KENO HILL SILVER DISTRICT MINING OPERATIONS

NOISE MONITORING AND MANAGEMENT PLAN

February 2021

Prepared by:

Alexco Keno Hill Mining Corp.

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1. INTRODUCTION

1.1 PROJECT SUMMARY

Alexco Keno Hill Mining Corp. (AKHM) is permitted to operate the Keno District Mill as well as the Bellekeno, Bermingham, Lucky Queen, Onek 990 and the Flame & Moth mines in the vicinity of Keno City, Yukon. The site is accessible by highway and access roads. The Flame & Moth Mine is currently in development and the mill is being recommissioned. Development activities that occurred at Flame & Moth in 2020 include installation of portal heater, installation of a booster fan underground and slushing in existing remuck for underground shop. Development of the Bermingham Mine is also ongoing. Lucky Queen and Onek are inactive and currently not authorized under Water Licence QZ18-044. This Noise Monitoring and Management Plan (the Plan) has been developed to address any potential noise effects that may occur with the active operations of the mines and Keno District Mill. The Plan was developed in consultation with Keno City residents prior to commencing operations.

1.2 SCOPE AND OBJECTIVES

The Plan was based in part on a Noise Impact Assessment (NIA) completed by Patching Associates Acoustical Engineering Ltd (PAAE) and conducted during the *Yukon Environmental and Socio-Economic Assessment Act* (YESAA) process (Project 2011-0315 – Lucky Queen and Onek Deposit Production {Yukon Government, 2012}). The present update to the Plan also considers a more recent NIA by PAAE conducted during the YESAA process (Project 2013-0161 – Flame & Moth Development and Production Program (Yukon Government, 2014)), as well as on a PAAE review of a noise monitoring memorandum by Access Consulting Group (PAAE, 2014b).

The NIA identified the noise sources from the Bellekeno and Flame & Moth mining-related activities, noise receptors, and predicted the anticipated noise level from all existing sources and those associated with Flame & Moth mining operations.

The objective of this plan is to describe best management practices and noise mitigation measures that will be employed to minimize noise and to track noise disturbance claims. AKHM committed to monitoring noise levels within the community at various locations to assess noise levels and to determine if the noise abatement measures are effective.

Section 2 of this Plan outlines noise sources from the Bellekeno, Bermingham, and Flame & Moth mines, Keno District Mill operations, and section 3 identifies noise receptors within Keno City. Section 4 summarizes the measures to mitigate potential noise-related impacts. The approach to noise management, through monitoring, creating a Noise Disturbance Registry, and reporting protocols, is described in Section 5.

1.3 RESPONSIBILITIES

The Mine Manager or appointed designate is responsible for the effective implementation of the Noise Monitoring and Management Plan, providing the resources needed for the implementation and continual improvement of the Plan.

2. POTENTIAL NOISE SOURCES

The NIA identified potential noise generators for the operation of the Bellekeno, Onek and Lucky Queen mines, and the development and operation of the Flame & Moth mine in the KHSD.

The following are the potential noise sources during mine operation include:

- Bellekeno mine operations;
- Flame & Moth mine operations;
- Keno District Mill;
- Onek 400 Level Adit Water Treatment Plant;
- Trucking activity and traffic noise (up to 2 km away from Keno City centre):
    - Wernecke Road;
    - Christal Lake Road;
    - Silver Trail Highway;
    - Keno City Bypass Road;
    - Bellekeno Haul Road; and
    - Flame & Moth Haul Road.

Noise sources associated with mine operation include portal fan and compressor, blasting, underground haul truck traffic to and from surface, and heavy and light vehicles to and from the mill via Calumet Road.

2.1 TRAFFIC ROUTING AND VOLUMES

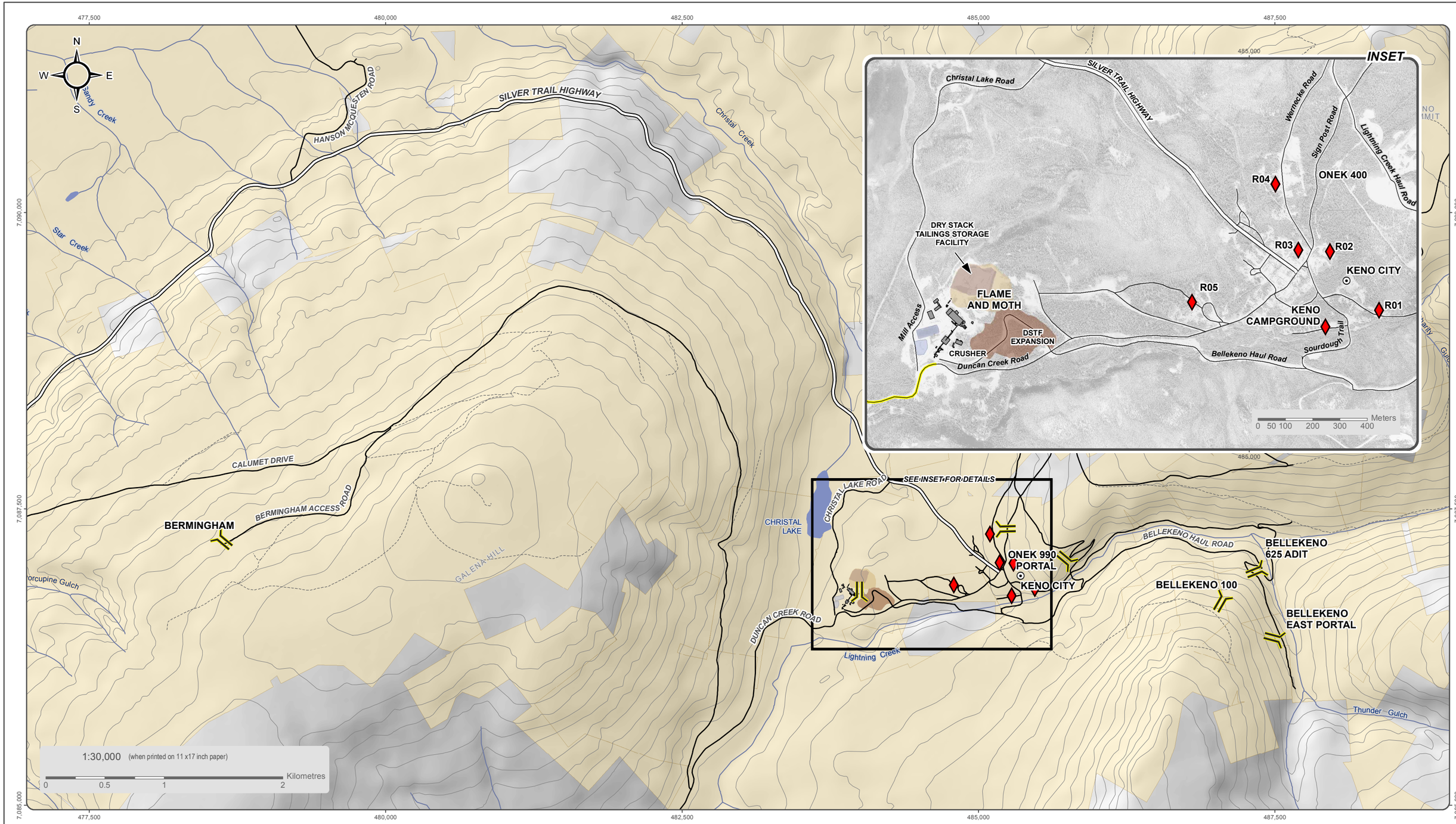
Mine traffic associated with the Flame & Moth mine will use the Christal Lake Road and a short haul road (~175 m) constructed between the portal and the crusher pad, as shown in Figure 1. The Bellekeno Project Bypass Road North is re-routed to allow development of the dry stack tailings facility (DSTF) expansion. As the mine operations at Flame & Moth begin, traffic from other deposits are expected to decrease, and the net level of traffic for the district should remain the same. A decrease in traffic along the Bellekeno Bypass Road is expected during Flame & Moth operations as Bellekeno mine operations are expected to be completed by that time. There will be no additional traffic through Keno City for the Flame & Moth Mine.

Table 1 summarizes the volume of traffic in the Keno City area for the mine development phase at Flame & Moth. These estimates are for traffic in/out of the Christal Lake Road since this is the only access road envisioned for the Flame & Moth Mine.

Table 1: Estimated Traffic During Development – Flame & Moth

Vehicle Type	Average Traffic Volume (roundtrips/week)
Light Truck	50
Water truck	3
Sewage truck	2
Semi trailer loads (mining equipment, building supplies, construction equipment, etc.)	7
Grader	1
Total	**63**

The Flame & Moth mine is currently in development and will run concurrently with the Bermingham Mine. Estimated traffic volumes associated with mining activities at Flame & Moth and Bermingham are shown in Table 2 and Table 3, respectively. Mine traffic associated with the Flame & Moth mine will use the Christal Lake Road and a short haul road (~175m) between the portal and the crusher pad, as shown in Figure 1, while traffic associated with Bermingham will use the Christal Lake Road and the road between Bermingham and the crusher.



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

Satelite imagery obtained from Yukon Geomatics map service http://mapservices.gov.yk.ca/ArcGIS/services on January 2018

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

- Noise Monitoring Station
- Alexco/ERDC Quartz Claims
- Mill Pond
- DSTF Phase II Expansion
- DSTF 322k Tonnes Design
- Current DSTF
- Existing Building
- Waterbody
- Watercourse
- Silver Trail Highway
- Other Road
- Limited-Use Road

AKHM

Alexco Environmental Group

ALEXCO KENO HILL MINING CORP.

FIGURE 1

NOISE SOURCES AND RECEPTORS

JULY 2018

D:\Project\All\Projects\Keno_Area_Mines\ALL-SITES\02-Map\04-Studies\Air_Noise_Dust\Noise_Monitoring_Stns_ _Berm_Extent_20180704.mxd

(Last edited by: amalishevska,04/01/2018/14:21 PM)

Table 2: Estimated Daily Traffic Count – Flame & Moth

		Shift Change	Day Shift	Shift Change	Night Shift
Vehicle Type – One way traffic count	**Travel Direction**	**6 am – 8 am**	**7 am – 7 pm**	**4 pm- 6 pm**	**7 pm – 7 am**
Light Trucks (< 1 ton) and Autos	Elsa to Mine/Mill	4	8	4	6
Buses	Elsa to Mine/Mill	2		2	
Heavy Trucks (>5 tonne) bulk materials	Elsa to Mine/Mill		3		
Ore Trucks (>20 tonne) hauling ore	Mine to Crusher		14		
Ore Trucks (>20 tonne) hauling tailings or empty	Crusher to Mine		14		
Total round trips per day		**6**	**39**	**6**	**6**

Notes:

1) Warehouse receiving and shipping normally confined to hours between 8 am and 4 pm. This will minimize heavy traffic during shift changes. Normally no heavy truck deliveries on night shift.
2) Bulk materials include fuel, reagents, materials, supplies and concentrate haulage.
3) Above values are considered typical of daily traffic anticipated during operations. Variations up to 50% are possible on any given day.
4) Based on 408 t/d production rate which results in highest ore haulage traffic count.

Table 3: Estimated Daily Traffic Count – Bermingham

		Shift Change	Day Shift	Shift Change	Night Shift
Vehicle Type – One way traffic count	**Travel Direction**	**6 am – 8 am**	**7 am – 7 pm**	**4 pm- 6 pm**	**7 pm – 7 am**
Light Trucks (< 1 ton) and Autos	Elsa to Mine/Mill	4	12	4	6
Buses	Elsa to Mine/Mill	2		2	
Heavy Trucks (>5 tonne) bulk materials	Elsa to Mine/Mill		3		
Ore Trucks (>20 tonne) hauling ore	Mine to Crusher		8		
Ore Trucks (>20 tonne) hauling tailings or empty	Crusher to Mine		8		
Total round trips per day		**6**	**31**	**6**	**6**

Notes:

1) Warehouse receiving and shipping normally confined to hours between 8 am and 4 pm. This will minimize heavy traffic during shift changes. Normally no heavy truck deliveries on night shift.
2) Bulk materials include fuel, reagents, materials, supplies and concentrate haulage.
3) Above values are considered typical of daily traffic anticipated during operations. Variations up to 50% are possible on any given day.
4) Based on 408 t/d production rate which results in highest ore haulage traffic count.

3. NOISE RECEPTORS

Five locations were selected in the NIA as being potential noise receptors within the 2 km radius study area around Keno City, listed in Table 4. The same locations are used to monitor for noise during the mine and closure phases of the mine. Bermingham mine is approximately 5 km away from Keno City on Galena Hill, therefore it remains outside the study area.

Table 4: Representative Locations Assessed in Keno City from the Noise Impact Assessment

Residence	GPS Location	Description
R01	N63.90827 W135.29599	East end Residence, north side of Lightning Creek Road
R02	N63.91019 W135.29968	Residence, east side of Sign Post Road
R03	N63.91023 W135.30205	Town Center, north from the Snack Bar
R04	N63.91239 W135.30376	Residence, west side of Wernecke Road
R05	N63.90851 W135.30993	Residence, about 850 m east from the Mill

The background noise levels experienced by these locations vary considerably, depending on location and local activities. Noise levels from current mining operations will be in addition to normal fluctuations in background levels. Climate parameters, such as relative humidity, temperature, and temperature inversions impact the sound level and propagation experienced by each of these receptors.

