Branch, YOR 2013-0161-090-1.
[134] *Ibid*
[135] Yukon News, September 24, 2014, "End of the Road, Start of a Dream" by Karen McColl; Yukon News, April 16, 2014 "Business owners champion Keno City" by Jacqueline Ronson.

negatively affect the community character that is important to tourism values. This is particularly likely when mining activity increases to its proposed potential, such as in the event of simultaneous operations at Lucky Queen, Onek, and Flame and Moth, continued operations at the mill site, and the expansion of the DSTF, a major source of auditory disturbance. The Designated Office is aware that one tourism business closed down and the residents moved away, which they indicated was a direct result of the Proponents activities near Keno City. Similarly, several residents have also suggested that their property values have and/or will decline as a result of the mining activity and mill infrastructure. While this may be true, there is at this time not enough information to confidently support this assertion, though the likelihood exists.

Due to the relatively short duration of residual effects to date, it is not possible to say for certain what the impact has already been or will be in terms of residents dependent on tourism to sustain and grow their businesses. Regardless, residents have observed that existing mining activities have resulted in few direct economic benefits for their local economy, and relative to their tourism market, have presented an overall challenge or impediment. The proposed Project is expected to result in adverse effects to the local economy as proposed, as it will continue to impact visual and auditory amenity values and community character, important to the local economy.

8.3 Project Effects – Noise and reduced visual amenity

The proposed Project will result in effects to visual and auditory amenity that will in turn, impact community wellbeing through a reduced enjoyment and happiness with their chosen community. Section 7 outlines the specific impacts to visual and auditory amenity. In terms of visual amenity, the shift in emphasis in mining operations to the mill site will likely reduce the traffic in and around Keno City (e.g. light trucks). For example, the Project reduces the likelihood for Lucky Queen and Onek to operate concurrently with Bellekeno Mine, which would have resulted in the largest and most visible increase in traffic to Keno residents (60% increase in traffic over Bellekeno Mine operations). However, the potential benefit of the Project to limit visible traffic and associated dust potential is offset by the proposed extended duration of all mine operations for an additional seven years. The total impact of traffic, however, is multi-faceted and not limited to visual amenity, but also contributes to noise and affects sense of place more generally (Section 8.5).

With respect to noise, Section 7 outlines how the Project will result in significant adverse effects to auditory amenity by generating noise and extending the duration of the residual effects of past projects (i.e. an additional 7 years for the operations at the Keno District Mill).

The effects characterization for this valued component was provided in Section 7. The relevance to Community Wellbeing is to highlight how noise and visual amenity are the key environmental/physical characteristics of “place.” Changes to viewscape and soundscape have generally been described by residents as creating an industrialized feel to the community that subsequently results in adverse effects to personal and community “sense of place,” as well as causing stress, annoyance, anxiety, and a general diminishment in their enjoyment of property and community. This is described further in Sections 8.4 and 8.5 below.

8.4 Project Effects – Stress, Anxiety, Mental Wellbeing

8.4.1 Overview

Unlike Section 6.0, Human Health, this section describes the overall impact of health to affect community wellbeing. The Proponents activities in the region have resulted in stress and negative impacts to mental

wellbeing for a number of Keno City residents.[136] Three key factors were identified as explicitly resulting in stress, anxiety, and effects to mental wellbeing:

- Environmental health
- Community change
- Social conflict

The above were identified from comments submitted during past assessments, as well as from the Health Impact Assessment completed for Yukon Government in 2012. Residual effects from the previous projects include the perception of contamination, community change (e.g. affecting sense of place), and social conflicts (e.g. relationship with Proponent). The proposed Project is likely to result in adverse effects to these components due to continued effects to visual and auditory amenity, the perception of contamination, and the continuing conflicts generated by the proximity of the ore processing facilities and deteriorating relationship with the Proponent.

8.4.2 Effects characterization and interactions

8.4.2.1 Environmental health

Environmental health or the perception of poor environmental health (e.g. contamination) can result in stress and anxiety, or other effects to mental wellbeing. The HIA (2012) for Keno noted that the perception of contamination can have a serious effect on health, due to stress and anxiety resulting in a deterioration of health as well as lifestyle impacts. Where impacts to environmental health are visible and result in changes to the landscape or viewscape, the severity of these impacts is likely to increase. Residents, for example, concerned about air quality are more likely to be affected by visible dust.

Currently, evidence suggests that residents in Keno City are affected by environmental health concerns. For example, the HIA identified stress and anxiety in a portion of the community related to concerns for environmental health effects, particularly in respect of air quality and drinking water. The Forum summary also shows a concern for the overall environmental health of the region, due to both the historical liabilities and the Proponents activities in the area. Indeed, many of the comments submitted to all three YESAB project assessments speak to the desire to concentrate project activities to previously impacted sites in order to reduce their spatial extent in the region. During the Forum, residents also emphasized a desire for greater reclamation efforts in the Keno Hill Silver District to improve the overall environmental health in the region.

Environmental health concerns for Keno City residents are primarily in relation to air quality and contamination of drinking water resources. These effects were assessed for the Bellekeno Mine Development and Lucky Queen and Onek mines, as well as in Section 6.0 Health (air quality and drinking water). Environmental health is often an important defining feature of a community's sense of place, described further in Section 8.5.

Air Quality

For the previous assessments, air quality monitoring was recommended, including recommendations for the methodology of monitoring to ensure that effects to air quality were accurately identified and mitigated. As well, the Yukon Government Department of Health and Social Services commissioned a

[136] Habitat Health Impact Consulting. (2012). Health Impact Assessment (HIA) for Mining Activities Near Keno City, Yukon. Prepared for: Yukon Government Department of Health and Social Services

Health Impact Assessment (HIA) of Mining Activities near Keno City, Yukon, issued September 30, 2012, that identified several outstanding concerns of residents at that time, including air monitoring type, air monitoring location, the dry stack tailings facility (i.e. track record, perceived long-term risk to community, expansion), and the adequacy of current mitigation measures. The results of the monitoring completed to date, the dust dispersion modeling completed to inform the current Project assessment, and the proposed mitigation by the Proponent address the majority of these concerns, and indicate that the potential adverse effects to air quality from the proposed Project in combination with Lucky Queen and Onek or Bellekeno can be mitigated. However, many residents still express skepticism and a lack of confidence with the monitoring done to date that may be influenced by their experience with increases to visible dust, which is an important social indicator of environmental health.