4. NOISE MITIGATION MEASURES

4.1 MITIGATIONS COMMITTED TO BY AKHM

AKHM commits to the following measures that mitigate potential impacts associated with noise:

- All traffic related to project operations that must use the bypass road. No traffic related to the operations will enter Keno City unless Keno City is the destination;
- All traffic related to the Bermingham development will remain a minimum of 500 m from the Keno City Campground;
- Under normal operating conditions, there will be no ore haulage to/from Onek between the hours of 19:00 and 07:00;
- The compressor at Onek and Flame & Moth will be housed in a sound dampening enclosure;
- The cone crushing plant is covered with an enclosed building or sprung cover structure similar to the fine ore stockpile cover, or similar enclosure;
- To reduce impacts from low frequency noise, under normal conditions the crusher will not be operated between the hours of 19:00 and 07:00;
- Limiting use of air-brakes in and around Keno where possible;
- Taking regular sound level measurements at the facility and mining areas to determine if there are any significant changes to sound emanating from the facility;
- Equipping facility related vehicles including heavy and light trucks with appropriate mufflers;
- Advising nearby residents of significant loud activities and schedule these loud events during daytime hours of 07:00 to 17:00;
- Ensuring all internal combustion engines are fitted with appropriate muffler systems;
- Maintaining a noise control standard when procuring equipment; and,
- Keeping record of any noise complaints filed by area residents. In the event that a valid noise complaint is received, respond promptly through the completion of a noise complaint investigation.

Additional mitigations could be triggered as a result of a noise complaint investigation, such as:

- A common source of annoyance is 'back-up beeper' warning devices. A broad-band beeper can be used instead of pure-tone devices which have been more common, as these have been found to be effective in reducing potential annoyance; and,
- Acoustical screening from berms to shield receivers from equipment noise.

5. NOISE MANAGEMENT

An effective noise management system consists of noise monitoring, a Noise Disturbance Notification and Registry process, and a reporting process. AKHM engaged Keno City residents on this Noise Monitoring and Management Plan in summer of 2020. Any subsequent engagements will be summarized and included as part of the QML annual report.

5.1 NOISE MONITORING

5.1.1 MONITORING EQUIPMENT

The noise monitoring profiles is measured using a Casella CEL-63X Sound Level Meter and a Casella CEL-495 Microphone. The microphone is mounted on a tripod at approximately 1.5 meters above ground and surrounded by a windscreen provided by Casella for use with the microphone to reduce wind impacts as required for outdoor sound measurements. The sound level meter and battery power source are housed inside a weather-proof case which is held in a locked metal box for extra security. Parameters including wind speed, wind direction, temperature and precipitation data from the Flame & Moth Meteorological Station, on top of the DSTF, associated with each noise monitoring event will be reported as these can have a significant effect on measured noise levels. Any notable noise sources associated with the monitoring event will also be documented where possible.

5.1.2 MONITORING PLAN

Noise monitoring is converted to 24-hr periods on a monthly basis, using a Casella CEL-63X Sound Level Meter and Casella CEL-495 microphone (which includes a wind screen for outdoor use). Longer sampling periods are recommended by PAAE (PAAE, 2014a), as well as measurement of equivalent sound level (Leq), percentile noise levels, octave and 1/3 octave band readings recorded. The isolation of contaminated noise sources is facilitated by the use of statistical noise levels in addition to Leq. This instrument also allows for the monitoring of low frequency noise (C-scale), which can now also be considered when assessing noise impacts. In addition, noise monitoring will also be carried out on site to evaluate occupational exposure of workers.

Additional changes to the monitoring plan include detailed recording of mining intensity and wind conditions at time of noise measurements and use of weather-proof cases in the event of cold temperatures to maintain the calibration of the meter. Additionally, AKHM will conduct instantaneous monitoring at specific locations if it is warranted by a noise complaint.

5.2 NOISE DISTURBANCE NOTIFICATION

In accordance with term and condition #47 of the YESAA Decision Document for project 2011-0315 (Yukon Government, 2014) and condition 10 of YESAA Decision Document for project 2017-0176 (Yukon Government, 2018), AKHM provided Keno City residents with a means to formally complain of noise disturbance. AKHM has created a Noise Disturbance Register to track noise disturbance claims. Appendix B presents a Disturbance Notification Form for residents. Copies of the Disturbance Notification Form are available at the Keno City Library or will be sent to Keno City residents upon request. Residents can request a form by emailing contactus@alexcoresource.com or calling 647-519-3537 with their complaints.

Noise disturbance incidents are investigated on a case-by-case basis. Responses to a noise disturbance claim will be based on the nature of the claim and may include (but are not limited to):

- AKHM will record the noise disturbance claim in the Disturbance Notification Register and will notify the complainant that the claim has been recorded;
- If warranted, AKHM personnel will conduct an onsite visit to further investigate the noise disturbance;

- AKHM personnel will attempt to link the identified noise disturbance with a source (a specific event or activity conducted as part of mining or construction) and will determine what measures may be taken to lessen the noise generation;
- If warranted, AKHM will conduct a follow-up visit over the duration of the noise generating event to determine whether the noise levels have been sufficiently decreased; and
- AKHM will then report back to the community and regulators.

5.3 REPORTING

Noise monitoring results are summarized and reported on a quarterly basis and provided to Keno City residents and YG Energy, Mines and Resources. A summary of community engagement and any noise complaints recorded over the same time period provided through submissions of the Disturbance Notification Form will be included with the monitoring results.

Based on the results of the monitoring and in discussion with the above-listed parties, additional mitigation measures, or adaptive management strategies will be identified and implemented as required.

5.4 EFFECTS MONITORING

Decision Document term and condition #45 stipulates effects monitoring of noise emissions in relation to impacts to local businesses. As detailed in Section 5.1 and 5.3, ongoing noise monitoring within Keno City is carried out and results submitted to stakeholders on a quarterly basis. The noise monitoring stations are located throughout Keno City and in proximity to local businesses, providing sufficient coverage to effectively monitor noise within the community. Furthermore, the Disturbance Notification form includes a field for the complainant to describe any effect on his/her business deriving from a specific noise event. Section 5.2 above describes the measures that will be undertaken to address a noise disturbance claim. Based on the results of the monitoring, and in discussion with the above-listed parties, additional mitigation measures or adaptive management strategies will be identified and implemented as required.

6. REFERENCES

Patching Associates Acoustical Engineering Ltd. (PAAE), 2014a. Noise Impact Assessment Update, Alexco Keno Hill Mining Corp., Proposed Flame & Moth Mine Project, Yukon Territory. Prepared for Yukon Environmental and Socio-Economic Assessment Board (YESAB), September 23, 2014.

Patching Associates Acoustical Engineering Ltd. (PAAE), 2014b. Review of Report from Access Consulting Group on Behalf of Alexco Resource Corp. Flame & Moth Project and June12, 2014 Response to YESAB IR, With Review of the Keno Noise Monitoring Document Review - YESAB March 2009. July 10, 2014.

Yukon Government, 2012. YESAA Decision Document. Lucky Queen and Onek Deposit Production. Project number 2011-0315.

Yukon Government, 2014. YESAA Decision Document. Flame & Moth Development and Production Program. Project number 2013-0161.

Yukon Government, 2018. YESAA Decision Document. Bermingham Development and Production Program. Project number 2017-0176.

APPENDIX A

NOISE IMPACT ASSESSMENT – KENO HILL SILVER DISTRICT OPERATIONS (PATCHING ASSOCIATES ACOUSTICAL ENGINEERING, 2014)

Noise Impact Assessment Update
Alexco Keno Hill Mining Corp.
Proposed Flame and Moth Mine Project
Yukon Territory

Rev 1

Prepared for:
Yukon Environmental and Socio-Economic Assessment Board (YESAB)

Prepared by:

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Patching Associates Acoustical Engineering Ltd.

Consultants in Acoustics, Noise Control and Vibrations

September 23, 2014

File: 2014-4090

Notice

This report has been prepared by Patching Associates Acoustical Engineering Ltd (PAAE) in response to a specific request for service from, and for the exclusive use of, the Client to whom it is addressed. The findings contained in this report are based, in part, upon information provided by others. The information contained in this study is not intended for the use of, nor is it intended to be relied upon, by any person, firm, or corporation other than the Client to whom it is addressed, with the exception of the applicable regulating authority to whom this document may be submitted.

PAAE accepts no liability or responsibility for any damages that may be suffered or incurred by any third party as a result of the use of, reliance on, or any decision made based on this report.

Abbreviations

AKHM.....Alexco Keno Hill Mining Corp
ASL .....Ambient Sound Level
CSS ..... Comprehensive Sound Survey
dBA.....A-Weighted deciBel
dBC.....C-Weighted deciBel
ISO .....International Organization for Standardization
L_{eq} ..... Energy Equivalent Sound Level
PAAE..... Patching Associates Acoustical Engineering Ltd.
YESAB.....Yukon Environmental and Socio-Economic Assessment Board

Project Nomenclature

Existing Project..... Bellekeno Mine and Keno District Mill
Proposed Project .....Flame and Moth Mine
Planned Projects ..... Onek and Lucky Queen Mines

Executive Summary

Patching Associates Acoustical Engineering Ltd. (PAAE) was retained by the Yukon Environmental and Socio-Economic Assessment Board (YESAB) to complete a noise impact assessment update for the proposed Alexco Keno Hill Mining Corp (AKHM) Flame and Moth Mine together with the current operations (i.e., existing Bellekeno Mine and Keno District Mill) and the planned Onek and Lucky Queen operations (previously announced planned projects undergoing regulatory permitting and licensing) in the Keno Hill Silver District located around the Keno City, 354 km north of Whitehorse, Yukon. This current study is an update to the previously completed evaluation completed by PAAE in July 2012 (PAAE File: 2012-3379; YESAB Online Registry File: 2011-0315-126-1).

The primary objectives of the study is to include the noise sources associated with the Proposed Flame and Moth project to those modelled in July 2012 by PAAE for the existing Bellekeno Mine and Keno District Mill, and the planned Onek and Lucky Queen operations – these are designated as the 'Current Mining Operations' as assessed in our previous report in 2012. The proposed Flame and Moth mine portal is located approximately 1 km southwest of Keno City and approximately 50 m from the Keno District Mill, and is designated as the 'proposed operations'

The sound power levels emitted from the existing, planned and proposed facilities were determined through the use of field measurements obtained by PAAE in 2012, manufacturer's data and theoretical calculations. These values were then used to model the installation and the surrounding area to determine the expected noise level at the receivers located in Keno City. The modeling was performed using the CadnaA noise-modeling package.

This analysis used the data from the 2012 PAAE monitoring, rather than the measurements taken by the Access Consulting Group, as the later measurements were presented as single number, 10-minute readings with no way to assess potential contamination from other nearby sources such as traffic. Some sources of this kind were reported in their report, but not quantified. The Access data was reviewed in a report by PAAE and presented to YESAB in July of 2014.

The following tables summarise the Predicted Sound Levels based on the daytime and nighttime normal operations of the project in the Keno City district mining area.

Table A: Summary of Predicted Sound Levels Generated by AKHM 'Current Mining Operations' (As Defined Above) Under Downwind Conditions (Daytime)

Residence	Predicted Facility Sound Levels Day-Time* (dBA)	Measured Ambient Sound Levels (dBA)	Predicted Sound Levels Day-Time plus Ambient Sound Levels (dBA)
R01	29	39	**39**
R02	30	35	**36**
R03	30	27	**32**
R04	31	34	**36**
R05	31	32	**34**

Note: *Predicted Facility Sound for current mining operation includes noise from the existing Bellekeno Mine and Keno District Mill.

Table B: Summary of Predicted Sound Levels Generated by AKHM 'Current Mining Operations' (As Defined Above) Under Downwind Conditions (Daytime)

Residence	Predicted Facility Sound Levels Night-Time* (dBA)	Measured Ambient Sound Levels (dBA)	Predicted Sound Levels Night-Time plus Ambient Sound Levels (dBA)
R01	19	38	**38**
R02	15	28	**28**
R03	23	26	**28**
R04	24	30	**31**
R05	13	–	**–**

Note: *Predicted Facility Sound for current mining operation includes noise from the existing Bellekeno Mine and Keno District Mill.
"—" indicates that the measured nighttime ambient sound level is not valid as per the 2012 comprehensive sound survey report.

Table C: Summary of Predicted Sound Levels Generated by AKHM 'Current Mining Operations' including Proposed Flame and Moth Mine under Downwind Conditions (Daytime)

(Assessment based on the implementation of the Onek Sign Post Portal Option and Planned North Bypass Road)

Residence	Predicted Facility Sound Levels Day-Time (dBA)	Measured Ambient Sound Levels (dBA)	Predicted Sound Levels Day-Time plus Ambient Sound Levels (dBA)	Predicted Sound Level Increase Above the Current Sound Level* (dB)
R01	29	39	**39**	**0**
R02	30	35	**36**	**0**
R03	32	27	**33**	**1**
R04	35	34	**38**	**2**
R05	32	32	**35**	**1**

Note: * This is the predicted sound level increase above the current sound level shown in Table A.

Table D: Summary of Predicted Sound Levels Generated by AKHM 'Current Mining Operations' including Proposed Flame and Moth Mine under Downwind Conditions (Nighttime)

(Assessment based on the implementation of the Onek Sign Post Portal Option and Planned North Bypass Road)

Residence	Predicted Facility Sound Levels Day-Time (dBA)	Measured Ambient Sound Levels (dBA)	Predicted Sound Levels Nighttime plus Ambient Sound Levels (dBA)	Predicted Sound Level Increase Above the Current Sound Level* (dB)
R01	21	38	**38**	**0**
R02	19	28	**29**	**1**
R03	26	26	**29**	**1**
R04	30	30	**33**	**2**
R05	23	–	**--**	**-**

Note:* This is the predicted sound level increase above the current sound level shown in Table B.
"—" indicates that the measured nighttime ambient sound level is not valid as per the 2012 comprehensive sound survey report.

Table E: Summary of Predicted Sound Levels Generated by AKHM 'Current Mining Operations' including Proposed Flame and Moth Mine under Downwind Conditions (Daytime)

(Assessment based on the implementation of the Onek 990 Portal Option and Planned Keno City Bypass Road)

Residence	Predicted Facility Sound Levels Day-Time (dBA)	Measured Ambient Sound Levels (dBA)	Predicted Sound Levels Day-Time plus Ambient Sound Levels (dBA)	Predicted Sound Level Increase Above the Current Sound Level* (dB)
R01	30	39	**39**	**0**
R02	30	35	**36**	**0**
R03	31	27	**32**	**0**
R04	32	34	**36**	**0**
R05	31	32	**35**	**1**

Note: * This is the predicted sound level increase above the current sound level shown in Table A.

Table F: Summary of Predicted Sound Levels Generated by AKHM 'Current Mining Operations' including Proposed Flame and Moth Mine under Downwind Conditions (Nighttime)

(Assessment based on the implementation of the Onek 990 Portal Option and Planned Keno City Bypass Road)

Residence	Predicted Facility Sound Levels Day-Time (dBA)	Measured Ambient Sound Levels (dBA)	Predicted Sound Levels Nighttime plus Ambient Sound Levels (dBA)	Predicted Sound Level Increase Above the Current Sound Level* (dB)
R01	22	38	**38**	**0**
R02	19	28	**29**	**1**
R03	24	26	**28**	**0**
R04	27	30	**32**	**1**
R05	19	–	**--**	**-**

Note: * This is the predicted sound level increase above the current sound level shown in Table B.
"—" indicates that the measured nighttime ambient sound level is not valid as per the 2012 comprehensive sound survey report.

The results of this assessment indicate that the predicted cumulative sound level from the operations of the proposed Flame and Moth mine together with the existing AKHM current operations (i.e., existing Bellekeno Mine and Keno District Mill), and the planned Onek and Lucky Queen projects, is expected to have negligible changes in sound level increase at the assessed residences under downwind conditions when compared to the current situation. This assumed all of the surface equipment running simultaneously and at full power level.

The predicted cumulative effects from the different mining operations including the proposed Flame and Moth mine will result in a negligible increase in A-weighted sound levels for the Keno City residences. The most impacted residence is R04, which is also the closest residence to Onek portal site, will have 3-4 dBA increase of sound level based on measured ambient sound level and 2 dBA increase based on current sound level. The level of low-frequency sound may cause some annoyance.

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Introduction

Patching Associates Acoustical Engineering Ltd. (PAAE) was retained by the Yukon Environmental and Socio-Economic Assessment Board (YESAB) to complete a noise impact assessment update for the proposed Alexco Keno Hill Mining Corp (AKHM) Flame and Moth Mine together with the current operations (i.e., existing Bellekeno Mine and Keno District Mill) and the planned Onek and Lucky Queen operations (previously announced planned projects undergoing regulatory permitting and licensing) in the Keno Hill Silver District located around the Keno City, 354 km north of Whitehorse, Yukon. This current study is an update to the previously completed evaluation completed by PAAE in July 2012 (PAAE File: 2012-3379).

The primary objectives of the study is to include the noise sources associated with the Proposed Flame and Moth project to those modelled in July 2012 by PAAE for the existing Bellekeno Mine and Keno District Mill, and the planned Onek and Lucky Queen operations – these are designated as the 'Current mining operations' as assessed in our previous report in 2012. The proposed Flame and Moth mine portal is located approximately 1 km southwest of Keno City and approximately 50 m from the Keno District Mill, and is designated as the 'proposed operations'.

Noise Criteria

Relative noise Level Increase

A variety of sources in natural, industrial, and community settings generate sound. In general, noise is defined as unwanted sound. Hearing damage is the most serious effect of noise, but the nuisance of particular sound characteristics may diminish the quality of life for those affected by the noise.

Research into the human perception of changes in sound level indicates the following:

- 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.

A doubling or halving of acoustic energy will change the resulting sound level by 3 dB, which corresponds to a change that is just perceptible. In practice, this means that a doubling of traffic volume on a roadway, doubling the number of people in a stadium, or doubling the number of wind turbines in a wind farm will, as a general rule, only result in a 3 dB, or just perceptible, increase in noise.

In order to facilitate design and discuss the potential impact for this project and in recognition of the suburban (semirural) nature of the immediate area near the existing, planned and proposed mining operations, all the typical equipment for the current, planned and proposed mining operations need to be considered, which include Bellekeno, Lucky Queen, Onek, Flame and Moth, the mill operations and the associated trucking activity and traffic noise.

The sound level increase from current mining operations will be quantified to evaluate the noise impact to the Keno City residents. The total cumulative sound level experienced in the Keno City residential area will be mining facility level combined with measured ambient noise level. The existing planned and proposed mining operations should not cause significant noise level increase above current conditions.

Transient vs. Continuous Noise (L_{eq} average)

The predicted sound level is an L_{eq} value, which is the 'equivalent-continuous' sound level. This index is an energy average of the varying sound levels over a specified period. The use of this index permits the description of a varying sound level environment as a single number. As the L_{eq} is an "average" level, the measured sound level may exceed the criterion level for a short period, provided that the duration is limited. Transient factors such as equipment start-ups, shut-downs, back-up beeping or unstable environmental propagation may cause the sound level to fluctuate and potentially exceed the criterion level for short periods. The L_{eq} value considers both the sound level and the length of time that the sound level occurs and higher level periods are acceptable as long as the duration is short. All of the sound levels discussed in this study are L_{eq} sound levels and the values presented and the "average" sound level a receiver would experience from day to day, night to night, and month to month. Appendix A provides a detailed explanation of the L_{eq} index.

For this evaluation, both the A-weighted scale and the C-weighted scale were used. Both scales address all frequencies in the human hearing range, but the C scale emphasizes lower frequencies more than does the A scale, and the difference between the levels measured on the two scales gives a simplified assessment of the low-frequency content of the sound.

Ambient Sound Level

In order to determine the existing sound environment and ambient sound level at the residences of interest in Keno City, PAAE conducted a comprehensive sound level (CSS) measurement at five different residential monitoring locations between June 25, 2012 and June 29, 2012. For more information on the CSS results, please refer to the Comprehensive Sound Survey report prepared for Yukon Environmental and Socio-Economic Assessment Board by PAAE on July 26, 2012 (PAAE File Number: 2012-3379; YESAB Online Registry File: 2011-0315-126-1). The ambient sound levels determined in this field survey for the five residences of interest have been used in this study for the completion of cumulative effects assessment of the potential noise impacts of the projects on residences in Keno City.

This analysis used the data from the 2012 PAAE monitoring, rather than the measurements taken by the Access Consulting Group, as the later measurements were presented as single number, 10-minute readings with no way to assess potential contamination from other nearby sources such as traffic. Some sources of this kind were reported in their report, but not quantified. The Access data was reviewed in a report by PAAE and presented to YESAB in July of 2014.

Project Study Area

The project study area is located around Keno City, a community of approximately 20 persons 354 km north of Whitehorse, Yukon. The terrain cover around the facility and mining area is mainly forested. Alexco Keno Hill Mining Corp (AKHM) currently operates the existing Bellekeno mine and Keno District Mill and proposes to strengthen its operation by incorporating production of two newly planned mines (referred to as Lucky Queen and Onek) ore deposits in the Keno Hill Silver District, and the currently proposed Flame and Moth mining project. These mining operations are located around the Keno City residential area. Lightning Creek runs along the south side of the Keno City.

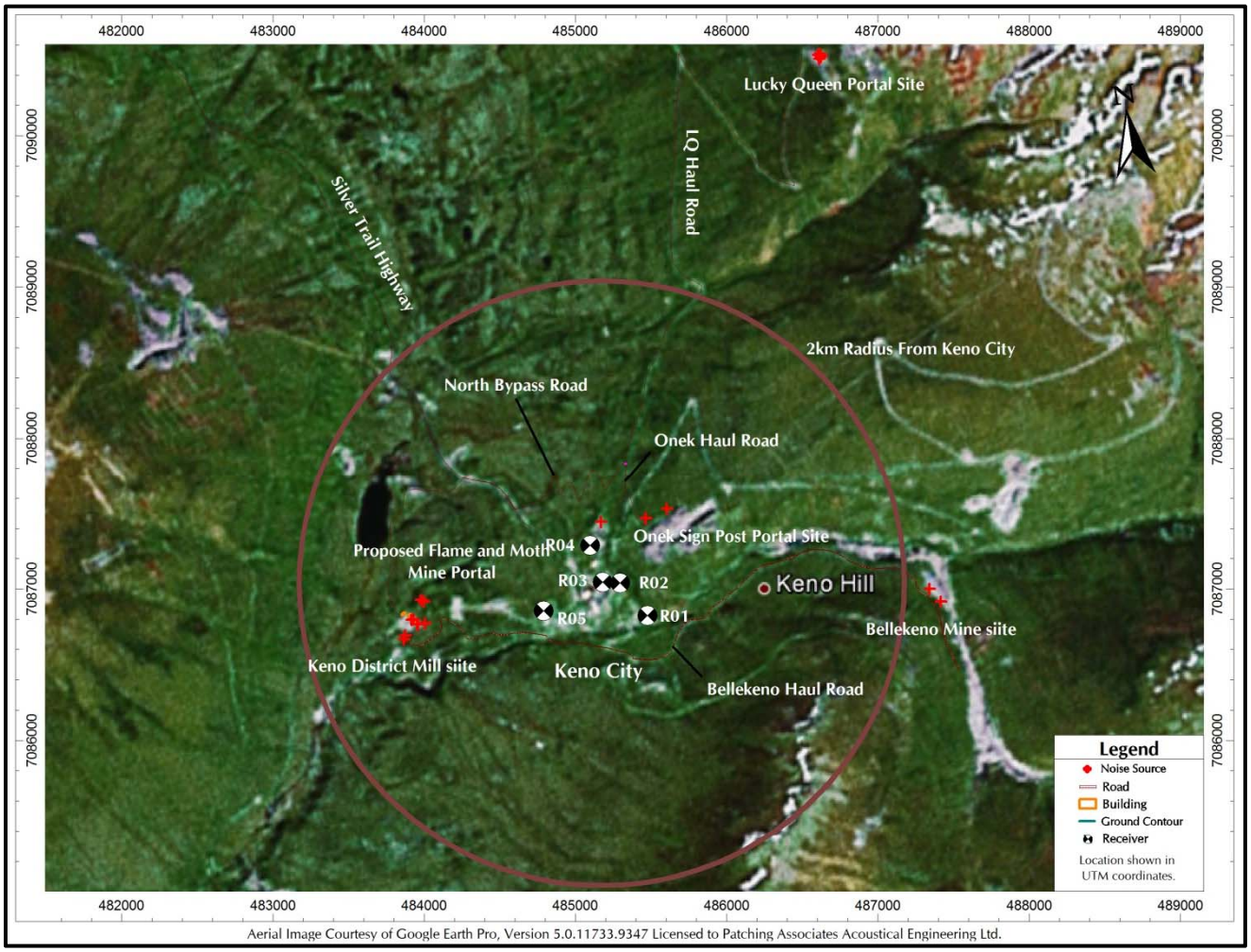
This study assesses the cumulative noise levels of the existing, planned and proposed operations at five receivers representing potential noise sensitive areas in the Keno City residential area, which are listed in Table 1.

Figure 1 presents an overview of the project study area map showing the five receivers (denoted as R01, R02, R03, R04 and R05) and the locations of the mines.

Table 1 – Representative Residence Locations Assessed in the Keno City

Residence	GPS Location	Description
R01	N63.90827 W135.29599	East end Residence, north side of Lightning Creek Road
R02	N63.91019 W135.29968	Residence, east side of Sign Post Road
R03	N63.91023 W135.30205	Town Center, north from the Snack Bar
R04	N63.91239 W135.30376	Residence, west side of Wernecke Road, closest to the Planned Onek Sign Post portal location
R05	N63.90851 W135.30993	Residence, about 850m east from the Mill

Figure 1: Overview of the Project Study Area.



Equipment Details

Based on information provided in the Flame and Moth Project description, most of the activities associated with the Flame and Moth project are similar or identical to the activities already occurring in the Keno Hill District.