The proposed Project involves a nearly three-fold increase in the total tonnage of tailings that will be stored on site, covering an additional 3 hectares. As such, though the modeling indicates that actual impacts to health are not likely to be significant, residents perceive this expansion as increasing their risk of exposure to harmful tailings, in part due to their lack of trust that mitigations will be implemented. Due to the residents' lack of trust in the Proponent and regulators, allowing an independent third party to conduct the monitoring and develop the monitoring schedule may increase the comfort level of residents with monitoring results, thus reducing their perception of contamination. However, even with improved monitoring and the implementation of mitigation, short-term and localized events will result in adverse effects to air quality.

Environmental Contamination

Residents have frequently expressed concern for the environmental health of Keno City with respect to metal levels in water and soil resources, including drinking water, as well as the health effects resulting from dust from tailings. Many of these concerns were presented at the April 15, 2014 Engagement Forum in respect of existing historical contamination (e.g. Onek 400 adit), and the potential for cumulative effects resulting from the Proponents activities. The perception of risk to environmental health is therefore likely influenced by existing sources of contamination that already contribute to a negative sense of environmental health in the community. For example, several residents cited the HIA for Mining Activity Near Keno City, Yukon, as contributing to a negative view of environmental health, due to the precautionary recommendations that residents use raised beds for gardening, avoid surface water for irrigation and/or human use, and wash locally-produced produce. As well, residents expressed frustration that more work had not been undertaken by the Elsa Reclamation Development Corporation (ERDC) to address historical contamination, while the fourth ore deposit in five years was going through the assessment and permitting process. Within this context, new sources of potential contaminant loading in proximity to the residential environment, (e.g. through the deposition of heavy metals in dust or ground or surface water contamination), were viewed as cumulative and unacceptable to many residents.

Residual effects of projects both existing and proposed primarily include potential impacts to aquatic resources and drinking water upon the effective implementation of mitigation measures. Although in Section 6.0 Human Health, the Designated Office found that adverse effects to air quality and drinking water could be mitigated, the potential for adverse effects remains, causing stress and anxiety for many residents. For example, the HIA noted that "uncertainty over the potential for permanent damage of the drinking water supply continues to cause stress and anxiety in a portion of the Keno residents."[137]

[137] Habitat Health Impact Consulting. (2012). Health Impact Assessment (HIA) for Mining Activities Near Keno City, Yukon. Prepared for: Yukon Government Department of Health and Social Services

Residents at the Engagement Forum continued to identify contamination as a concern; residents may be more sensitive to this issue given the history of the area and existing contamination sources.

8.4.2.2 Community Change

Community change is a significant source of stress, anxiety, and negative impacts to mental wellbeing. The degree to which community change results in these impacts depend on a variety of factors including the rate of change, whether the change is seen as positive or beneficial, and how much control or input an individual has over the change. The following is an excerpt from the HIA, which identifies several components of community change that have been associated with stress or mental health:[138]

- Changes in the surrounding landscape and environment
- Changes in social networks and support systems
- Changes in governance structures
- Increasing residential proximity to industrial activity
- Individual perceptions of powerlessness and lack of control

These types of changes have occurred in Keno City, evidenced in the anecdotal information provided by residents, and further supported by the Health Impact Assessment. For example, comments relating to the perception of fairness and a lack of trust likely reflect a sense of powerlessness. Similarly, the proximity of industrial activity to the community has been the chief concern among residents during all three of the related assessments of the Proponents Quartz Mining License. In a petition submitted to the Yukon Legislature in 2012, residents cited a fundamental change to the community character as being their primary grievance. Since 2012, at least two residents, (partners), moved away in direct response to this perceived community change.[139] The uncertainty of future plans, including whether the mill site and DSTF will continue to be proposed for expansion, also cause stress and anxiety, as residents do not know what to expect in the future and have little input or control. The residual effects of the Proponents activities, existing and proposed, to community change are described further in Section 8.2.4.

In terms of the landscape and environment, the Designated Office finds that noise is a significant concern for many residents in terms of impact to the soundscape, the associated sense of place, how this may affect tourism (i.e. economic impacts), and its perceived role in the overall change to community character (e.g. the sense of Keno as a “mine site”, residential use and enjoyment).[140] The perception of contamination was also noted as a significant cause of stress and anxiety for a portion of the community, [141]as described above in relation to environmental health.

Potential effects to the local economy, as described above in Section 8.2, are also a significant source of stress and anxiety amongst many residents, due their dependency on tourism, and many of the residents have expressed an interest and preference for a tourism-based economy. Further, potentially adverse effects to tourism businesses that residents have made significant personal investments are likely to cause greater personal stress.

[138] Downey and Van Willigen 2005; Wallerstein, 1992; Marque and Lima, 2011, Albrecht et al., 2007, in Habitat Health Impact Consulting. (2012). Health Impact Assessment (HIA) for Mining Activities Near Keno City, Yukon. Prepared for: Yukon Government Department of Health and Social Services
[139] Comment Submission, Insa Schultenkotter, YOR Document 2013-0161-101-1
[140] Summary of Keno Community Engagement Forum, April 15, 2014, YOR Document 2013-0161-094-3
[141] Habitat Health Impact Consulting. (2012). Health Impact Assessment (HIA) for Mining Activities Near Keno City, Yukon. Prepared for: Yukon Government Department of Health and Social Services

The proposed Project involves the use of the mill and mill site infrastructure for an additional seven years, extending the duration of effects that have resulted in community change to date (e.g. noise, traffic, etc). Therefore, it is expected that the Project will contribute to stress, anxiety, and other effects to mental wellbeing currently experienced by a number of Keno City residents.