The proposed Flame and Moth mining operations would occur where the ore deposits are located underground. The proposed Project does not include any changes to mining operations at the Bellekeno, Onek or Lucky Queen deposits. The Flame and Moth ore will be milled at the licensed Keno District Mill and will utilize many of the existing infrastructures at the licenced Mill.

The facility equipment details included in the noise model for the existing (existing Bellekeno Mine and Keno District Mill), planned (Onek and Lucky Queen) and proposed Flame and Moth mining operations are shown in Table 2. The planned Onek and Lucky Queen projects are currently undergoing permitting and licensing.

Table 2: Major Equipment

Equipment Description	Equipment Details
Proposed Flame and Moth Mine Facility and Transportation	• Proposed Ventilation Fan: Two fans operating in parallel on the fresh air raise and assumed to generate combined fresh air flow rate of 165,000 cubic feet per minute (CFM) through a 3 metre diameter bored raise equipped with man-way during normal operations. The two fans were assumed to operate at an estimated total pressure of 1.8 kPa and combined power draw of 190 kW (255 hp). • Proposed Water Treatment Plant: Noise emission assumed to be the same as those of the Onek Water Treatment Plant. • Proposed Flame and Moth 15-ton Haul Truck Traffic from portal to the crusher: Total average of approximately 28 round trips per 24 hour period along the new 175 metre mine haul route. • Negligible changes to the net level of traffic expected in Keno City as per the proposed Flame and Moth project description document.

Table 2: Major Equipment Details - Continued

Equipment Description	Equipment Details
Existing and Planned Bellekeno Mine Site Facility and transportation	• Existing Sullair LS-25S compressor unit • Existing fresh Air Intake • Currently Total 44 round trips along Bellekeno haul road daytime (0700-1900), 30 kph, which include 22 light trucks and 22 heavy trucks (ore trucks, heavy trucks and buses), no transportation nighttime • Future Planned Total 62 round trips daytime, 30 kph, which include 22 light trucks and 40 heavy trucks (ore trucks, heavy trucks and buses),no transportation nighttime • Noise emission from the light truck and heavy truck assumed equal to current light truck and haul truck, measured by PAAE staff between June 25th and 29th ,2012
Existing and Planned Mill site Operation	• Crusher, full load operation, currently running every other day, daytime operation • Cat 930G front-end Loader Loading rock for crusher, daytime operation • Mill Building, Internal equipment running day and night • Dry stack tailings facility (DSTF) area (one Packer Cat CS543E and one Backhoe daytime operation) • Noise emission from the above equipment measured by PAAE staff between June 25th and 29th ,2012
Existing and Planned Lucky Queen Portal Facility and Transportation	• Existing 500 kW Cummins genset • Existing Gardner-Denver D800 compressor unit • Existing fresh air intake • Noise emission from the above equipment measured by PAAE staff between June 25th and 29th ,2012 • Planned Cat 930G front-end Loader, 40% usage, daytime operation • Planned Tandem axle dump truck (12 yard truck) , 40% usage, daytime operation • Planned 15-ton underground haul truck, 40% usage, daytime operation • Total 27 Round trips daytime, 40 kph, which include 6 light trucks and 21 heavy trucks (ore trucks, heavy trucks and buses), no transportation nighttime. The route will follow Wernecke road and Planned updated north bypass road.

Table 2: Major Equipment Details - Continued

Equipment Description	Equipment Details
Planned Onek Facility and Transportation -- Sign Post Portal	• Planned 200 Hp electric driven Ingersoll Rand R150IU rotary screw compressor, housed in sound dampening enclosure, assumed open area less than 1.5% • Planned ventilation fan, 30 Hp, 36" Diameter, assumed 1274rpm, less than 12000 fpm tip speed. There will be inlet and exhaust sound dampeners, will decrease noise by about 10 dBA • Planned Cat 930G front-end Loader, 40% acoustical usage, daytime operation • Planned Tandem axle dump truck (12 yard truck) , 40% acoustical usage, daytime operation • Planned 15-ton underground haul truck, 40% acoustical usage, daytime operation • Total 37 Round trips daytime, 40 kph, which include 6 light trucks and 31 heavy trucks (ore trucks, heavy trucks and buses), no transportation nighttime • A 80m long x 4m high x 5m wide sound berm will be constructed along the west side of Sign Post Portal Pad to deflect noise, or an equivalent sound curtain will be installed. The route will cross the Sign Post Road and Wernecke Road, and follow the planned updated north bypass road.
Planned Onek Water Treatment Plant	• 5Hp water pump, assumed 3600 RPM and 3 hp compressor, assumed 1800 RPM. Both equipment run continuously, housed in insulated sea cans, assumed open area less than 1.5%.
Planned Onek Facility and Surface Transportation --990 Portal	• Planned compressor, ventilation fan, Cat 930G front-end Loader, Tandem axle dump truck (12 yard truck) , 15-ton underground haul truck, keep the same running situation as Sign Post portal option. • Total 37 Round trips daytime, 40 kph, which include 6 light trucks and 31 heavy trucks (ore trucks, heavy trucks and buses), no transportation nighttime • The haul route will be developed from Onek 990 Portal, crossing Lightning Creek Road and the Onek Access Bridge across Lightning Creek to the Bellekeno Haul Road.

Table 2 (Cont.): Major Equipment Details

Equipment Description	Equipment Details
Planned Onek Facility and Underground Transportation – 990 Portal Option.	• Planned compressor, ventilation fan, Cat 930G front-end Loader, Tandem axle dump truck (12 yard truck) , 15-ton underground haul truck, keep the same running situation as Sign Post portal option. • Total 37 Round trips daytime, 40 kph, which include 6 light trucks and 31 heavy trucks (ore trucks, heavy trucks and buses), no transportation nighttime • Ore haul trucks will transport ore directly from underground to mill (no surface ore transfer)

Blasting Noise

Based on information provided in the proposed Flame and Moth project document, surface blasting would occur until the portal reaches 20 metres underground; from that point, 24-hour blasting will occur underground only. As such, the duration of surface blasting events would be considered as a short-term event. Due to the short duration of surface blasting, and after consultation with YESAB staff, this assessment focused on the long-term steady surface activities that would generate noise at the various mining and mill sites during normal operations.

Notwithstanding the short duration of surface blasting, the following noise management plans should be adopted to minimize the impact of the noise levels:

- Surface blasting at the proposed Flame and Moth surface portal should be conducted only during the dayshift from 7 AM to 7 PM.
- A community notification protocol should be developed and posted within Keno City outlining blasting schedules during the initial portal development.
- Noise barriers should be used around blasting site, when and where possible.

Planned Operations and Mitigation Measures

The details of the proposed Flame and Moth mine surface noise sources are included in Table 2, and will primarily include noise from continuous operations of the proposed water treatment plant, ventilation fans, 15-ton haul traffic from the portal to the crusher (roundtrip).

It is expected that the ore haulage from the Flame and Moth mine will offset some of the tonnage that would have been sourced from the existing Bellekeno mine, planned Lucky Queen and Onek deposits, and therefore overall potential traffic noise impact on Keno City will be reduced from operations at Flame and Moth. There will be no increase in traffic through Keno City as a result of the Flame and Moth Mine because access to the mine would be through the existing Christal Lake road which provides access from the Silver Trail Highway to the Keno District Mill.

In addition to the existing noise management plan for the existing Keno District operations, it is assumed that the following mitigation and noise management measures would be incorporated into the proposed Flame and Moth mining operations, in addition to the ones presented above for blasting:

- Noise enclosures and silencers will be part of the ventilation system for the proposed Flame and Moth portal.
- Community notification would be completed prior to any significantly loud noise event.
- The use of existing bypass roads around Keno City will continue to be used.
- Access to the Flame and Moth mine will be routed through the Christal Lake road.
- The use of engine breaks would be avoided in the vicinity of Keno City.

Method

The distance to the residences and facilities physical layout information were obtained from aerial image courtesy of Google Earth Pro (Version 7.1.2.2041 Licensed to Patching Associates Acoustical Engineering), AKHM and field reconnaissance performed in June of 2012 by PAAE staff. Sound power levels were determined for the proposed Flame and Moth equipment together with the existing Bellekeno Mine and Keno District Mill and the Onek and Lucky Queen equipment. Sound propagation calculations were then undertaken to determine the sound pressure level that will exist at the residences of concern in Keno City. All calculations were undertaken in octave bands.

The octave band sound power level for each source that will exist at the facility was determined through the use of field measurements, manufacturer's data and theoretical calculations. The results of the sound propagation calculations were compared to the current mining operational sound level to determine if the cumulative operations of the proposed Flame and Moth operations together with the existing Bellekeno Mine and Keno District Mill and the Onek and Lucky Queen Mines will cause higher noise level to the residences in Keno City.

Sound Propagation Calculations

The noise modeling was conducted using the noise modeling software package CadnaA (version 4.4.145) by Datakustik. CadnaA is an advanced noise propagation model that considers geometric spreading, reflection, atmospheric sound absorption, ground impedance effects, site topography and geometry, vegetation and environmental conditions. The calculations performed in CadnaA were conducted in accordance with ISO 9613. The ground cover was modeled as porous ground, consistent with site observations (ISO 9613 classification of porous ground includes ground covered by grass, trees or other vegetation, and any other ground surfaces suitable for growth of vegetation {e.g., farmland}). As the area is forested, this is the appropriate ground type.

The ISO 9613 uses a slight downwind condition from each noise source to each receiver. The model temperature was set to 10º C and a relative humidity of 80% and a ground absorption coefficient of 0.6. As such, the ISO 9613 model produces results representative of meteorological conditions favouring sound propagation (e.g., downwind or mild temperature inversion conditions). These conditions do not occur all the time at the receivers and the sound levels are expected to be lower than those predicted for most of the time. The temperature modelled (i.e., 10º C) is typical average temperature over the 12-month period when outdoor activities are expected, and 80% relative humidity; the temperature and humidity values are conditions with a minimum value of air absorption as per ISO 9613 algorithm. Therefore the environmental conditions modeled represent "close-to-worst-case" sound propagation conditions. The CadnaA model calculates the contribution level of each noise source at the receiver location in octave bands as well as calculating the overall facility sound level.

It should be noted that environmental factors reduce the higher frequencies more than lower frequency sounds, so the A-weighted noise decreases with distance more than the C-weighted levels.

Modelling Confidence

The algorithms used for the noise modelling follow the ISO 9613 standard. The published accuracy for this standard is ±3 dBA between 100 m to 1000 m. Accuracy levels beyond 1000 m are not published. Professional experience based on similar noise models and measurements conducted over large distances shows that, as expected, as the distance increases, the associated accuracy in prediction decreases, but also from experience, predicted levels under downwind conditions agree reasonably well with measured levels. Experience has shown that environmental factors such as wind, temperature inversions, topography and ground cover contribute notably more to perceived noise beyond distances of 1500 m of the various noise sources.

Sound Power Level Calculations

Octave band sound power levels were calculated for all of the noise sources that are present at the proposed Flame and Moth operations together with the existing Bellekeno Mine and Keno District Mill and the Onek and Lucky Queen Mines. These octave band sound power levels and the source of the data are presented in Table 3.

Table 3 – Source Octave Band Sound Power Levels

Source Description	Data Source	Linear Octave Band Centre Frequency (dB, ref 1 pW)									Total (dBA)	Total (dBC)
		31.5	63	125	250	500	1k	2k	4k	8k		
Bellekeno Mine Fresh Air Intake	Field Measurements	86	92	98	103	110	110	102	97	83	**112**	**114**
Mill Crusher in full operation	Field Measurements	118	113	111	110	110	107	105	98	89	**112**	**120**
Lucky Queen Portal Genset Exhaust	Field Measurements	107	113	118	112	112	105	101	87	71	**112**	**120**
Lucky Queen Portal Genset wall	Field Measurements	109	114	119	114	108	103	99	90	87	**110**	**121**
Lucky Queen Portal Genset Open Door	Field Measurements	107	107	111	111	107	105	103	95	86	**110**	**116**
Mill DSTF Track Excavator	Field Measurements	131	108	116	107	105	105	95	96	88	**109**	**128**
Lucky Queen Portal Genset Exhaust Muffler	Field Measurements	104	106	111	110	109	100	98	86	71	**109**	**116**
Bellekeno Mine Compressor Unit	Field Measurements	90	90	105	107	105	105	98	90	83	**108**	**112**
Lucky Queen Portal Air Inlet	Field Measurements	79	94	87	92	103	104	101	95	85	**108**	**108**
Lucky Queen Portal Genset Air Outlet	Field Measurements	96	102	108	107	104	102	100	92	83	**107**	**112**
Lucky Queen Portal Compressor Wall	Field Measurements	98	107	106	105	102	99	101	93	87	**106**	**112**

Table 3 (Cont.) – Source Octave Band Sound Power Levels

Source Description	Data Source	Linear Octave Band Centre Frequency (dB, ref 1 pW)									Total (dBA)	Total (dBC)
		31.5	63	125	250	500	1k	2k	4k	8k		
Lucky Queen Portal Compressor Open Door	Field Measurements	86	97	93	96	94	98	99	93	88	**103**	**104**
Mill DSTF Packer	Field Measurements	129	113	105	100	100	99	95	87	81	**103**	**126**
Lucky Queen Portal Gen doors closed	Field Measurements	95	106	110	103	99	96	93	88	80	**102**	**112**
Bellekeno Haul Volvo Truck	Field Measurements	103	101	99	100	96	95	93	87	80	**100**	**107**
Mill Cat 930G Wheel Loader	Field Measurements	106	110	99	92	95	98	91	79	68	**100**	**111**
Mill Building wall	Field Measurements	111	111	104	98	93	94	75	73	66	**97**	**113**
Onek Comp Building Open Area (Doors Closed)	Theoretical	85	83	87	87	89	90	91	87	80	**96**	**97**
Onek Portal Haul Truck	Field Measurements	99	97	95	96	92	91	89	83	76	**96**	**103**
Onek Dump Truck	Field Measurements	99	97	95	96	92	91	89	83	76	**96**	**103**
LQ Portal Haul Truck	Field Measurements	99	97	95	96	92	91	89	83	76	**96**	**103**
LQ Dump Truck	Field Measurements	99	97	95	96	92	91	89	83	76	**96**	**103**
Onek Fan Package	Theoretical	101	102	101	98	93	90	83	79	73	**96**	**106**
Onek Cat 930G Wheel Loader	Field Measurements	102	106	95	88	91	94	87	75	68	**96**	**107**
LQ Cat 930G Wheel Loader	Field Measurements	102	106	95	88	91	94	87	75	68	**96**	**107**
Mill Air Bag Exhaust	Field Measurements	91	98	88	88	89	88	88	89	88	**95**	**100**
Proposed Flame and Moth Mine Ventilation Fan (x2) Inlet	Theoretical	96	97	96	93	88	85	78	74	68	**91**	**102**
Mill South Open Door	Field Measurements	96	92	86	82	81	85	83	82	76	**90**	**97**
Mill Building Open Doors	Field Measurements	94	87	84	83	83	81	84	82	73	**89**	**94**
Onek Comp Building Wall	Field Measurements	103	95	93	90	90	77	77	67	59	**89**	**102**
Proposed Flame and Moth Mine Ventilation Fan (x2) Discharge	Theoretical	94	95	94	91	86	83	76	72	66	**89**	**100**

Table 3 (Cont.) – Source Octave Band Sound Power Levels

Source Description	Data Source	Linear Octave Band Centre Frequency (dB, ref 1 pW)									Total (dBA)	Total (dBC)
		31.5	63	125	250	500	1k	2k	4k	8k		
Light truck	Field Measurements	92	92	91	87	84	81	80	70	68	**87**	**96**
East End Building	Field Measurements	104	97	89	84	84	79	74	63	55	**85**	**102**
Mill Building Louvers	Field Measurements	85	84	81	80	76	77	76	72	65	**82**	**89**
Proposed Flame and Moth WTP Facility Building Open Area (Doors Closed)	Previous Study	68	66	70	71	72	73	74	70	63	**79**	**80**
WTP Facility Building Open Area (Doors Closed)	Theoretical	68	66	70	71	72	73	74	70	63	**79**	**80**
WTP Facility Building Wall	Theoretical	86	79	76	73	72	60	60	49	42	**72**	**85**
Proposed Flame and Moth WTP Facility Building Wall	Previous Study	86	79	76	73	72	60	60	49	42	**72**	**85**
Bellekeno Planned Total Daytime Haul Truck Traffic (12h),1m	Field Measurements/ Theoretical	52	50	49	49	45	44	42	36	28	**49**	**56**
Onek Planned Total Daytime Haul Truck Traffic (12h),1m	Field Measurements/ Theoretical	50	49	47	48	43	42	40	35	27	**47**	**54**
Proposed Flame and Moth Haul Truck Traffic	Previous Study	50	49	47	48	43	42	40	35	27	**47**	**54**
Bellekeno Current Total Daytime Haul Truck Traffic (12h),1m	Field Measurements/ Theoretical	50	48	47	46	42	41	39	34	26	**46**	**54**
LQ Planned Total Daytime (12h),1m	Field Measurements/ Theoretical	48	47	45	46	42	41	39	33	26	**46**	**53**

Modeling Results

The objective of this study is to predict the cumulative sound level from the normal operations of the proposed Flame and Moth mine together with the existing Bellekeno Mine and Keno District Mill and the Onek and Lucky Queen Mines at five potentially most affected receiver locations in Keno City.

The predictions based on the CadnaA model for the various operations are summarized in Tables 4, 5 to 9 along with the comparison to current mining conditions.

Table 4 - Summary of Predicted Sound Levels Generated by AKHM Current Mining Operations under Downwind Conditions (Daytime)

Residence	Predicted Facility Sound Levels Day-Time* (dBA)	Measured Ambient Sound Levels (dBA)	Predicted Sound Levels Day-Time plus Ambient Sound Levels (dBA)
R01	29	39	**39**
R02	30	35	**36**
R03	30	27	**32**
R04	31	34	**36**
R05	31	32	**34**

Note: *Predicted Facility Sound for current mining operation includes noise from the existing Bellekeno Mine and Keno District Mill.

Table 5 - Summary of Predicted Sound Levels Generated by AKHM Current Mining Operations under Downwind Conditions (Nighttime)

Residence	Predicted Facility Sound Levels Night-Time* (dBA)	Measured Ambient Sound Levels (dBA)	Predicted Sound Levels Night-Time plus Ambient Sound Levels (dBA)
R01	19	38	**38**
R02	15	28	**28**
R03	23	26	**28**
R04	24	30	**31**
R05	13	--	**--**

Note: *Predicted Facility Sound for current mining operation includes noise from the existing Bellekeno Mine and Keno District Mill. "—" indicates that the measured nighttime ambient sound level is not valid as per the 2012 comprehensive sound survey report.

Table 6 - Summary of Predicted Sound Levels Generated by AKHM Current and Planned Mining Operations including Proposed Flame and Moth Mine under Downwind Conditions (Daytime)

--(Onek Sign Post Portal Option and Planned North Bypass Road)

Residence	Predicted Facility Sound Levels Day-Time (dBA)	Measured Ambient Sound Levels (dBA)	Predicted Sound Levels Day-Time plus Ambient Sound Levels (dBA)	Predicted Sound Level Increase Above the Current Sound Level* (dB)
R01	29	39	**39**	**0**
R02	30	35	**36**	**0**
R03	32	27	**33**	**1**
R04	35	34	**38**	**2**
R05	32	32	**35**	**1**

Note: * This is the predicted sound level increase above the current sound level shown in Table 4.
** Planned mining operations include previously disclosed planned Onek and Lucky Queen Projects.

Table 7 - Summary of Predicted Sound Levels Generated by AKHM Current and Planned Mining Operations including Proposed Flame and Moth Mine under Downwind Conditions (Nighttime)

--(Onek Sign Post Portal Option and Planned North Bypass Road)

Residence	Predicted Facility Sound Levels Day-Time (dBA)	Measured Ambient Sound Levels (dBA)	Predicted Sound Levels Nighttime plus Ambient Sound Levels (dBA)	Predicted Sound Level Increase Above the Current Sound Level* (dB)
R01	21	38	**38**	**0**
R02	19	28	**29**	**1**
R03	26	26	**29**	**1**
R04	30	30	**33**	**2**
R05	23	--	**--**	**-**

Note: * This is the predicted sound level increase above the current sound level shown in Table 5.
** Planned mining operations include previously disclosed planned Onek and Lucky Queen Projects.
"—" indicates that the measured nighttime ambient sound level is not valid as per the 2012 comprehensive sound survey report.

Table 8 - Summary of Predicted Sound Levels Generated by AKHM Current and Planned Mining Operations including Proposed Flame and Moth Mine under Downwind Conditions (Daytime)

--(Onek 990 Portal Option and Planned Keno City Bypass Road)

Residence	Predicted Facility Sound Levels Day-Time (dBA)	Measured Ambient Sound Levels (dBA)	Predicted Sound Levels Day-Time plus Ambient Sound Levels (dBA)	Predicted Sound Level Increase Above the Current Sound Level* (dB)
R01	30	39	**39**	**0**
R02	30	35	**36**	**0**
R03	31	27	**32**	**0**
R04	32	34	**36**	**0**
R05	31	32	**35**	**1**

Note: * This is the predicted sound level increase above the current sound level shown in Table 4.
** Planned mining operations include previously disclosed planned Onek and Lucky Queen Projects.

Table 9 - Summary of Predicted Sound Levels Generated by AKHM Current and Planned Mining Operations including Proposed Flame and Moth Mine under Downwind Conditions (Nighttime)

--(Onek 990 Portal Option and Planned Keno City Bypass Road)

Residence	Predicted Facility Sound Levels Day-Time (dBA)	Measured Ambient Sound Levels (dBA)	Predicted Sound Levels Nighttime plus Ambient Sound Levels (dBA)	Predicted Sound Level Increase Above the Current Sound Level* (dB)
R01	22	38	**38**	**0**
R02	19	28	**29**	**1**
R03	24	26	**28**	**0**
R04	27	30	**32**	**1**
R05	19	--	**--**	**-**

Note:* This is the predicted sound level increase above the current sound level shown in Table 5.
** Planned mining operations include previously disclosed planned Onek and Lucky Queen Projects.
"—" indicates that the measured nighttime ambient sound level is not valid as per the 2012 comprehensive sound survey report.

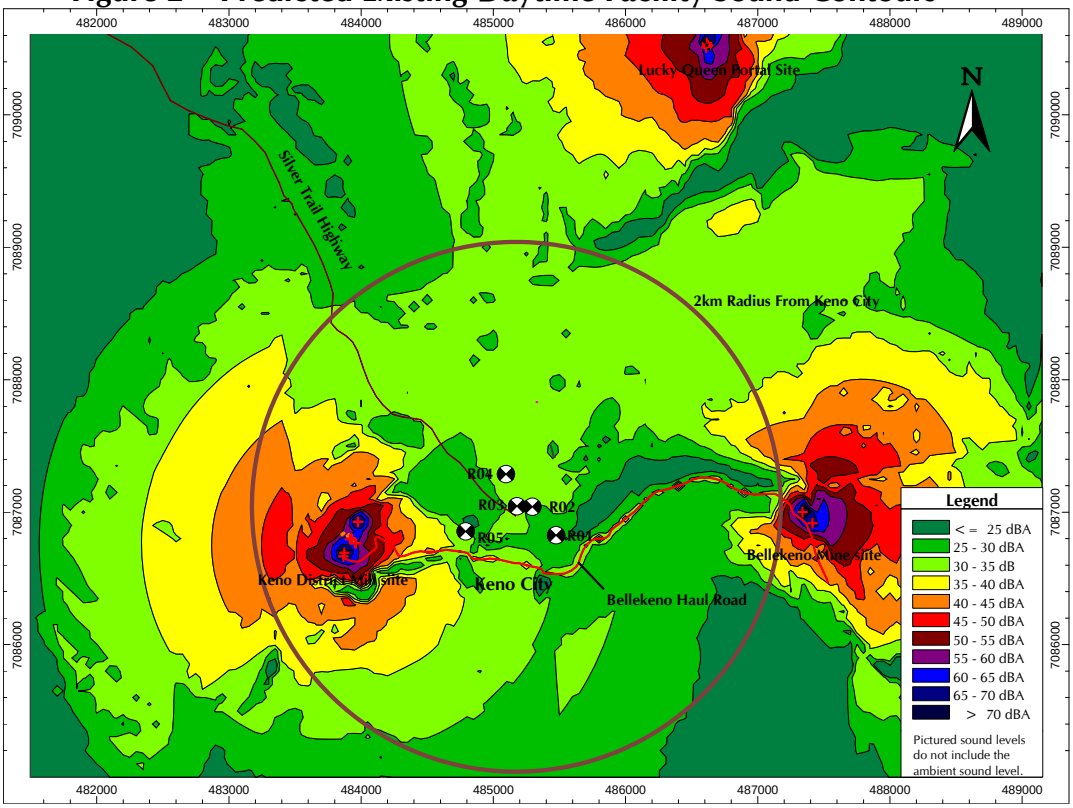
The results of this assessment indicate that the predicted cumulative sound level from the operations of the proposed Flame and Moth mine together with the existing AKHM current operations (i.e., existing Bellekeno Mine and Keno District Mill) and Onek and Lucky Queen operations (planned projects) is expected to have negligible changes in sound level increase at the assessed residences under downwind conditions when compared to the current situation. This assumed all the surface equipment running simultaneously and at full power level at all times.

The predicted cumulative effects from the different mining operations including the proposed Flame and Moth mine will have negligible effect on the Keno City residences. The most impacted residence is R04, which is also the closest residence to Onek portal site, will have 3-4 dBA increase of sound level based on measured ambient sound pressure level and only a 2 dBA increase based on current sound level.

Upon completion of mining, decommissioning and reclamation of the facilities, the sound environment is expected to revert to ambient conditions. As such, the project effect is reversible.