8.4.2.3 Social conflict

Comments submitted during the assessment process highlight a poor relationship between many of the fulltime residents and the Proponent. A significant proportion of the concerns heard at the Keno Community Engagement Forum centred on residents' experiences with the Proponent, regulators and the development assessment process. Residents indicated that several terms and conditions had not been enforced, and that the Proponent had not followed the actions outlined in various Management Plans (e.g. Traffic Management Plan). Further, residents indicated that the complaint process has not been clear and/or accessible, with inadequate or no follow-up. While the accuracy of each example may be disputed, the net effect is that residents feel marginalized, disrespected, let-down and angry. Although the experiences of residents are not uniform, the record indicates that over the past five years, their relationship with the Proponent has not improved. Based on the increased uniformity of residents' comments during this assessment, it appears that the relationship has deteriorated. As such, the proposed Project may result in further social conflict where/if trust is not improved.

8.5 Project Effect – Community Character and Sense of Place

8.5.1 Overview

Community character refers to the physical, social and cultural, and economic components of a particular place that give it its essential quality.[142] Different individuals within a community may define aspects of its character differently depending on their own personal values, but there is often important and defining areas of overlap. Changes to community character can affect an individual's sense of "place," with subsequent impacts to wellbeing and quality of life. Sense of place in this context differs slightly from community character, referring to the attachment, belonging, and comfort that residents have to a particular community character.

The primary adverse residual effects to community character identified in this assessment include increased noise, visible dust, traffic, and the changes to the social setting due to conflicts. The key activities contributing to these effects are ore processing facilities and the expansion of the DSTF, as well as the cumulative effects of multiple mines around the community.

8.5.2 Effects characterization and interaction

The potential for effects to community character depends on an individual's understanding or perception of community character, and the meaning of any changes to indicators used to define that community character. In the Keno context, differing views on the community character of Keno City are documented in the assessment record for past assessments, as well as differing views on how projects in the area might affect that character.[143] However, there are some dominant themes from those residents who have described the community character in comment submissions. Themes include its geographic and scenic elements (e.g. surrounding natural environment, rural nature, historical and cultural history, beauty, quiet,

[142] Pivo, G. (1992). How Do You Define Community Character? Adapting the Environmental Impact Statement Process to Snoqualmie, Washington. *Small Town*. 23(3): 4 – 17

[143] Habitat Health Impact Consulting. (2012). Health Impact Assessment (HIA) for Mining Activities Near Keno City, Yukon. Prepared for: Yukon Government Department of Health and Social Services

its "end-of-the-road" quality), and its' socio-economic characteristics (mining town and influences, excellent/impressive tourist attractions).

The biggest tension in the assessment record relates to differences in how mining is perceived to be a part of the community's essential character, with differing views on how this should inform land use decisions. For example, while all residents submitting comments during the Bellekeno assessment expressed support for mining in the region and acknowledged its history in the area, many residents suggested that the proximity of the mill and tailings facility to the town site would affect its character. To this end, several residents contrasted Keno City with Elsa during the Engagement Forum to describe the essential differences in character they contributed to the presence/proximity of ore processing facilities, and the heightened presence of mining.

Notwithstanding any differences in views, the Health Impact Assessment for Mining Activities Near Keno City (2012) concluded that there "is ample evidence to support the contention that the community of Keno has been changing and continues to change in response to recent and planned mining activities,"[144] based on both the assessment record and in-person interviews. The adverse impacts identified from this change (as experienced by a portion of the residents) included the following:

- Changing character of the community – from a quiet and serene tourist setting to a noisy industrial setting
- Decreased enjoyment of living in the area and changes to personal sense of place
- Fear of having little to no control of the industrial activities within and surrounding the community
- Fear of not being able to enjoy one's own property and adjacent lands
- Diminished access and quality of outdoor recreational areas due to traffic, noise, and air pollution and other visual changes to the landscape
- Increased time away from or moving away from the community to avoid effects

The Designated Office finds that the above changes identified in the HIA are consistent with the views submitted during this assessment in respect of both residual effects from existing activities and the effects of the proposed Project.

The Designated Office observed that there was considerable agreement amongst residents present at the Engagement Forum that mining activities near Keno had affected elements important to its character, such as through noise, increased traffic and visible dust. The Summary of Keno Community Engagement Forum summarizes the views of 11 out of the 12-fulltime residents that were present, with one resident having not contributed to the discussions. The frequent characterization of this effect during the Forum was the sense that Keno City was becoming a "mine site," rather than a mining community. This characterization was also used in several individual comment submissions, for which there were eight from residents.[145] Indeed, the language used by many residents to describe the potential effects to community character and sense of place (including several long-time residents), indicate that these changes are perceived as significant, and are viewed by many to be a fundamental change in character. Given that there was no significant mining infrastructure close to Keno since the Mackeno Mill in 1954, it

[144] Habitat Health Impact Consulting. (2012). Health Impact Assessment (HIA) for Mining Activities Near Keno City, Yukon. Prepared for: Yukon Government Department of Health and Social Services. Pg. 41

[145] Comment submission, Blackburn and Bindig, YOR 2013-0161-100-1; Comment Submission, Mike Mancini, YOR 2013-0161-103-1

is perhaps not surprising why many residents would perceive these changes as significant to Keno City's character.

Several Project activities are likely to contribute to an increasing and prolonged industrialized character of Keno City. First, the auditory effects from the Project and existing activities (e.g. from ore hauling, milling, crushing, operation of the DSTF, etc.) described in Section 7 are a key impact to the soundscape of Keno City. A second pathway is from blasting, which may result in vibrations felt by residents and visitors in Keno City. Third, the overall visual and auditory effects from mining activity and increased traffic, including the visible dust created by traffic and road use, and deteriorating road conditions, will contribute to this change in character. The proposed mining activity in conjunction with proposed activities at Lucky Queen and Onek, has caused many residents to use words like "surrounded," "overwhelmed" and "claustrophobic," to describe the effects to their sense of place.

8.5.3 Significance Determination

Although the effects to each component or indicator have been characterized individually, the overlap and linkages between these components result in synergistic effects to Community Wellbeing. For example, the effects of noise and visible dust to the character of the community affects both individual and community sense of place, as well as negatively affecting tourism amenity values. Similarly, the community's relationship with the company and their experience of powerless-ness results in effects to health and wellbeing, such as stress and anxiety, which in turn impacts sense of place, and the experience of effects such as noise. While the effects to each of these indicators individually might not be significant, the Designated Office has determined that the combined effects are significant.

First, residents have stated, based on personal experience with residual effects of existing activities, that adverse effects to their quality of life, to which the Project would contribute and prolong, are significant. Particularly important to the community is the experience of noise and visible dust, and effects to mental wellbeing stemming from changes in community dynamics (e.g. conflicts, ability to fulfill community and personal goals, a part in decision-making about things that affect their quality of life, etc.). These effects were identified by the majority of fulltime residents. Further evidence for the significance of these effects is the petition submitted to the Yukon Legislature in 2012 after the HIA (2012) was completed, signed by nine residents, indicating that the character of Keno City had fundamentally changed, and requesting compensation. As well, two residents have moved away permanently, citing the Proponent's activities and the resultant effects to quality of life as the reason.

Second, the combination of the effects to these indicators has rapidly and dramatically changed the character of the community. For example, as described in Section 7.2 of this Report, low frequency noise may have increased nearly four-fold at sensitive receptor R04. While the actual dBC level may not be considered significant to health, the difference in magnitude from ambient levels is high. The role of noise in changing community character, combined with the increased dust and traffic, has significantly altered many residents sense of place. Similar to noise, TSP data collected suggests that TSP concentrations over a 24-hour period are well below the Yukon Ambient Air Quality Standards, such that health effects to residents are not likely. However, residents stated that visible dust was a significant issue, potentially indicating that the change from baseline (i.e. the magnitude) was a concern for them, particularly in respect of the frequency of visible dust. Residents consistently characterized this change as Keno City turning from a "mining community" into a "mine site" due to impacts from noise, dust, traffic, as well as the general scale of development (e.g. four mine proposals in 5 years). In terms of sense of place, the rate of change can be as important as the scale or type of change. In Keno City residents have noted that the changes (the residual effects of the past projects), occurred relatively rapidly (e.g. in less than two years), with many pointing out the three proposals in less than 5 years to develop four ore deposits, all of which

are in relatively close proximity to the community, (e.g. two are within 500 – 1000 m). The rate and pace of change is significant to sense of place values, as people have less time to adapt to the change, which further increases its magnitude.

The residual effects from previous projects based on past performance by the Proponent and past experiences with the Proponent, has led to increased significance of the magnitude of effects to community wellbeing. For example, the resident's experience of powerless-ness to guide activities that have a direct influence on their community (e.g. not considered a "stakeholder," a sense of not having had a meaningful opportunity to assess/identify alternatives for the siting of infrastructure), has resulted in effects to mental wellbeing (e.g. stress, anxiety, conflicts) and sense of place that reduce the overall social acceptability of effects. As well, the poor relationship with the Proponent and regulators has contributed to a general sense of being marginalized, feelings of mistrust, anger, and resentment, which has significantly affected the Proponent's social license to operate in and around Keno City. These social impacts are adverse residual effects stemming not just from the Proponent's previous projects or activities, but also from the governance processes that facilitate the Proponent's activities and which now make up an important part of the social context in which the Project is proposed. The social context results in a higher magnitude of effects to community wellbeing, as residents are likely to experience a more degraded sense of place from effects such as noise, dust, and changes to community character.

Economic benefits of resource development projects have been shown to sometimes improve aspects of quality of life and/or wellbeing important to people, (such as via jobs, positive demographic change, positive feelings toward company), and/or to increase social acceptability of effects.[146] However, as the majority of residents indicate that there have been little to no direct economic benefits or spin-offs from past projects, any potential positive effects to community wellbeing have not been realized. Further, many residents, due to the importance of tourism to the local economy, view the Project (and in particular the proximity of the mill and DSTF infrastructure as the focal point of mining activity), as posing a significant risk to their local economy. Economic benefits are only one component of community wellbeing, and the importance of this component depends on the community in question (e.g. some communities may place a higher value depending on their needs, employment rate, dependency on resource, etc.). Increasingly, other indicators of wellbeing, such as positive sense of place and environmental health, have been shown to play a significant role in a community's perception and experience of their quality of life. Nonetheless, the absence of any direct benefits to the community in comparison to the effects to quality of life have contributed to the view that there is an inequitable distribution of impacts from previous projects; the inequity of the distribution of adverse effects increases their significance, by reducing social license. (e.g. reduced social license results in a lower tolerance for effects).

Given the above discussion, the Designated Office has concluded that the Project is likely to result in significant adverse effects to Community Wellbeing; the residual effects to community wellbeing have already been significant, without the additional effects from Lucky Queen and Onek mines. The proposed Project will prolong the duration of effects from the mill and mill site infrastructure, such as noise and impacts to community character (e.g. by funnelling mining traffic into the Keno City valley). The duration of effects is long in connection with other projects, as the proposed 7-year operational window will be cumulative with the 5 years to date. Although the mill has not been operational for 5 years, road and mill site construction, mine portal developments, and extensive exploration drilling in close proximity to the

[146] Gross, Catherine. (2007) Community perspectives of wind energy in Australia: The application of justice and community fairness framework to increase social acceptance. *Energy Policy*.35:5 pages 2727 – 2736.

community have also occurred during this period. As such, the resulting cumulative impacts to community wellbeing are for duration greater than 10 years.