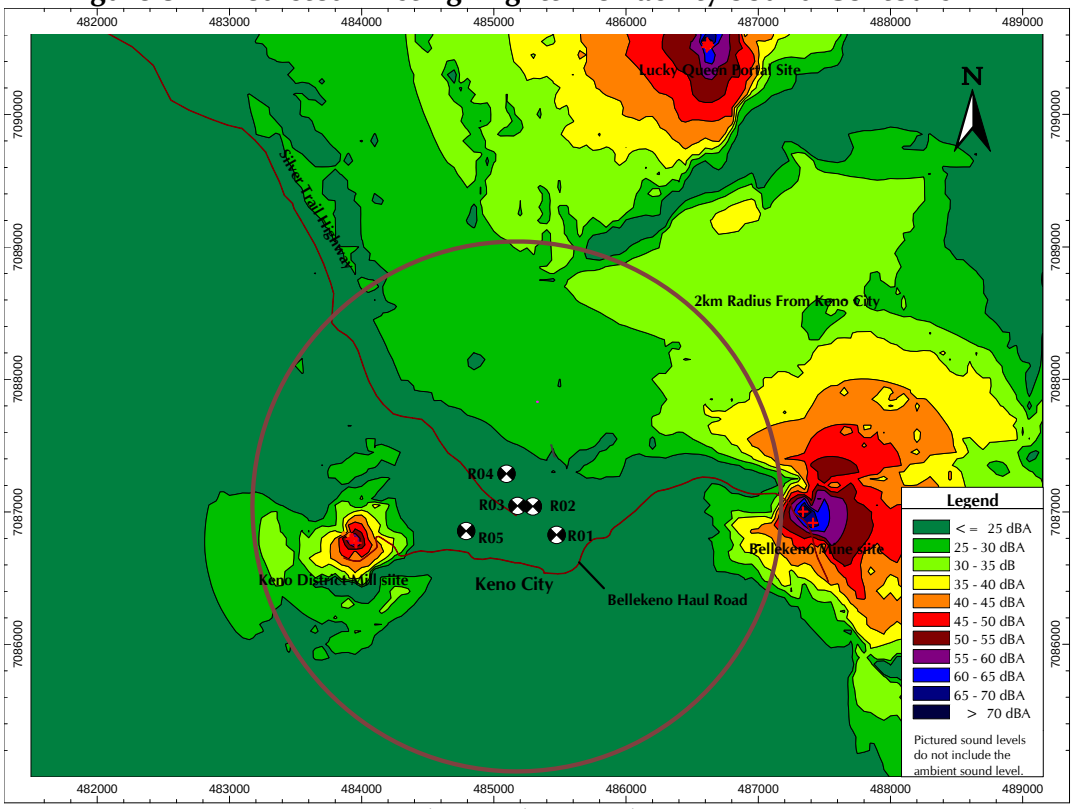
Figures 2, 3 to 7 show the predicted sound levels for the area during mining and mill operations. The labeled sound levels are the predicted sound levels from only the facility (ambient sound level is not included). The scales on all the figures are the Universal Transverse Mercator (UTM) coordinates in zone 8V.

Figure 2 – Predicted Existing Daytime Facility Sound Contours



Study Area Location Shown in UTM Coordinates

Figure 3 – Predicted Existing Nighttime Facility Sound Contours



Study Area Location Shown in UTM Coordinates

Figure 4 – Predicted Existing and Planned Daytime Facility Sound Contours
--(Onek Sign Post Portal Option and Planned North Bypass Road)

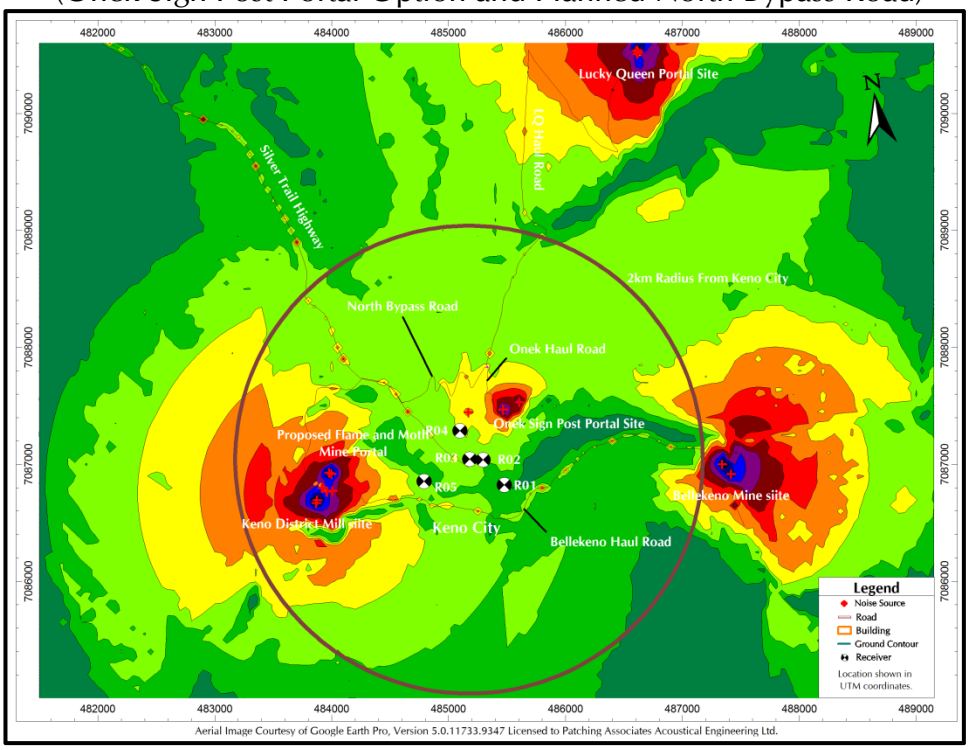


Figure 5 – Predicted Existing and Planned Nighttime Facility Sound Contours
--(Onek Sign Post Portal Option and Planned North Bypass Road)

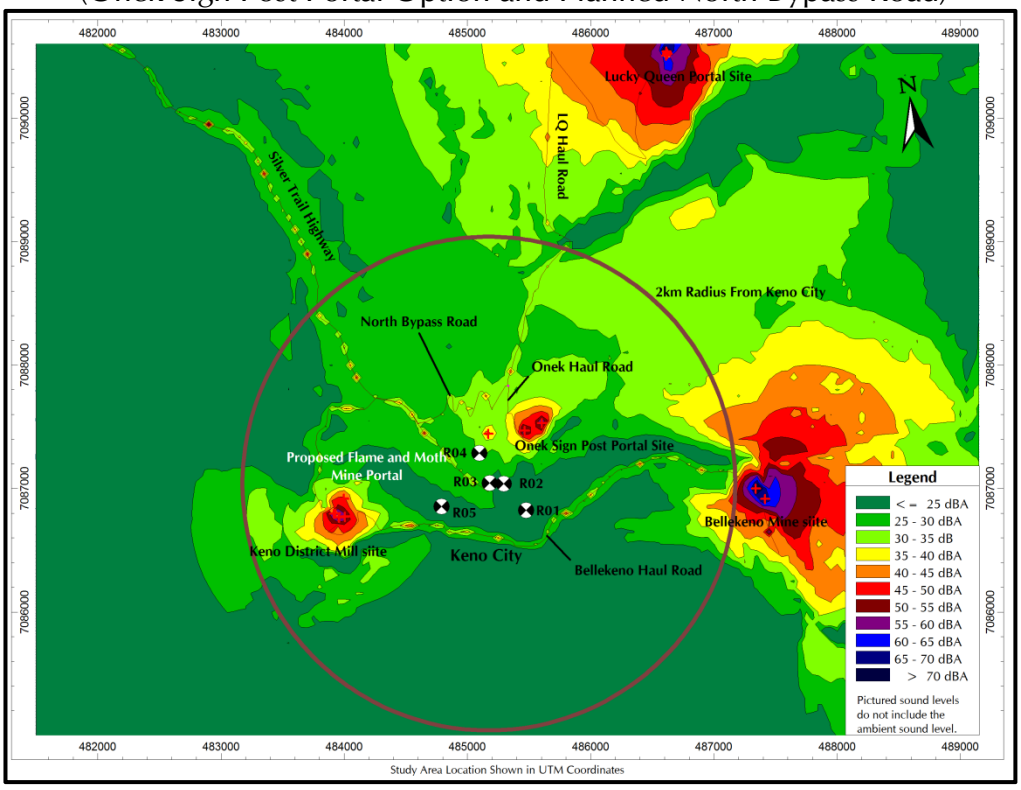


Figure 6 – Predicted Existing and Planned Daytime Facility Sound Contours
--(Onek 990 Portal Option and Planned Keno City Bypass Road)

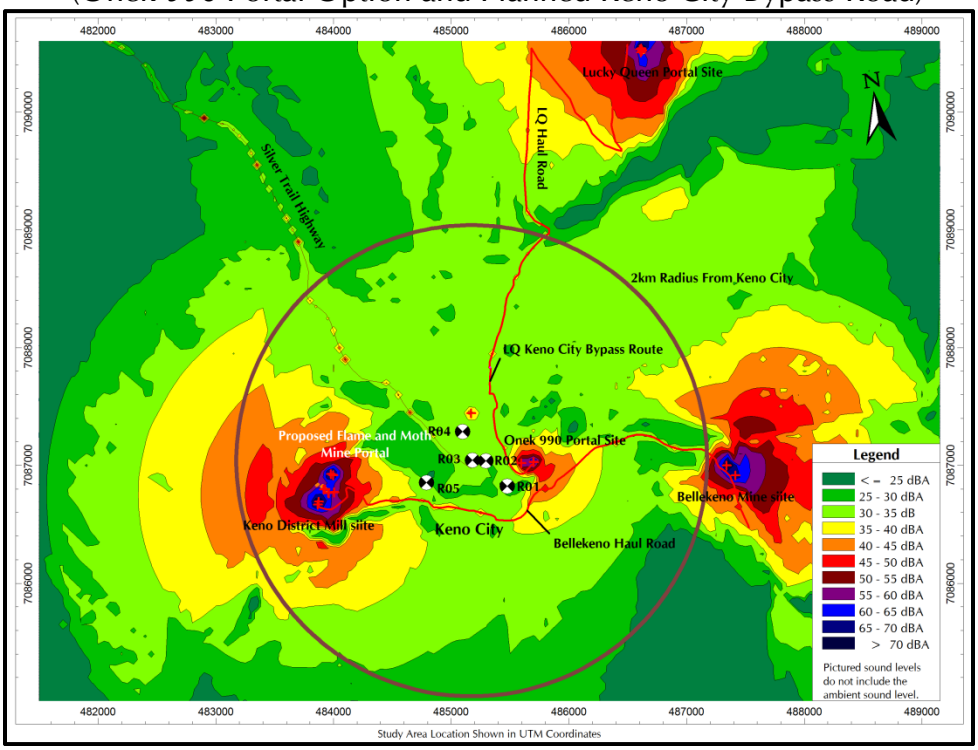
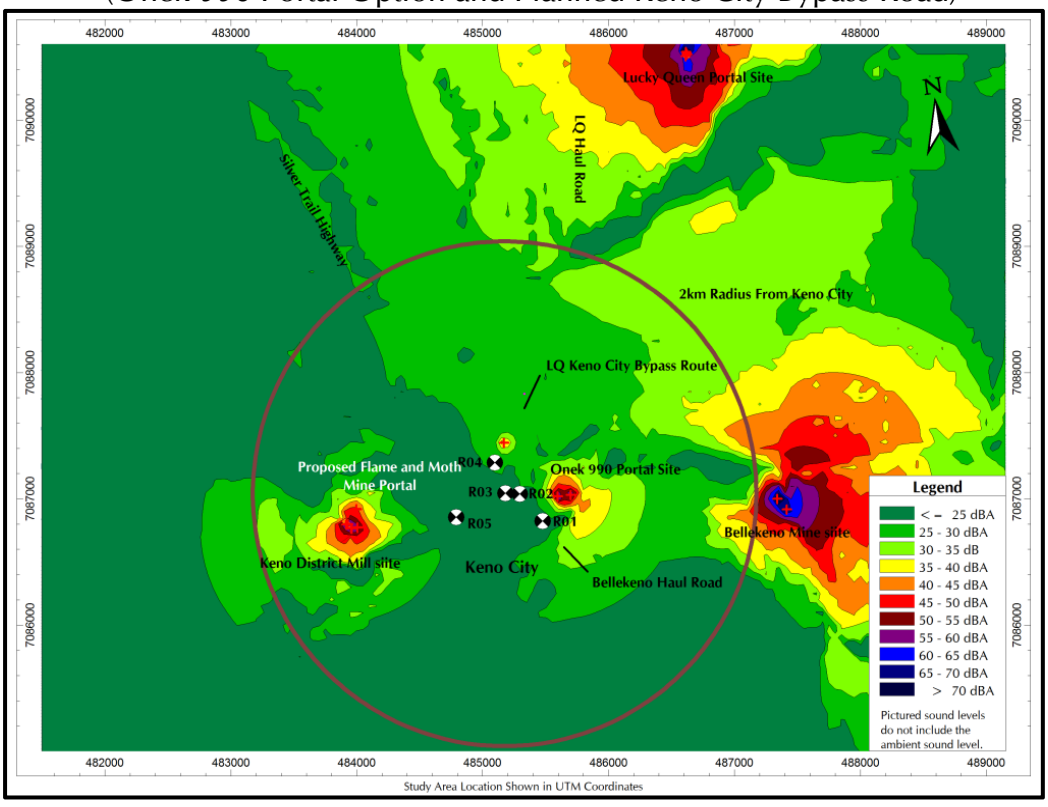


Figure 7 – Predicted Existing and Planned Nighttime Facility Sound Contours
--(Onek 990 Portal Option and Planned Keno City Bypass Road)



Source Order Rankings

Based on the CadnaA model results, the sound sources can be ranked by the sound levels at the receivers. The source order ranking for the daytime and nighttime scenarios are shown in Tables 10 and 13 for conditions with a wind from the project operational areas to the most impacted residence, which is residence R04 located about 384 meters from the planned Onek Sign Post Portal facility.