In considering how/if these significant adverse effects can be mitigated, the Designated Office considered the extent to which the significance of effects has been influenced by the residents' experiences with the Proponent and the Proponent's past performance. Comments submitted to the YOR for the previous assessments of Bellekeno and Lucky Queen and Onek, as well as for the proposed Project, indicate that these factors are a central concern, and a concern that has become more uniform and/or widespread in the community. With the exception of mitigation for visible dust, and potentially effective mitigation for noise, the key areas where mitigation could still be applied are in relation to the local economy and improving the relationship, trust, and respect between the Proponent and the community. Though there will still be a change in the community character of Keno City, the extent that this change continues to alienate residents may be mitigated (offset) by including residents in the mine planning processes for developments that affect them, and by looking for opportunities to develop and/or enhance economic benefits for residents.

The Mayo Designated Office has determined that the Project will have significant adverse socio-economic project effects on Community Wellbeing. This significance determination is based explicitly on a 7-year operational window for effects lasting until 2021. A longer duration for effects will change this significance determination**.** These effects can be eliminated, reduced or controlled by the application of the following terms and conditions:

The mitigation recommended in Sections 6 and 7 of this Report, including the Proponent's Commitments, as set out in the recommended terms and conditions. However, the mitigation below expands on previous mitigation for socio-economic values.

33. The Proponent shall employ a neutral, third-party mediator with proven education, training and experience in mediation and dispute resolution to administer engagement between the Proponent and the residents of Keno City, to collaboratively develop a Keno City Socio-Economic Mitigation Plan, that includes at least the following components:
    a. The formal identification of socio-economic values affected by the Proponent's activities and specific objectives and actions to meet identified objectives (e.g. noise objectives met through restrictions on air brake use in and around Keno City etc.).
    b. The comprehensive sound monitoring and mitigation plan, the purpose and contents of which are outlined in Section 7.3.3, under term and condition #32 a, b, c, and d.
    c. The establishment of a Communication Protocol to achieve consistency and fairness in the means, method and timing and frequency of communications between the Proponent and residents, including the communication requirements for different activities (notification, meeting, etc.). All communications shall be documented and reported with an agreed upon frequency that is reasonable for both the Proponent and residents.
    d. Inclusion of a formal complaint resolution protocol to be administered by an independent third party to accept and investigate reasonable complaints relating to noise, dust, traffic, and any other concern related to the Proponents activities that may directly affect Keno City residents quality of life, as outlined in the Socio-Economic Mitigation Plan. Government bodies who may have received complaints should also advise the third party charged with receiving complaints. Complaints and any corrective actions shall be documented and reported quarterly with reports distributed to the Proponent, the regulator and the residents of Keno City.

e. The identification and implementation of actions by the Proponent to offset impacts to the local economy from their operations (e.g. from reduced property values, impacts to tourism, etc.).

f. Mitigation for impacts affecting community wellbeing, (including impacts to the local economy, reduced quality of life from noise, etc.), shall include consideration of appropriate compensation.

34. The Keno City Socio-economic Mitigation Plan shall be developed immediately, prior to Project implementation, and shall be reported on annually.

35. To reduce uncertainty, the Proponent shall begin early engagement with the residents of Keno City, via a third-party mediator, to discuss the Proponent's preferred long-term regional plan/vision that includes a transparent assessment of potential future alternatives for tailings and mill site infrastructure. This engagement shall be documented and reported to the regulator.

9.0 RESIDUAL EFFECTS

The residual effects of the Project may still be significant, as there is uncertainty regarding the effectiveness of mitigation to improve the relationship between residents and the Proponent's adjacent mining operations, and whether the application of economic offset mitigations will improve overall Community Wellbeing, particularly given the duration of potential effects (i.e. over 10 years, or a generation). As well, ore extraction and hauling at Lucky Queen and Onek mines have not occurred to date, so the significance of residual effects from these activities are not certain yet. The effectiveness of mitigation also depends on the willingness of both the Proponent and the residents to work together. However, at this juncture, the Designated Office has determined that the successful application of the above mitigation will result in marked improvements to Community Wellbeing to a point that the adverse effects resulting from the Project in combination with the residual effects of past projects will not be significant. The unsuccessful application of the above mitigation measures will result in significant adverse effects to Community Wellbeing.

10.0 CONCLUSION OF THE ASSESSMENT

The Mayo Designated Office has given full and fair consideration to information received during this assessment, as per s. 39 of YESAA. The Mayo Designated Office has also taken into consideration the matters referred to in s. 42(1) of YESAA.

Although the effects to all identified VESECs are predicted to be significant, perhaps the most difficult effects to mitigate will be those to the community of Keno City. Of all components of the Project, the continued operation of the Mill and the expansion of the DSTF are the primary components that will produce significant adverse effects to the community of Keno City. The Proponent and the regulator must begin immediate and directed work to reduce adverse effects to residents of Keno City from the mining operations so close to the community. Community concerns have increased through time, as this is the third assessment of mining operations with direct effects to Keno City. A concerted effort must be made by the Proponent and the regulator to improve relations with the residents of Keno City. The continuation of activities that result in significant adverse effects to residents of Keno City from the Proponent's operations are unacceptable in the absence of effective mitigation.

The mitigations below pertaining to the socio-economic effects of the Project will not achieve real reductions in effects to the residents of Keno City if they are not fully implemented and enforced. In addition, to avoid further significant adverse effects from future projects in proximity to Keno City, the Proponent is advised to make a concerted effort to include residents of Keno City in the planning of those projects to improve relations and achieve project design that produce the lowest possible adverse effects to the community.

Under s. 56(1)(b) of *the Yukon Environmental and Socio-economic Assessment Act*, the Mayo Designated Office recommends to the Decision Bodies that the Project be allowed to proceed, subject to specified terms and conditions. The Designated Office determined that the Project will have significant adverse environmental and socio-economic effects in or outside Yukon that can be mitigated by those terms and conditions.

The terms and conditions of the recommendations are as follows:

1. The Proponent shall revise their site specific water quality objectives (SSWQOs) for As, Cd, Pb, Ag and Zn at station KV-6; for Cd, Pb, Ag and Zn at station KV-7; and for As, Cd, Cu, Pb, Ag and Zn at KV-81 to reflect the typical background concentration (e.g. mean + two standard deviations) at those stations rather than the upper limit of background. The Proponent shall employ the Canadian Council of Ministers of the Environment (CCME 2003) guidelines for the derivation of site specific water quality objectives in the development of SSWQOs with the intent of reducing, to the extent practicable, the release of contaminants at concentrations in excess of the typical water quality for those stations (i.e. non-degradation).

2. The Proponent shall revise their proposed Effluent Quality Standards (EQS) for water quality station KV-104 to reflect the revised SSWQOs developed in mitigation number one (1). The Proponent shall demonstrate to regulators, by way of updated modelling, that the revised EQS will not produce exceedances of the updated SSWQOs in the receiving environment. In addition, the revised EQS shall include standards for ammonia, nitrate, nitrite and selenium.

3. The Proponent shall provide regulators with supporting rationale for the use of the draft United States Environmental Protection Agency water quality guideline for selenium as opposed to the current Canadian Water Quality Guidelines for the Protection of Aquatic Life. The supporting rationale should include a site-specific discussion of selenium concentrations in reproductive tissues of fish in Christal and Lightning Creeks and how these concentrations are related to selenium concentrations in the water.

4. All water discharged from mine de-watering shall be treated through the proposed water treatment plant prior to discharge to the receiving environment at station KV-104.

5. Any future discharge from the Mill Pond shall be treated through the proposed water treatment plant prior to release.

Rationale: Additional contaminant loadings to Christal Creek in excess of water quality guidelines and/or typical background concentrations are not protective of aquatic life and

should not be permitted. It seems inappropriate for the Proponent to be permitted to discharge effluent from the Mill Pond with much higher contaminant concentrations than necessary if a treatment plant exists at the site.

6. In support of the licencing process, the Proponent shall provide regulators with the results of a sensitivity analysis of metal attenuation rates that are lower than predicted by column tests. This analysis shall include a model run assuming no attenuation of metals.
7. In support of the licencing process, the Proponent shall provide regulators with the results of additional depth discrete groundwater monitoring at depths equal to the proposed mine workings to allow for an understanding of the potentiometric groundwater surface to confirm groundwater inflows to the underground workings and the potential for adit discharge at closure. If adit discharge is predicted or cannot be ruled out post closure, the Proponent shall maintain active water treatment on site until the effectiveness of the passive bioreactor can be demonstrated to achieve necessary protection of aquatic life.
8. In support of the licencing process, the Proponent shall provide regulators with the results of additional depth discrete groundwater monitoring with sufficient coverage to determine the groundwater flow in the area of the Flame and Moth Mine and define any groundwater divides that exist.
9. In support of the licencing process, the Proponent shall provide regulators with the results of a sensitivity analysis of their water balance illustrating the effects of estimated maximum and minimum flows (dry and wet years) for all inflows and outflowsof the water balance model.
10. In support of the licencing process, the Proponent shall provide regulators with updated geochemical analysis comparing both non-mineralized and mineralized zones to provide certainty that all of potential contaminants of concern have been identified.
11. The Proponent shall update their Adaptive Management Plan to include reference to the Flame and Moth Mine and corrective actions specific to the Flame and Moth Mine where applicable.
12. The Proponent shall update events 12 and 13 of their Adaptive Management Plan to trigger investigations of sources of contaminants that show trends of increasing contaminant loads before they exceed the water quality objectives to reduce the potential of exceedances and associated significant adverse effects.
13. In support of the licencing process, the Proponent shall provide regulators with an updated Adaptive Management Plan outlining actions to be taken in the event that potentially acid producing or metal leaching waste rock is left on surface during such events as a temporary shutdown of operations.
14. In support of the licencing process, the Proponent shall provide regulators with the results of borehole logs from subsurface investigations in the footprint of the proposed dry stacked tailings storage (DSTF) expansion area. These subsurface investigations should

be sufficient in number to provide representative sampling from across the footprint of the proposed DSTF expansion to support the conclusions of the DSTF design and stability analysis. This subsurface monitoring shall include the installation of stability monitoring equipment, ground temperature cables and groundwater monitoring wells to build adequate baseline data prior to construction. These monitoring systems shall be monitored throughout the design life of the facility.

15. In the event that water is observed in monitoring well BH39 in the existing dry stacked tailing storage facility, this water shall be collected and sent for full metals analysis to confirm its origin. The results of this analysis shall be reported to regulators in a timely manner.

Rationale: This mitigation is intended to inform the ongoing expansion of the DSTF to ensure that all pertinent information is available throughout the development of the new facility.

16. The Proponent shall install a geosynthetic liner beneath the expanded DSTF to contain and capture any seepage that may occur from the facility in future and allow for treatment prior to release to the receiving environment.
17. In support of the licencing process, the Proponent shall provide regulators with a discussion and analysis of the potential effects of blasting at the Flame and Moth Mine to the integrity of long-term monitoring wells and instrumentation in the area of the Mill and DSTF.
18. The Proponent shall implement the revised Dust Abatement and Monitoring Plan, which shall be reflected in an updated Monitoring and Surveillance Plan and Adaptive Management Plan.
19. The Proponent shall monitor levels of TSP, PM10, PM2.5 and metals speciation of TSP.
20. The Proponent shall revise the trigger values for initiating the Adaptive Management Plan to include consideration of the ability to identify events when metal levels in TSP on the site are elevated above health-based criteria. Use of a long-term historical average that is derived from periods without active milling may be an appropriate revision/method for the trigger value.
21. The mitigations with respect to groundwater wells and monitoring identified in Section 5.0 Aquatic Resources must be implemented.
22. The AMP event shall be revised to include the potential for groundwater contamination from Flame and Moth, in addition to Onek 990, until such time as the groundwater flow can be adequately characterized to rule out this possibility. The wording of the AMP event shall be revised to allow for the AMP response to be initiated when there is uncertainty regarding the source of the contamination.
23. The narrative trigger in the AMP should capture increasing trends in concentrations of a wider range of contaminants that proactively mitigates for exceedances to the Canadian Drinking Water Quality guidelines before they occur.