Table 10 – Source Order Ranking for Current and Planned Mining and Mill Operations including proposed Flame and Moth Operations

Assessment based on the implementation of the Onek Sign Post Portal option, at Receiver R04, Downwind Condition (Daytime)

Ranking	Noise Source	Levels (dBA)	Levels (dBC)
1	Crusher in full operation	28.6	40.2
2	Onek Cat 930G Wheel Loader	25.9	38.8
3	Onek Portal Haul Truck	25.7	34.2
4	Onek Dump Truck	25.7	34.2
5	Onek Fan Package	25.6	37.6
6	Mill DSTF Track Excavator	24.6	50.6
7	WTP Facility Building Open Area (Doors Closed)	22.3	23.6
8	Onek Comp Building Open Area (Doors Closed)	20.9	23.4
9	Lucky Queen Portal Genset Exhaust	18.7	31.3
10	Mill DSTF Packer	18.3	48.1
11	Lucky Queen Portal Gen wall	18.2	32.3
12	Onek Comp Building Wall	16.5	31.0
13	Mill Cat 930G Wheel Loader	16.3	32.2
14	Lucky Queen Portal Genset Exhaust Muffler	15.3	25.8
15	Lucky Queen Portal Genset Air Outlet	14.4	25.3
16	Silver Trail Highway	14.3	21.5
17	Mill Building wall	12.5	33.5
18	Lucky Queen Portal Air Inlet	12.3	16.2
19	Lucky Queen Portal Gen doors closed	8.6	23.1
20	Lucky Queen Portal Compressor Wall	7.3	21.5
21	Air Bag Exhaust	5.4	19.7
22	Proposed Flame and Moth Mine Ventilation Fan (x2) Inlet	3.8	20.1
23	Proposed Flame and Moth Mine Ventilation Fan (x2) Discharge	1.7	18.1
24	Lucky Queen Portal Genset Open Door	0.3	16.1
25	Lucky Queen Portal Compressor Open Door	-1.1	10.6

Table 10 – Source Order Ranking for Current and Planned Mining and Mill Operations including proposed Flame and Moth Operations (Continued)

Assessment based on the implementation of the Onek Sign Post Portal option, at Receiver R04, Downwind Condition (Daytime)

Ranking	Noise Source	Levels (dBA)	Levels (dBC)
26	Bellekeno Mine Fresh Air Intake	-1.3	3.8
27	Bellekeno Mine Compressor Unit	-1.4	7.3
28	Mill Building Open Doors	-3.8	13.6
29	Mill South Open Door	-14.9	5.6
30	Proposed Flame and Moth WTP Facility Building Wall	<-14.9	<5.6
31	Proposed Flame and Moth WTP Facility Building Open Area (Doors Closed)	<-14.9	<5.6
32	Proposed Flame and Moth Haul Truck Traffic	<-14.9	<5.6
	Total Sound Level - No Ambient	**35.1**	**53.4**
	Ambient Sound Level	35.0	N/A
	Total Cumulative Sound Level - With Ambient	**38.1**	**N/A**
	AER PSL	40.0	N/A

Note: The most usual measure of sound is the sound pressure level (SPL), with 0 dB SPL set at 2.0 X 10^{-5} N/m^2 (also written 20 μPa). As a result of the logarithm function used in the decibel scale, negative sound level values shown in the above table indicates that the relative sound level contribution by the applicable sound source is less than 20 μPa (or 0 dB) at the receiver location and so is negligible and inaudible.

Table 11 – Source Order Ranking for Current and Planned Mining and Mill Operations including proposed Flame and Moth Operations

Assessment based on the implementation of the Onek Sign Post Portal option, at Receiver R04, Downwind Condition (Daytime)

Ranking	Noise Source	Levels (dBA)	Levels (dBC)
1	Onek Fan Package	25.6	37.6
2	WTP Facility Building Open Area (Doors Closed)	22.3	23.6
3	Onek Comp Building Open Area (Doors Closed)	20.9	23.4
4	Lucky Queen Portal Genset Exhaust	18.7	31.3
5	Lucky Queen Portal Gen wall	18.2	32.3
6	Onek Comp Building Wall	16.5	31.0
7	Lucky Queen Portal Genset Exhaust Muffler	15.3	25.8
8	Lucky Queen Portal Genset Air Outlet	14.4	25.3
9	Silver Trail Highway	14.3	21.5
10	WTP Facility Building Wall	13.8	32.7
11	Mill Building wall	12.5	33.5
12	Lucky Queen Portal Air Inlet	12.3	16.2

Table 11 – Source Order Ranking for Current and Planned Mining and Mill Operations including proposed Flame and Moth Operations (Continued)

Assessment based on the implementation of the Onek Sign Post Portal option, at Receiver R04, Downwind Condition (Daytime)

Ranking	Noise Source	Levels (dBA)	Levels (dBC)
13	Lucky Queen Portal Gen doors closed	8.6	23.1
14	Lucky Queen Portal Compressor Wall	7.3	21.5
15	Air Bag Exhaust	5.4	19.7
16	Proposed Flame and Moth Mine Ventilation Fan (x2) Inlet	3.8	20.1
17	Proposed Flame and Moth Mine Ventilation Fan (x2) Discharge	1.7	18.1
18	Lucky Queen Portal Genset Open Door	0.3	16.1
19	Lucky Queen Portal Compressor Open Door	-1.1	10.6
20	Lucky Queen Portal Compressor Open Door	-1.1	10.6
21	Bellekeno Mine Fresh Air Intake	-1.3	3.8
22	Bellekeno Mine Fresh Air Intake	-1.3	3.8
23	Bellekeno Mine Compressor Unit	-1.4	7.3
24	Bellekeno Mine Compressor Unit	-1.4	7.3
25	Mill Building Open Doors	-3.8	13.6
26	Mill Building Open Doors	-3.8	13.6
27	Mill South Open Door	-14.9	5.6
28	Mill South Open Door	-14.9	5.6
29	Proposed Flame and Moth WTP Facility Building Wall	<-14.9	<5.6
30	Proposed Flame and Moth WTP Facility Building Open Area (Doors Closed)	<-14.9	<5.6
31	Proposed Flame and Moth Haul Truck Traffic	<-14.9	<5.6
	Total Sound Level - No Ambient	**30.0**	**42.1**
	Ambient Sound Level	35.0	N/A
	Total Sound Level - With Ambient	**36.2**	**N/A**
	AER PSL	40.0	N/A

Note: The most usual measure of sound is the sound pressure level (SPL), with 0 dB SPL set at 2.0 X 10^{-5} N/m^2 (also written 20 μPa). As a result of the logarithm function used in the decibel scale, negative sound level values shown in the above table indicates that the relative sound level contribution by the applicable sound source is less than 20 μPa (or 0 dB) at the receiver location and so is negligible and inaudible.

Table 12 – Source Order Ranking for Current and Planned Mining and Mill Operations including proposed Flame and Moth Operations

Assessment based on the implementation of the Onek Sign Post Portal option, at Receiver R04, Downwind Condition (Daytime)

Ranking	Noise Source	Levels (dBA)	Levels (dBC)
1	Crusher in full operation	28.6	40.2
2	Mill DSTF Track Excavator	24.6	50.6
3	WTP Facility Building Open Area (Doors Closed)	22.3	23.6
4	Lucky Queen Portal Genset Exhaust	18.7	31.3
5	Mill DSTF Packer	18.3	48.1
6	Lucky Queen Portal Gen wall	18.2	32.3
7	Mill Cat 930G Wheel Loader	16.3	32.2
8	Lucky Queen Portal Genset Exhaust Muffler	15.3	25.8
9	Lucky Queen Portal Genset Air Outlet	14.4	25.3
10	Onek Comp Building Wall	14.2	30.7
11	WTP Facility Building Wall	13.8	32.7
12	Mill Building wall	12.5	33.5
13	Lucky Queen Portal Air Inlet	12.3	16.2
14	Onek Comp Building Open Area (Doors Closed)	11.0	17.6
15	Silver Trail Highway	10.9	17.8
16	Lucky Queen Portal Gen doors closed	8.6	23.1
17	Lucky Queen Portal Compressor Wall	7.3	21.5
18	Mill Air Bag Exhaust	5.4	19.7
19	Onek Fan Package	4.4	22.3
20	Proposed Flame and Moth Mine Ventilation Fan (x2) Inlet	3.8	20.1
21	Onek Cat 930G Wheel Loader	2.9	24.5
22	Onek Portal Haul Truck	2.6	19.0
23	Onek Dump Truck	2.6	19.0
24	Proposed Flame and Moth Mine Ventilation Fan (x2) Discharge	1.7	18.1
25	Mill East End Building	0.4	23.7
26	Lucky Queen Portal Genset Open Door	0.3	16.1
27	LQ Portal Haul Truck	0.2	14.0
28	LQ Dump Truck	0.2	14.0
29	LQ Cat 930G Wheel Loader	-0.8	19.5
30	Lucky Queen Portal Compressor Open Door	-1.1	10.6
31	Bellekeno Mine Fresh Air Intake	-1.3	3.8

Table 12 – Source Order Ranking for Current and Planned Mining and Mill Operations including proposed Flame and Moth Operations (Continued)

Assessment based on the implementation of the Onek Sign Post Portal option, at Receiver R04, Downwind Condition (Daytime)

Ranking	Noise Source	Levels (dBA)	Levels (dBC)
32	Bellekeno Mine Compressor Unit	-1.4	7.3
33	Mill Building Open Doors	-3.8	13.6
34	Mill South Open Door	-14.9	5.6
35	Proposed Flame and Moth WTP Facility Building Wall	<-14.9	<5.6
36	Proposed Flame and Moth WTP Facility Building Open Area (Doors Closed)	<-14.9	<5.6
37	Proposed Flame and Moth Haul Truck Traffic	<-14.9	<5.6
	Total Sound Level - No Ambient	**32.2**	**53.1**
	Ambient Sound Level	35.0	N/A
	Total Sound Level - With Ambient	**36.8**	**N/A**
	AER PSL	40.0	N/A

Note: The most usual measure of sound is the sound pressure level (SPL), with 0 dB SPL set at 2.0 X 10^{-5} N/m^2 (also written 20 μPa). As a result of the logarithm function used in the decibel scale, negative sound level values shown in the above table indicates that the relative sound level contribution by the applicable sound source is less than 20 μPa (or 0 dB) at the receiver location and so is negligible and inaudible.

Table 13 – Source Order Ranking for Current and Planned Mining and Mill Operations including proposed Flame and Moth Operations

Assessment based on the implementation of the Onek Sign Post Portal option, at Receiver R04, Downwind Condition (Daytime)

Ranking	Noise Source	Levels (dBA)	Levels (dBC)
1	WTP Facility Building Open Area (Doors Closed)	22.3	23.6
2	Lucky Queen Portal Genset Exhaust	18.7	31.3
3	Lucky Queen Portal Gen wall	18.2	32.3
4	Lucky Queen Portal Genset Exhaust Muffler	15.3	25.8
5	Lucky Queen Portal Genset Air Outlet	14.4	25.3
6	Onek Comp Building Wall	14.2	30.7
7	WTP Facility Building Wall	13.8	32.7
8	Mill Building wall	12.5	33.5
9	Lucky Queen Portal Air Inlet	12.3	16.2
10	Onek Comp Building Open Area (Doors Closed)	11.0	17.6
11	Lucky Queen Portal Gen doors closed	8.6	23.1
12	Lucky Queen Portal Compressor Wall	7.3	21.5
13	Mill Air Bag Exhaust	5.4	19.7
14	Onek Fan Package	4.4	22.3
15	Proposed Flame and Moth Mine Ventilation Fan (x2) Inlet	3.8	20.1
16	Proposed Flame and Moth Mine Ventilation Fan (x2) Discharge	1.7	18.1
17	Mill East End Building	0.4	23.7
18	Lucky Queen Portal Genset Open Door	0.3	16.1
19	Lucky Queen Portal Compressor Open Door	-1.1	10.6
20	Bellekeno Mine Fresh Air Intake	-1.3	3.8
21	Bellekeno Mine Compressor Unit	-1.4	7.3
22	Mill Building Open Doors	-3.8	13.6
23	Mill South Open Door	-14.9	5.6
24	Proposed Flame and Moth WTP Facility Building Wall	<-14.9	<5.6
25	Proposed Flame and Moth WTP Facility Building Open Area (Doors Closed)	<-14.9	<5.6
26	Proposed Flame and Moth Haul Truck Traffic	<-14.9	<5.6
	Total Sound Level - No Ambient	**26.9**	**40.2**
	Ambient Sound Level	35.0	N/A
	Total Sound Level - With Ambient	**35.6**	**N/A**
	AER PSL	40.0	N/A

Note: The most usual measure of sound is the sound pressure level (SPL), with 0 dB SPL set at 2.0 X 10^{-5} N/m^2 (also written 20 μPa). As a result of the logarithm function used in the decibel scale, negative sound level values shown in the above table indicates that the relative sound level contribution by the applicable sound source is less than 20 μPa (or 0 dB) at the receiver location and so is negligible and inaudible.