24. In addition to notifying the Water Inspector, residents shall be immediately notified if there are exceedances to any parameters listed in the Canadian Drinking Water Quality Guidelines. Notification shall also include instructions on where to obtain water, if necessary, (e.g. identified back up well), and other information on health-related risks, measures, and actions being taken.
25. A suitable back up well shall be identified and monitored, in addition to other groundwater wells.
26. Blasting shall not be undertaken during unfavourable weather conditions (e.g. westerly winds, lower than average humidity) to avoid deposition of dust on neighbours and the delayed dissipation of visible dust from the atmosphere. The conditions under which blasting shall not be undertaken shall be explicitly identified for the residents of Keno City.
27. In addition to notifications regarding traffic increases, the Proponent shall post and/or notify their operation schedules and potential dust-generating events in a manner that is approved by Keno City residents and that allows sufficient time to plan (e.g. regular meetings, approved posting locations, approved frequency of posting and meetings, etc.)
28. The Proponent shall include a section in their Annual Report for Social Impacts Monitoring, in consideration of monitoring and implementation of mitigation for valued components identified in the Socio-economic Mitigation Plan, including visual aesthetic factors.
29. The DSTF shall be reclaimed in consideration of improving the visual amenity of the site in addition to long-term stability. Visual amenity objectives shall be identified by the community of Keno City.
30. Prior to commencing operations, the Proponent shall install a noise reducing cover over the mill crusher.
31. To reduce impacts from low frequency noise, the Proponent shall not operate the crusher, DSTF track excavator or DSTF packer between the hours of 19:00 and 07:00.
32. The Proponent shall employ a neutral, third party mediator with proven education, training and experience in mediation and dispute resolution to administer engagement between the Proponent and the residents of Keno City to collaboratively develop the following:

a. A comprehensive sound monitoring and mitigation plan that is administered by an independent third party noise specialist and reported on annually as part of the reporting requirements in the Proponent's quartz mining licence. The primary objectives of this plan shall include the development and implementation of a comprehensive and defensible sound monitoring program aimed at monitoring noise, including low frequency noise, at sensitive receptors in the community.

b. Based on ongoing monitoring, the independent noise specialist shall provide the residents of Keno City and the Proponent with a comprehensive list of additional

mitigations available to address concerns of noise from the Proponent's ongoing operations.

c. To address any outstanding concerns of noise, the mediator shall administer discussions between the Proponent and the residents of Keno City to identify reasonable noise reducing mitigations. These mitigations shall include consideration of appropriate compensation as a possible mitigation. The Proponent shall implement noise mitigations including compensation as soon as practicable following identification of appropriate noise reducing measures.

d. The Proponent and residents of Keno City through guidance from a mediator shall develop a noise compliant and resolution protocol to be administered by an independent third party to accept and investigate reasonable complaints of noise. Complaints and any corrective actions shall be documented and reported quarterly with reports distributed to the Proponent, the regulator and the residents of Keno City.

The mitigation recommended in Sections 6 and 7 of this Report, including the Proponent's Commitments, as set out in the recommended terms and conditions. However, the mitigation below expands on previous mitigation for socio-economic values.

33. The Proponent shall employ a neutral, third-party mediator with proven education, training and experience in mediation and dispute resolution to administer engagement between the Proponent and the residents of Keno City, to collaboratively develop a Keno City Socio-Economic Mitigation Plan, that includes at least the following components:

a. The formal identification of socio-economic values affected by the Proponent's activities and specific objectives and actions to meet identified objectives (e.g. noise objectives met through restrictions on air brake use in and around Keno City etc.).

b. The comprehensive sound monitoring and mitigation plan, the purpose and contents of which are outlined in Section 7.3.3, under term and condition #32 a, b, c, and d.

c. The establishment of a Communication Protocol to achieve consistency and fairness in the means, method and timing and frequency of communications between the Proponent and residents, including the communication requirements for different activities (notification, meeting, etc.). All communications shall be documented and reported with an agreed upon frequency that is reasonable for both the Proponent and residents.

d. Inclusion of a formal complaint resolution protocol to be administered by an independent third party to accept and investigate reasonable complaints relating to noise, dust, traffic, and any other concern related to the Proponents activities that may directly affect Keno City residents quality of life, as outlined in the Socio-Economic Mitigation Plan. Government bodies who may have received complaints should also advise the third party charged with receiving complaints. Complaints and any corrective actions shall be documented and reported quarterly with reports distributed to the Proponent, the regulator and the residents of Keno City.

e. The identification and implementation of actions by the Proponent to offset impacts to the local economy from their operations (e.g. from reduced property values, impacts to tourism, etc.).

f. Mitigation for impacts affecting community wellbeing, (including impacts to the local economy, reduced quality of life from noise, etc.), shall include consideration of appropriate compensation.

34. The Keno City Socio-economic Mitigation Plan shall be developed immediately, prior to Project implementation, and shall be reported on annually.

35. To reduce uncertainty, the Proponent shall begin early engagement with the residents of Keno City, via a third-party mediator, to discuss the Proponent's preferred long-term regional plan/vision that includes a transparent assessment of potential future alternatives for tailings and mill site infrastructure. This engagement shall be documented and reported to the regulator.

Appendix A RELEVANT PROPONENT COMMITMENTS

The following is a compilation of relevant commitments proposed by the Proponent that were considered by the Mayo Designated Office because they contribute to the mitigation of significant adverse effects of the project. The inclusion of these commitments was essential to the final determination of whether a specific project effect was determined to be significantly adverse. The recommendation is based on the understanding that they will be reflected as terms and conditions of the Proponent's permit.

Aquatic Resources

- Installation and operation of a water treatment plant
- In-situ treatment of flooded underground at closure
- Installation of a bioreactor at closure to treat seepage and adit discharge
- Compliance monitoring of effluent discharge
- Monitoring of contaminant concentrations in the receiving environment
- Environmental effects monitoring to detect changes in aquatic resources in the receiving environment
- Regular toxicity testing of mine effluent
- Installation of a geosynthetic liner beneath the DSTF

Human Health

In the Project Proposal, AKHM committed to:

- Not operating the expanded DSTF simultaneously with the operation of the current DSTF;
- Having completed the final reclamation of the current DSTF when the expanded DSTF becomes operational

In the Revised Dust Abatement and Monitoring Plan:

- Progressive reclamation of the current and expanded DSTF (such as placement of cover and revegetation);
- Enclosing the crusher and ventilated building (also a term and condition of their current license that has not yet been implemented);
- Regularly applying dust suppressant agents (such as calcium chloride or similar) to unpaved roads;
- Applying a dust suppressant agent (tackifier product) to exposed tailings surfaces prior to progressive reclamation;
- Implementing monitoring for PM10 in addition to TSP, at a frequency of 4 times per month, sampling events at least 4 days apart;

- Relocating air quality monitoring station TSP-1 from its location south-east of the current DSTF to the western limit of Keno City (near receptor R05);
- Implementing an additional air quality monitoring station at the eastern end of Keno City (near receptor R02);
- Continuing air quality monitoring at station TSP-2 which is the historic monitoring station located at the north-west fence line, west of the current DSTF and north of the crusher; and,
- Revising component 17 of the Adaptive Management Plan (AMP) to incorporate TSP data collected in Keno City as well as PM10 data collected at the three sampling sites, and evaluating monitoring results against triggers and thresholds determined during licensing process to identify requirements for additional mitigation.Groundwater Monitoring Plan (further characterization of the groundwater hydrology)
- Component 14 of the Adaptive Management Plan (AMP):
    - Event: A significant increasing trend is observed in groundwater near Keno City trends due to the Onek 990 mine.
    - Narrative Trigger: Total zinc, arsenic or cadmium significantly exceeds baseline measurements for a given monitoring well, or parameters listed in the Canadian Drinking Water Quality Guidelines are exceeded.
    - Indicators: Total zinc, arsenic, cadmium and parameters listed in the Canadian Drinking Water guidelines.
    - Thresholds: Total zinc, arsenic or cadmium exceeds the highest baseline measurement, and exceeds Canadian drinking water quality guidelines.
    - Monitoring locations: Groundwater monitoring wells (ON-MW-02, ON-MW-03, KC-MW-4, KV-84Nd).
    - Response:
        - Notification to the Water Inspector that the trigger has been triggered within three working days.
        - Increased sampling frequency may be required around the area of the exceedence, and will be implemented to help determine potential causes.
        - Quarterly results of the monitoring program will be communicated to the Yukon Government, Keno residents and the First Nation of Nacho Nyäk Dun. Any mitigation measures identified through the meetings with the stakeholders will inform the responses.
        - Investigation of the root cause of the exceedance.
        - If a root cause of exceedence can be readily identified and remedied, the remedy will be implemented in a timely manner, and the water 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.

Visual and Auditory Amenity

Dust:

- Not operating the expanded DSTF simultaneously with the operation of the current DSTF;

- Having completed the final reclamation of the current DSTF when the expanded DSTF becomes operational
- Progressive reclamation of the current and expanded DSTF (such as placement of cover and revegetation);
- Enclosing the crusher and ventilated building (also a term and condition of their current license that has not yet been implemented);
- Regularly applying dust suppressant agents (such as calcium chloride or similar) to unpaved roads;
- Applying a dust suppressant agent (tackifier product) to exposed tailings surfaces prior to progressive reclamation;
- Relocating air quality monitoring station TSP-1 from its location south-east of the current DSTF to the western limit of Keno City (near receptor R05);
- Implementing an additional air quality monitoring station at the eastern end of Keno City (near receptor R02);
- Continuing air quality monitoring at station TSP-2 which is the historic monitoring station located at the north-west fence line, west of the current DSTF and north of the crusher.
- If Keno residents raise concerns about dust from Flame and Moth, Alexco will work with the stakeholders toidentify additional mitigation options.

Traffic and mine infrastructure

- To the extent possible employees will use project bussing and pool transportation from Mayo/Elsa to themine and mill site, thereby reducing overall vehicle traffic. Fleet vehicles will be utilized by staff as necessary;
- Alexco will continue to work with tourism and heritage representatives and the community to develop signage to be installed along the Silver Trail Highway to Keno and within Keno that shows a road/trail map of the area indicating the roads that are in active mining use, identifies key tourist features, and lists generalsafety precautions and traffic management procedures for active roads.
- Progressive reclamation and revegetation pursuant to sections 6.1 (Progressive Reclamation) and 6.2 (Revegetation) of the Preliminary Reclamation and Closure Plan
- Reclamation of the mill area and ancillary facilities, and the DSTF, “to an aesthetically acceptable level,”[147] as per Section 7.6 and 7.7 of the Preliminary Reclamation and Closure Plan.
- Blasting at the Flame and Moth surface portal will only be conducted during the dayshift period (7am to 7pm) until the portal reaches a distance of 20 m underground. At the point 24 hour blasting will occur. A community notification protocol will be developed and posted within Keno City outlining blasting schedules during the initial portal development.
- Noise silencer or enclosure will be part of the ventilation fan for Flame and Moth Portal.

[147]Alexco Keno Hill Mining Corp., Preliminary Reclamation and Closure Plan, Section 7.6, page 45, YOR Document 2013-0161-045-1

- The use of existing bypass roads around Keno City will continue.
- Access to the Flame and Moth Mine will be routed through Christal Lake Road.
- The use of engine brakes will be avoided in the vicinity of Keno City.
- Flame and Moth Mine traffic management protocols have been incorporated in the revised draft Traffic Management Plan.

Appendix B REFERENCES

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