Best Practices Approach

The project proponent is also encouraged to adopt and incorporate a best practices approach to noise management into their facility maintenance and operating procedures in order to minimize noise disturbances as much as possible. This may include such things as:

- Taking regular sound level measurements at the facility and mining areas to determine if there are any significant changes to sound emanating from the facility.
- Equipping facility related vehicles including heavy and light trucks with appropriate mufflers.
- Advise nearby residents of significant loud activities and schedule these loud events during daytime hours of 7 AM to 5 PM.
- Ensure all internal combustion engines are fitted with appropriate muffler systems.
- A common source of annoyance is 'back-up beeper' warning devices. It is strongly recommended that a broad-band beeper is used instead of pure-tone devices which have been more common, as these have been found to be effective in reducing potential annoyance.
- Take advantage of acoustical screening from berms to shield receivers from equipment noise.
- Maintaining a noise control standard when procuring equipment.
- Keeping record of all noise complaint filed by area residents. In the event that a valid noise complaint is received, respond promptly through the completion of a noise complaint Investigation.

For awareness purposes, the following occupational noise best practices are also recommended for occupational health and safety purposes:

- Ensuring that appropriate personal hearing protection devices (e.g., ear muffs and ear plugs) are available to employees and contractors to minimize hearing loss, hearing protection are often required at 85 dBA, and double hearing protection (ear muffs & plugs) must be worn and signage must be present when noise levels are at or exceed 105 dBA. Generally, areas with noise levels greater than 85 dBA must have signs indicating that hearing protection is required. No unprotected exposure is permitted for exposure level greater than 115 dBA.
- Ensuring that the personal hearing protection devices are approved and classified or graded by the Canadian Standards Association (CSA).
- Ensure there are up-to-date employee and contractor's orientation training and awareness for reducing noise exposure.
- Ensure there are appropriate programs of Audiometric Testing of exposed workers for hearing conservation thereby minimizing hearing loss.

Conclusion

Patching Associates Acoustical Engineering Ltd. (PAAE) was retained by the Yukon Environmental and Socio-Economic Assessment Board (YESAB) to complete a noise impact assessment update for the proposed Alexco Keno Hill Mining Corp (AKHM) Flame and Moth Mine together with the current operations (i.e., existing Bellekeno Mine and Keno District Mill) and the planned Onek and Lucky Queen operations (previously announced planned projects undergoing regulatory permitting and licensing) in the Keno Hill Silver District located around the Keno City, 354 km north of Whitehorse, Yukon. This current study is an update to the previously completed evaluation completed by PAAE in July 2012 (PAAE File: 2012-3379).

The primary objectives of the study is to include the noise sources associated with the Proposed Flame and Moth project to those modelled in July 2012 by PAAE for the existing Bellekeno Mine and Keno District Mill, and the planned Onek and Lucky Queen operations. The proposed Flame and Moth mine portal is located approximately 1 km southwest of Keno City and approximately 50 m from the Keno District Mill.

The results of this assessment indicate that the predicted cumulative sound level from the operations of the proposed Flame and Moth mine together with the existing AKHM current operations (i.e., existing Bellekeno Mine and Keno District Mill) and Onek and Lucky Queen operations (planned projects) is expected to have negligible changes in sound level increase at the assessed residences under downwind conditions when compared to the current situation. This assumed all of the surface equipment running simultaneously and at full power level.

The predicted cumulative effects from the different mining operations including the proposed Flame and Moth mine will have negligible effect on the Keno City residences. The most impacted residence is R04, which is also the closest residence to Onek portal site, will have 3-4 dBA increase of sound level based on measured ambient sound pressure level and 2 dBA increase based on current sound level.

The difference between the predicted A-weighted and C-weighted noise levels indicate a strong possibility of annoyance due to the low-frequency content of the noise levels. Only as a secondary and case specific requirement, the Alberta Energy Regulator (AER) uses the difference between these parameters, combined with the presence of a definite tonal component to assess whether an adjustment to their Permissible Sound Level (PSL) is justified. If the difference is 20 dB or higher *and* there is a distinct tone, then a 5 dBA penalty is applied, reducing the PSL to 35 dBA L_{eq} at nighttime. In Table 12, the predicted difference in the A-weighted and C-weighted levels exceeds 20 dB, but the predicted level (32.2 dBA from industrial activity) is already below the 'adjusted' PSL of 35 dBA (per the AER Directive 38) – there is also no definitive tonal component given the available data.

Upon completion of mining, decommissioning and reclamation of the facilities, the sound environment is expected to revert to ambient conditions.

References

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International Organization for Standardization (ISO). 1993. *Standard 9613-1, Acoustics – Attenuation of Sound during Propagation Outdoors – Part 1: Calculation of Absorption of Sound by the Atmosphere*, Geneva Switzerland.

International Organization for Standardization (ISO) 1996. *Standard 9613-2, Acoustics – Attenuation of Sound During Propagation Outdoors – Part 2: General Method of Calculation*, Geneva Switzerland.

APPENDIX A

Explanation of Technical Details Regarding Sound Measurement and Analysis

Technical Details

Sound is the phenomena of vibrations transmitted through air, or other medium such as water or a building structure. The range of pressure amplitudes, intensities, and frequencies of the sound energy is very wide, and many specialized fields have developed using different ranges of these variables, such as room acoustics and medical ultrasound.

Due to the wide range of intensities, which are perceived as sound, standard engineering units become inconvenient. Sound levels are commonly measured on a logarithmic scale, with the level (in decibels, or dB) being proportional to ten times the common logarithm of the sound energy or intensity. Normal human hearing covers a range of about twelve to fourteen orders of magnitude in energy, from the threshold of hearing to the threshold of pain. On the decibel scale, the threshold of hearing is set as zero, written as 0 dB, while the threshold of pain varies between 120 to 140 dB. The most usual measure of sound is the sound pressure level (SPL), with 0 dB SPL set at 2.0×10^{-5} N/m^2 (also written 20 μPa), which corresponds to a sound intensity of 10^{-12} Watts/m^2 (or 1 picoWatt/m^2, written 1 pW/m^2).

Normal human hearing spans a frequency range from about 20 Hertz (Hz, or cycles per second) to about 20,000 Hz (written 20 KHz). However, the sensitivity of human hearing is not the same at all frequencies. To accommodate the variation in sensitivity, various frequency-weighting scales have been developed. The most common is the A-weighting scale, which is based on the sensitivity of human hearing at moderate levels; this scale reflects the low sensitivity to sounds of very high or very low frequencies. Sound levels measured on the A-weighted scale are written in A-weighted decibels, commonly shown as dBA or dB(A).

When sound is measured using the A-weighting scale, the reading is often called the "Noise level", to confirm that human sensitivity and reactions are being addressed. A table of some common noise sources and their associated noise levels are shown in Table A1.

When the A-weighting scale is not used, the measurement is said to have a "linear" weighting, or to be unweighted, and may be called a "linear" level. As the linear reading is an accurate measurement of the physical (sound) pressure, the term "Sound Pressure Level", or SPL, is usually (but not universally) reserved for unweighted measurements.

Noise is usually defined as "unwanted sound", which indicates that it is not just the physical sound that is important, but also the human reaction to the sound that leads to the perception of sound as noise. It implies a judgment of the quality or quantity of sound experienced. As a human reaction to sound is involved, noise levels are usually given in A-weighted decibels (dBA). An alternate definition of noise is "sound made by somebody else", which emphasizes that the ability to control the level of the sound alters the perception of noise.

Table B1- Noise Levels of Familiar Sources

Source Or Environment	Noise Level (dBA)
High Pressure Steam Venting To Atmosphere (3m)	121
Steam Boiler (2m)	90-95
Drilling Rig (10m)	80-90
Pneumatic Drill (15m)	85
Pump Jack (10m)	68-72
Truck (15m)	65-70
Business Office	65
Conversational Speech (1m)	60
Light Auto Traffic (30m)	50
Living Room	40
Library	35
Soft Whisper (5m)	20-35

The single number A-weighted level is often inadequate for engineering purposes, although it does supply a good estimate of people's reaction to a noise environment. As noise sources, control measures, and materials differ in the frequency dependence of their noise responses or production, sound is measured with a narrower frequency bandwidth; the specific methodology varies with the application. For most work, the acoustic frequency range is divided into frequency bands where the center frequency of each band is twice the frequency of the next lower band; these are called "Octave" bands, as their frequency relation is called an "Octave" in music, where the field of acoustics has its roots. For more detailed work, the octave bands, and certain standard octave and 1/3 octave bands have been specified by international agreements.

Where the noise at the receiver is steady, it is easy to assess the noise level. However, both the production of noise at the source and the transmission of noise can vary with time; most noise levels are not constant, either because of the motion of the noise source (as in traffic noise), because the noise source itself varies, or because the transmission of sound to the receiver location is not steady as over long distances. This is almost always the case for environmental noise studies. Several single number descriptors have been developed and are used to assess noise in these conditions.

The most common is the measurement of the "equivalent continuous" sound level, or L_{eq}, which is the level of a hypothetical source of a constant level which would give the same total sound energy as is measured during the sampling period. This is the "energy" average noise level. Typical sampling periods are one hour, nighttime (9 hours) or one day (24 hours); the sampling period used must be reported when using this unit.

The greatest value of the L_{eq} is that the contributions of different sources to the total noise level can be assessed, or in a case where a new noise source is to be added to a planned environment, the total noise level from new and old sources can be easily calculated. It is also sensitive to short term high noise levels.

Statistical noise levels are sometimes used to assess an unsteady noise environment. They indicate the levels that are exceeded a fixed percentage of the measurement time period measured. For example, the 10%-ile level, written L_{10}, is the levels exceeded 10% of the time; this level is a good measure of frequent noisy occurrences such as steady road traffic. The 90% level, L_{90}, is the level exceeded 90% of the time, and is the background level, or noise floor. A steady noise source will modify the background level, while an intermittent noise source such as road or rail traffic will affect the short-term levels only.

One disadvantage with the L_{eq} measure, when used alone, is that nearby loud sources (e.g. dogs barking, or birds singing) can confuse the assessment of the situation when it is the noise from a distant plant that is the concern. For this reason, the equivalent level and the statistical levels can be used together to better understand the noise environment. One such indication is the difference between the L_{eq} and the L_{90} levels. A large difference between the L_{eq} and L_{90}, greater than 10 dB, indicates the intrusion of short-term noise events on the general background level. A small difference, less than 5 dB, indicates a very steady noise environment. If the L_{eq} value exceeds the L_{10} value this indicates the presence of significant short-term loud events.

For most noise measurement, instruments are adjusted so that the time response of the instrument is similar to the response of the human ear; this is the "Fast" setting. Measurement with the "Fast" setting therefore assesses the sound environment according to the way humans would hear it and react to it. Where the noise level varies substantially and an average level is wanted without the complexity of and L_{eq} or statistical measurement, the "Slow" setting is used on the sound level meter. The "Slow" setting is also typically used in industrial settings where hearing damage is a concern. Where the noise level changes very rapidly, for example due to impacts or detonations, the "Fast" and "Slow" settings do not respond quickly enough to assess the maximum levels, and the "Impulse" meter setting us used.

The Sound Power Level (abbreviated L_w, SWL or PWL) is the decibel equivalent of the total energy emitted from a source in the form of noise. The reference level for the sound power is 10^{-12} Watts, or 1 picoWatt (abbreviated pW). The sound power level is given by:

$$L_w, \text{SWL, PWL} = 10 \times \log_{10} (\text{Emitted Power} / 1\ \text{pW})\ \text{dB}$$

Therefore, a source emitting 1 Watt of power in the form of sound would have a sound power level of 120 dB. Sound power levels can be expressed in terms of frequency bands, an overall linear-weighted level or A-weighted, as is the case for sound pressure levels. However, sound power levels are inherent to the source of noise, whereas the sound pressure level is dependent on the source, but also on the distance from the source and other environmental factors.

APPENDIX B

DISTURBANCE NOTIFICATION FORM

DISTURBANCE NOTIFICATION FORM

ALEXCO KENO HILL MINING CORP. – KENO HILL SILVER DISTRICT MINING OPERATIONS

Name of Complainant:

Phone Number & Address of Complainant:

Date	Start Time/ End Time	Location	Description of Noise, Traffic or Dust Disturbance (e.g. likely source, magnitude, duration, ongoing or isolated incident)	How did the disturbance disrupt your life and/or your business/livelihood?

This form has been created for Keno Residents to formally complain of disturbance associated with Alexco Keno Hill Mining Corp.'s Keno Hill Silver District Operations. Please call 647-519-3537 or email contactus@alexcoresource.com with your complaints. Should you choose to use the form, please complete all fields and return to contactus@alexcoresource.com

Signature: Date: