Appendix 10.5-A

Noise and Vibration Technical Data Report

AJAX MINE PROJECT
Noise and Vibration Technical Data Report



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Executive Summary

This technical data report describes a noise and vibration assessment completed to support the effects assessment for the KGHM Ajax Mining Inc. (KAM) proposed Ajax Project (the Project).

This Project is an open pit copper-gold mine at the historic Afton Mining Camp, located south of the City of Kamloops, British Columbia.

NOISE ASSESSMENT

The noise assessment focused on the Project noise effect on humans. A total of 37 noise receptors were identified, including residences, schools, daycares, hospitals, First Nation communities, potential city development areas, and traditional land use areas. In the consideration of noise receptors, the receptors closest to the Project were selected. Noise effects diminish at increasing distances from the sources. If the Project effect meets the threshold at the closest receptors in different directions, the effect is expected to be less at further distances.

The existing acoustic environment (i.e. baseline) was investigated by two baseline studies. The baseline studies quantified the baseline sound level at selected locations within the Project study area through field measurements. The studies included six locations that represent different developed and undeveloped areas. Two locations are in a rural environment. Two locations are located near the Aberdeen development boundary, representative of a rural to suburban area transition. Two locations are within the suburban residential community of Aberdeen.

Two Project phases were explored in the noise assessment: construction and operation. In the construction phase, noise effects during Year -1 were assessed. Based on the review of the mine plan and equipment list, the Year -1 construction scenario was considered representative of the worst case scenario. Piling activities near the east arm of Jacko Lake prior to the Construction phase were also assessed as a separate scenario. In the operation phase, noise effects during Year 2 and Years 4 and 8 were assessed. Year 2 operation phase was chosen because it represents the production year with in-pit equipment operating at higher elevations and with less barrier effects from pit walls. Year 4 has the highest material movement and production tonnage but the haulage distance is shorter. Year 8 represents less production tonnage but the longest haulage distance, which may result in higher noise emission from the haulage fleet. In a conservative approach, both years were combined into one scenario (Years 4 and 8) using the maximum equipment quantity from Year 4 and the haulage distance from Year 8.

Decommissioning, Closure, and Post Closure activities are expected to have no interaction or negligible to minor interaction with the noise effect. The quantity of equipment required for the decommissioning is expected to be well below the requirement for the construction phase, thus noise effects exceeding acceptable levels are not expected. Noise effects during dismantling, site cleanup and reclamation activities can be managed to acceptable levels by

implementation of best practices, standard mitigation and management measures used for the construction phase.

The noise assessment was conducted using prediction methods developed by the International Organization for Standardization (ISO), which are commonly used by noise practitioners and are accepted by provincial and federal agencies.

Noise effects were predicted at the 37 noise receptors for different scenarios during Project construction and operation. The decommissioning phase was not included because the noise effect is expected to be less than the noise effect in the construction phase. Compliance with the British Columbia (BC) Oil and Gas Commission (OGC) Noise Control Guideline noise thresholds (permissible sound level [PSL]) was assessed for the operation phase. The BC OGC Noise Control Guideline pertains only to operation and does not provide defined noise level limits for construction and decommissioning activities. Results from the construction phase were compared with the Health Canada guidance for change in percent highly annoyed (%HA).

Noise effects from the Project operation phase were predicted to comply with the BC OGC Noise Control Guideline. At the closest receptor, the predicted nighttime level is below the PSL of 40 dBA. During operation and construction phases, the predicted noise levels meet the Health Canada noise guidance (less 6.5% change in %HA) and the World Health Organization sleep disturbance thresholds (42 dBA night time) at all noise receptors. The only exception is a location near east end of Jacko Lake where short term (less than two months duration) daytime piling activities noise effects exceeded the Health Canada noise threshold. Public access to this area is restricted during piling activities.

VIBRATION ASSESSEMENT

The vibration effect assessment focused on the blast induced ground vibration and air blast overpressure effects on human habitats and structures. A total of 41 vibration receptors were identified, including residences, commercial structures, potential city development areas, Jacko Lake sensitive fish habitat areas, First Nation communities, traditional land use area, and open recreation areas. Similar to the noise receptors, the receptors closest to the Project were selected. Vibration effects diminish at increased distances from the sources. If the Project effect meets the threshold at the closest receptors in different directions, the effect is expected to be less at further distances.

There is no vibration baseline study for the Project. Vibration level is typically assessed for the event without the consideration of a baseline level. Most guidelines and regulatory limits are only applicable to the event only without the consideration of a baseline level. The masking effect from background vibration level or cumulative vibration level from another event is typically not included.

In the vibration assessment, the blast induced vibration effect during the operation phase was the primary focus. In addition, ground vibration effects from construction equipment, piling, and drilling were also assessed.

The vibration assessment used prediction methods developed by the United States Bureau of Mines (USBM) and the International Society of Explosives Engineers (ISEE). Technical literature from these organizations provides commonly used and accepted equations for vibration prediction in blast design application.

The vibration assessment results were compared to thresholds recommended by the United States Bureau of Mines, the Ministry of Ontario Environment and Climate Change, and other best available guidelines.

Blast designs were developed to meet the guideline for structural damange, human annoyance, and aquatic life protection. The predicted ground vibration level at all residential receptors at further distance was between 1 to 2 mm/s, well below the human annoyance threshold of 5 mm/s and the structural damage threshold of 10 mm/s. This level of ground vibration is unlikely to cause any damage in the drywall of residential or commercial structures. Drywall is usually the weakest structural component member in residential and commercial structures to blast induced ground vibrations. The predicted air blast overpressure level at the Kamloops development boundary and the closest residential structure is 113 and 112 dBL, respectively. The predicted air blast overpressure levels for all homes, industrial structures and towers were all below the structural damage (120 dBL) and annoyance thresholds (115 dBL).

The vibration levels at most receptors are expected to be well below the damage thresholds for residences, commercial structures, utilities, and below the levels of acceptable human annoyance. The only exception is Jacko Lake, where the predicted levels exceed the annoyance thresholds when blasting occurs near the western portion of the pit. Public access to this area is restricted during Operational blasting.

Abbreviations

%HA	percent highly annoyed
AER	Alberta Energy Regulator
ANSI	American National Standards Institute
ASL	ambient sound level
BC	British Columbia
BSL	basic sound level
CDB	city development boundary
CSL	comprehensive sound level
dB	linear decibel level
dBA	A-weighted decibel level
dBC	C-weighted decibel level
dBL	linear decibel level
DFO	Fisheries and Oceans Canada
°C	degree Celsius
EA	environmental assessment
EMRSF	East Mine Rock Storage Facility
EPA	Environmental Protection Agency
g/cc	gram per cubic centimeter
hr	hour
HVAC	heating, ventilation and air conditioning
IPMRSF	In-Pit Mine Rock Storage Facility

ISEE	International Society of Explosives Engineers
ISO	International Organization for Standardization
KAM	KGHM Ajax Mining Inc.
km	kilometre
LSA	local noise study area
L_d	daytime equivalent sound level
L_{dn}	day-night equivalent sound level
L_{eq}	equivalent sound level
LFN	low frequency noise
L_n	night time equivalent sound level
m	metres
masl	meter above sea level
mm	millimetres
MOE	Ministry of Environment
MOECC	Ontario Ministry of Environment and Climate Change
ms	millisecond
m/s	meter per second
MRSF	mine rock storage facilities
NEF	noise exposure forecast
No.	number
NR	noise reduction
OGC	Oil and Gas Commission
Project	KGHM Ajax Mining Project

PPV	peak particle velocity
PSL	permissible sound level
PWL	sound power level
RSA	regional noise study area
SL	sound level
SMRSF	South Mine Rock Storage Facility
SPL	sound pressure level
SSN	Stk'emlupsemc te Secwepemc Nation
TDR	technical data report
TEMRSF	Tailings Embankment Mine Rock Storage Facility
TL	transmission loss
TSF	tailings storage facility
USBM	United States Bureau of Mines
UTM	Universal Transverse Mercator
WHO	World Health Organization

1.0 INTRODUCTION

KGHM Ajax Mining Inc. proposes to develop the Project, an open pit copper-gold mine at the historic Afton Mining Camp, south of the City of Kamloops, BC. The Project is located in the south-central interior of British Columbia, southeast of the junction of the Trans-Canada Highway No. 1 and the Coquihalla Highway (No. 5), within the Thompson Nicola Regional District.

The Project lies in the traditional territory of the Secwepemc Nation. Within the Secwepemc Nation, the Tk'emlúps te Secwepemc and the Skeetchestn Indian Band are the Aboriginal communities in closest proximity to the Project. In a cooperative effort, the Tk'emlúps te Secwepemc and Skeetchestn Indian Bands have formed the Stk'emlupsemc te Secwepemc Nation (SSN), as a division of the greater Secwepemc Nation. The Ashcroft Indian Band and Lower Nicola Indian Band, whose members are part of the Nlaka'pamux Nation also assert their Aboriginal rights to the Project area—an area of common interest with the SSN.

The Ajax property includes two historic pits: the Ajax West Pit, and the Ajax East Pit. Both pits were formerly mined in the 1980s and 1990s. As many as 25 rock types have been recognized in the Project area, some of which are "hybrid" units resulting from the intermixing of multiple rock types.

Key Project facilities include the Tailings Storage Facility (TSF), which is planned as a conventional tailings storage facility; water management ponds; Peterson Creek diversion, and the Tailings Embankments, which will be constructed using mine rock; and four mine rock storage facilities (MRSF). The four MRSFs are the:

- South Mine Rock Storage Facility (SMRSF),
- East Mine Rock Storage Facility (EMRSF),
- West Mine Rock Storage Facility (WMRSF), and
- In-Pit Mine Rock Storage Facility (IPMRSF).

Several facilities that will be part of the operation phase but not remain after project closure include the:

- plant facilities and administration buildings,
- reclamation stockpiles,
- explosives facility,
- truck stop and fuel storage,
- power lines, and
- access roads.

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August 21, 2015

The mine plan for the Project predicts an operation based on a mill throughput of 65,000 tonnes of ore per day from the Ajax Pit with up to a 23 year mine life. The construction phase of the Project will be approximately two and a half years, and following the 23 year operation the decommissioning and closure phase is expected to take up to 5 years. Over the mine life the Project will produce approximately 140 million pounds of copper and 130,000 ounces of gold annually with the concentrate shipped by truck to the Port of Vancouver.

This technical data report (TDR) includes eight sections:

- Section 1 is the introduction to the TDR
- Section 2 examines local and regional settings such as receptor location and baseline conditions
- Section 3 summarizes the regulatory framework used for the assessment
- Section 4 explains the assessment approach
- Section 5 presents the modelling results for construction and operational phases of the Project
- Section 6 presents Summary and Conclusions
- Section 7 lists the References
- Section 8 contains the Closure statements

Important supplemental reports and detailed information are provided in five Appendices:

- Appendix A– Noise Baseline
- Appendix B–Permissible Sound Level Determination
- Appendix C–Noise Emission Sources
- Appendix D–Ajax Mine Blast Review, Conclusions and Recommendation
- Appendix E–Commonly Used Noise Terminology

2.0 SETTING

The Project is situated at the historic Afton Mining Camp, south of the City of Kamloops. The City of Kamloops itself occupies the valley bottom, with neighborhoods extending up the south valley wall towards the Project up to approximately 900 metres masl. Physically separating the built-up urban landscape in Kamloops from the Project site is Coal Hill (1,092 metres asl), Ironmask Hill (995 metres asl), and Sugarloaf Mountain (1,130 metres asl). This feature forms a natural barrier between the Project and the City that will help confine some of the noise and vibration effects from the Project.

There are developed and undeveloped areas near the Project. Many environmental factors can affect the existing acoustic environment (i.e. baseline sound level) in both developed and undeveloped areas. These factors can vary to the minute because of changing natural forces and human activities.

Variability in seasonal and meteorological conditions will affect the ambient sound level at a location. In most rural acoustic environments, the ambient sound level is characterized by natural sounds sources including insects, animals, wind and rain interacting with natural surfaces. These sources are somewhat variable down to the minute because of changing natural forces. In developed area with more human activities (i.e. suburban area, business and commercial districts), the acoustic environment may vary from one location to another due to the level of activities during different time periods. Regional transportation infrastructures such as the Kamloops airport, Trans-Canada Highway, and the railways are noise emission sources that contribute to the existing acoustic environment.

In contrast to the acoustic environment, the background environmental ground-borne vibration levels in an outdoor rural area without any local human activities is typically below the threshold of human perception (FTA 2006). The typical threshold of human perception of ground vibration is 0.5 mm/s peak particle velocity (Blasters' Handbook 2011); however, the perceptibility threshold varies from person to person. In an urban and suburban environment, a person may be subjected to a wide range of vibration effect, depending on the location, time of the day, proximity to day-to-day vibration sources (i.e. vehicle, train, construction activities). Vibration level in an indoor residential environment is created by local events such as vacuum cleaning, washing machine, movement of people or slamming of doors. Such indoor events will create different levels of perceptible vibration. The structural integrity of the building will also affect the indoor vibration level.

2.1 ASSESSMENT AREAS AND RECEPTOR LOCATIONS

2.1.1 Assessment Areas

The local noise study area (LSA) is defined as a 1.5 km buffer around the Plant boundary. The regional noise study area (RSA) is defined as a 30 km by km 3.0 km that includes all receptor of interest. Selected noise receptors are considered within the RSA. Predicted noise results within the TDR will be depicted in this TDR.

The vibration LSA is defined as a 3 km distance from the mine pit. The RSA is the same as the LSA defined for the vibration assessment. The vibration RSA is defined as a 14 km x 14 km area in the assessment. The RSA will include the maximum effect from vibration at the receptors. Predicted vibration results within the RSA will be depicted in this TDR.

The noise LSA and RSA are shown in Figure 2-1. The vibration LSA and RSA are shown in Figure 2-2.

2.1.2 Noise Receptors

The selection of noise receptors is based on the regulatory framework (Section 3). In the provincial noise guideline, a noise receptor as a dwelling unit can be any permanently or seasonally occupied residence with the exception of a Project employee residence or Project-related construction camp. The federal noise guidance has a broader definition of noise receptors. In the Health Canada noise guidance, both residential and non-residential locations can be classified as noise receptors. In consideration of both the provincial noise guideline and federal noise guidance, the following are considered noise receptors:

- Residences
- Daycares
- Schools
- Hospitals
- Places of worship
- Nursing homes
- First Nations communities

The noise assessment includes the noise receptors closest to the Project. A sensitive receptor listing with 196 receptors for Air Quality (HA) assessment and Human Health and Ecological Risk Assessment (HHERA) was developed for the Project. A subset (28 out of 196) of the receptor list was used for the noise assessment. The subset selection was based on the rationale that noise levels attenuate or decrease over long distances from their sources. If the Project noise effect meets the threshold at the closest receptors in different directions, the noise effect is expected to be less at further distances. In addition, eight traditional land use locations and the T'Kaloops First Nation Reserve are also included as noise receptors in the assessment. Noise prediction results are shown in a noise contour map (see Section 5.1) within the 30 km x 30 km RSA.

The receptors are shown in Figure 2-1 and the locations are summarized in Table 2-1.

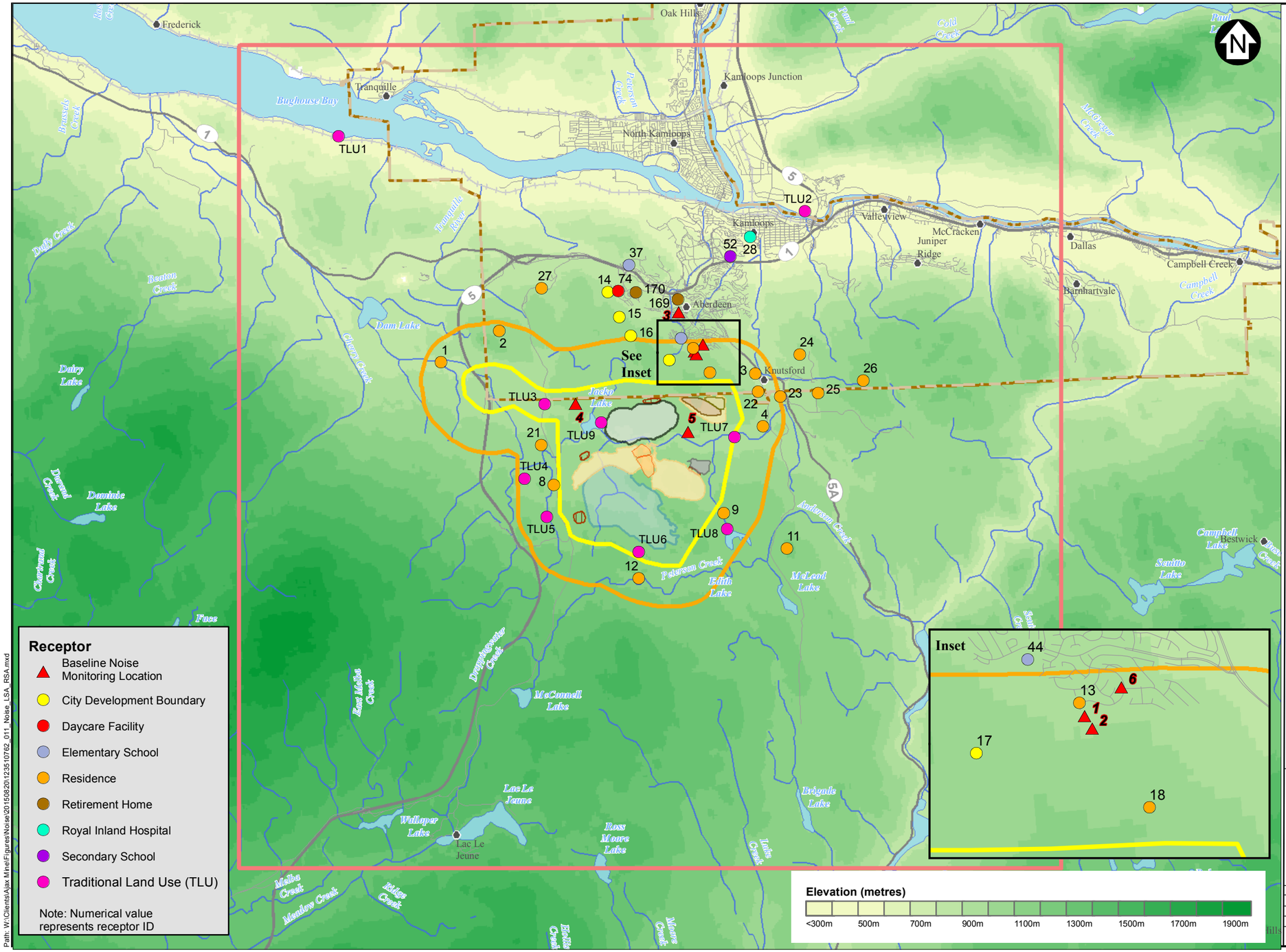
Table 2-1 Noise Receptors Locations

Noise Receptor Location ID	Receptor Type	UTM (Zone 10)	
		East (m)	North (m)
1	Residence	677081	5611958
2	Residence	679209	5613105
3	Residence	688538	5611542
4	Residence	688824	5609617
8	Residence	681197	5607480
9	Residence	687390	5606458
11	Residence	689692	5605170
12	Residence	684290	5604072
13	Aberdeen Development	686283	5612470
14	City Development Boundary (CDB)1	683168	5614516
15	CDB 2	683582	5613613
16	CDB 3	684006	5612929
17	CDB 4	685402	5612040
18	CDB 5	686880	5611577
21	Residence	680734	5608934
22	Residence	688644	5610892
23	Residence	689454	5610713
24	Residence	690170	5612246
25	Residence	690834	5610838
26	Residence	692479	5611288
27	Residence	680747	5614653
28	Royal Inland Hospital	688351	5616532
37	Dufferin Elementary	683939	5615505
44	Pacific Way Elementary	685839	5612841
52	Sahali Secondary	687639	5615818
74	Tots & Teddies	683549	5614551
169	Kamloops Senior Village	685722	5614250
170	Ridgepointe at Pineview Retirement Home	684190	5614503
TLU1	Kamloops Lake Pump house	673346	5620197

Table 2-1 Noise Receptors Locations

Noise Receptor Location ID	Receptor Type	UTM (Zone 10)	
		East (m)	North (m)
TLU2	T'Kaloops First Nation Reserve	690352	5617468
TLU3	Inks Lake	680861	5610428
TLU4	Jacko Creek	680123	5607713
TLU5	Upper Peterson Creek	680943	5606322
TLU6	Goose Lake Road	684287	5605045
TLU7	Peterson Creek Discharge	687781	5609227
TLU8	Edith Lake	687517	5605878
TLU9	Jacko Lake Prayer Tree	682931	5609762

Figure 2-1
Noise Study Area and Receptor Location



NOTES:
1. BASE MAP: DEM (55m) ERM
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD83 UTM, ZONE 10 NORTH, METER.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:150,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA AND CANADA

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KGHM

KGHM Ajax Mining Inc.

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2.1.3 Vibration Receptors

Vibration receptors are primarily locations where a structure would be subject to blast-induced ground vibrations and air blast overpressure. Other locations such as sensitive fish habitat and open recreation area where potential blast induced vibration effects might occur are included. A total of 41 locations within and outside the vibration LSA were identified. These locations included the following classifications:

- Sensitive fish habitat area
- Residences and similar structures
- Kamloops city boundaries
- Traditional land use area
- First Nation communities
- Industrial grade structures
- Commercial utility structures – cell tower
- Commercial utility structures – tanks
- Log cabin
- Open recreation area
- Road cut failure area
- Historical underground workings

Similar to the noise receptor, the vibration assessment used the vibration receptors closest to the Project. If the Project vibration effect meets the threshold at the closest receptors in different directions, the noise and vibration effect is expected to be less at further distances. The vibration receptors are presented in Figure 2-2 and the locations are summarized in Table 2-2.

Table 2-2 Vibration Receptors Locations

Vibration Receptor ID	Receptor Type	UTM (Zone 10)		Distance from Final Pit Boundary (m)	Classification
		East (m)	North (m)		
1a	Jacko Lake Sensitive Fish Habitat Area #1	683013	5609620	100	Sensitive fish habitat area
1b	Jacko Lake Sensitive Fish Habitat Area #2	682982	5609349	160	Sensitive fish habitat area
2	Jacko Lake boat launch area	682479	5610105	718	Open recreation area
3	Urban Growth Boundary	686071	5611759	1641	Kamloops city boundaries
4	Residence 1	687108	5608805	1872	Residences and similar structures

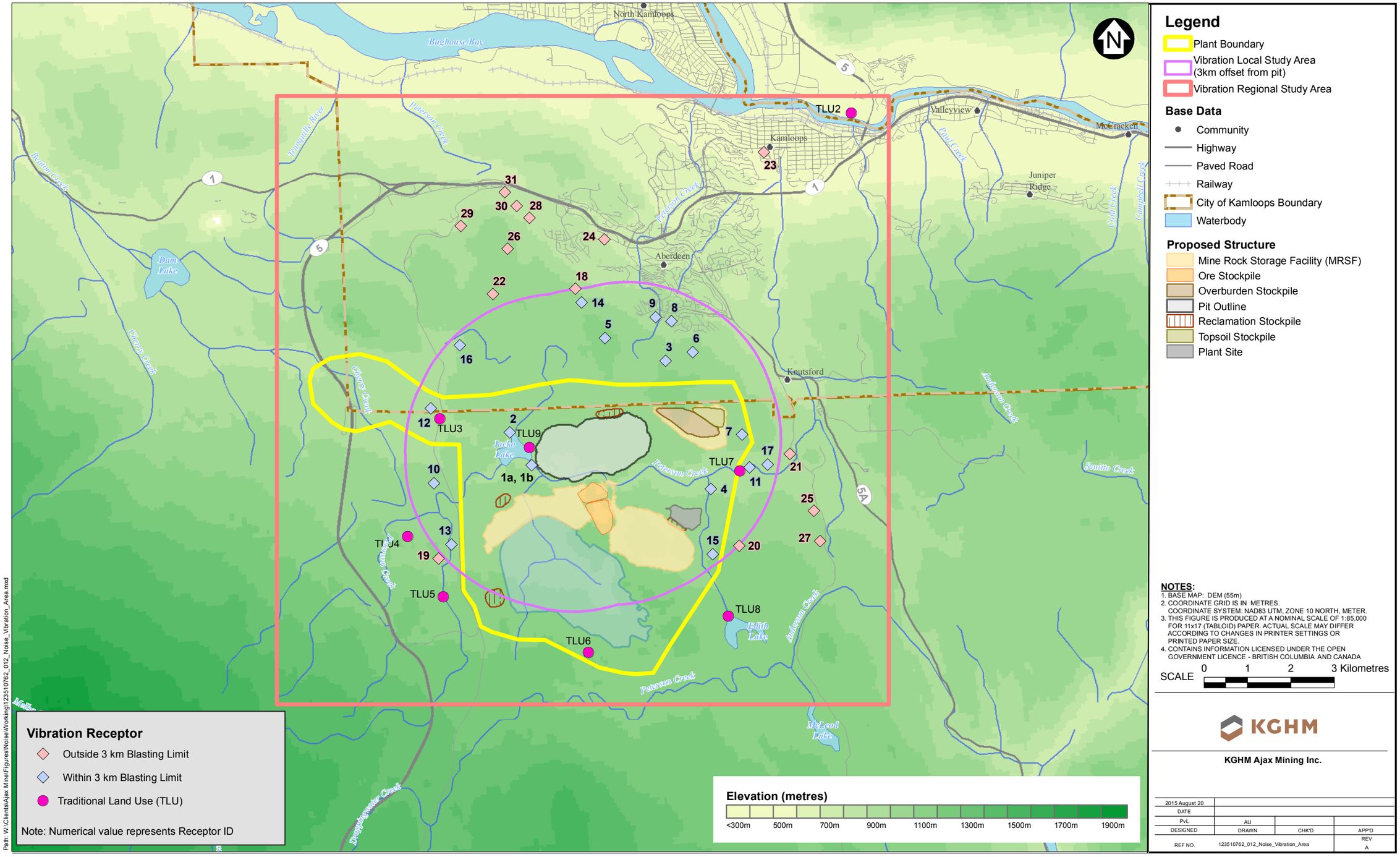
Table 2-2 Vibration Receptors Locations

Vibration Receptor ID	Receptor Type	UTM (Zone 10)		Distance from Final Pit Boundary (m)	Classification
		East (m)	North (m)		
5	Cell Tower 1	684670	5612282	1897	Commercial utility structures
6	Cell Tower 2	686694	5611960	2128	Commercial utility structures
7	Residence 2	687830	5610061	2308	Log cabin
8	City of Kamloops residences	686204	5612667	2385	Residences and similar structures
9	Elementary Pacific Way School	685837	5612766	2462	Industrial grade structure
10	Residence 3	680726	5608936	2462	Residences and similar structures
11	Site 1	688006	5609299	2564	Residences and similar structures
12	Inks Lake	680656	5610659	2615	Open recreation area
13	Residence 3	681134	5607524	2692	Residences and similar structures
14	Site 2	684133	5613104	2769	Open recreation area
15	Residence 4	687156	5607302	2821	Residences and similar structures
16	Site 3	681324	5612115	2821	Open recreation area
17	Site 4	688422	5609370	2949	Residences and similar structures
18	Python Minifile historic underground	683988	5613418	3103	Historic underground workings
19	Residence 5	680838	5607202	3154	Residences and similar structures
20	Residence 6	687769	5607496	3154	Residences and similar structures
21	Residence 7	688933	5609611	3410	Residences and similar structures
22	Galaxy historic underground	682091	5613299	3462	Historic underground workings
23	Royal Inland Hospital	688338	5616565	3974	Industrial grade structure

Table 2-2 Vibration Receptors Locations

Vibration Receptor ID	Receptor Type	UTM (Zone 10)		Distance from Final Pit Boundary (m)	Classification
		East (m)	North (m)		
24	Roadcut Failure Zone (Kamloops)	684655	5614556	4179	Road cut failure area
25	Pet Boarding	689488	5608300	4231	Residences and similar structures
26	Proposed bike trail (Official)	682428	5614338	4308	Open recreation area
27	Wedding event site location	689627	5607604	4667	Industrial grade structure
28	Surface storage tank 1	682928	5615053	4872	Commercial utility structures
29	Iron Mask historic underground	681346	5614868	5128	Historic underground workings
20	Surface storage tank 2	682632	5615327	5205	Commercial utility structures
31	Surface storage tank 3	682362	5615641	5564	Commercial utility structures
TLU1	Kamloops Lake Pump house	673346	5620197	14100	Traditional Land Use Area
TLU2	T'Kaloops First Nation Reserve	690352	5617468	8545	First Nation Community
TLU3	Inks Lake	680861	5610428	2360	Traditional Land Use Area
TLU4	Jacko Creek	680123	5607713	3470	Traditional Land Use Area
TLU5	Upper Peterson Creek	680943	5606322	3740	Traditional Land Use Area
TLU6	Goose Lake Road	684287	5605045	4020	Traditional Land Use Area
TLU7	Peterson Creek Discharge	687781	5609227	2150	Traditional Land Use Area
TLU8	Edith Lake	687517	5605878	4150	Traditional Land Use Area
TLU9	Jacko Lake Prayer Tree	682931	5609762	552	Traditional Land Use Area

Figure 2-2
Vibration Assessment Area and Receptor Location



NOTES:
1. BASE MAP: DEM (55m)
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD83 UTM, ZONE 10 NORTH, METER.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:85,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA AND CANADA

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KGHM Ajax Mining Inc.

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2.2 BASELINE CONDITIONS

2.2.1 Noise Baseline

2.2.1.1 Baseline Monitoring Program

The baseline studies quantified the baseline sound level at selected locations within the Project study area through field measurements. The baseline monitoring program included six locations that represent different developed and undeveloped areas. Locations 1 and 2 are near the Aberdeen community development boundary, and are representative of a rural to suburban area transition. Locations 3 and 6 are within the suburban residential community of Aberdeen. Location 4 and 5 are in a rural environment. Figure 2-1 presents the six noise monitoring locations chosen for the baseline analysis. Table 2-3 details the six measurement locations including the Universal Transverse Mercator (UTM) coordinates.

Table 2-3 Baseline Monitoring Locations

Monitoring Location ID	Monitoring Location	Description	Measurement period	UTM (Zone 10)	
				East (m)	North (m)
1	Abbeyglen/Pacific way intersection	South end of the Aberdeen development, at the intersection of Pacific Way and Abbeyglen Way.	December 1 to 5, 2012	686325	5612358
2	South of the Aberdeen community	South end of the Aberdeen development, at the end of Pacific Way. (south of location 1)	December 5 to 12, 2012	686390	5612252
3	Pacific Way and Howe Road Intersection	Open field at the intersection of Pacific Way and Howe Rd, close to the City of Kamloops road weather information system (RWIS) meteorological station.	December 16 to 21, 2012	685751	5613789
4	Jacko Lake	Location approximately 600 m north west of Jacko Lake, inside the project boundary, north of the main haul road.	June 10 to 15, 2014	681985	5610442
5	Straw House	2560 Goose Lake Rd, Kamloops, BC (approximately 3 km NNE of Goose Lake) just outside the project boundary.	June 10 to 15, 2014	686088	5609417
6	Aberdeen Residence	Residential area in the community of Aberdeen, south of Aberdeen Dr. and north of the project boundary	June 10 to 15, 2014	686639	5612604

The measurement results are compared to the baseline sound level estimation based on the British Columbia Oil and Gas Commission (BC OGC 2009) Noise Control Best Practices Guideline and the United States Environmental Protection Agency (US EPA 1974) Office of Noise Abatement and Control Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety. In addition, the results will be incorporated in the environmental assessment to quantify the change in acoustic environment due to the Project noise effect.

2.2.1.2 Methods

The methods used during the noise monitoring programs were consistent with the requirements outlined in BC OGC noise guideline. Furthermore, where information was not specified, specifications were taken from the Alberta Energy Regulator (AER) Directive 038: Noise Control, which the BC OGC noise guideline is based on. Directive 038 requires that a noise survey be conducted with a minimum Type 2 integrating sound level meter under weather conditions acceptable for noise measurements. Rain precipitation and high wind speed exceeding 15 km/hr are not considered acceptable weather conditions.

Health Canada guidance does not prescribe specific noise monitoring methods; however, the guidance recognizes measurement or estimated methods in establishing the baseline sound levels for the communities.

Two multiday noise monitoring studies were conducted at a total of six monitoring locations. The first study was conducted during winter (December 2012) and the second study was conducted during summer (June 2014).

Type 1 integrating sound level meters meeting the American National Standards Institute (ANSI) S1.43-1997 standard were used for the sound monitoring studies. Weather stations and weather meters were used in collecting the meteorological information during the monitoring periods. Audio sound recordings were reviewed to identify noise sources such as natural sounds (e.g. high wind, rain) and local activities for each monitoring period. Data that were not representative of normal site activity or measured outside acceptable weather conditions were filtered from the data set prior to the calculation of any averages or other statistics. Hourly daytime, and nighttime sound level values were then calculated for the measurement period. As per the BC OGC noise guideline, the daytime period is07:00 to 22:00 and the nighttime period is from 22:00 to07:00.

Details of methods used in the baseline monitoring program are presented in Appendix A.

2.2.1.3 Results

The hourly, daytime, and nighttime noise levels were calculated for each long-term measurement location. In determining the hourly equivalent sound level ($L_{eq, 1hr}$), a minimum cumulative time period of 30 minutes is required. The daytime (L_d) and nighttime (L_n) equivalent

sound level at all monitoring locations during each 24 hour measurement period is summarized in Table 2-4. In addition, the day-night equivalent sound level (L_{dn}) for each 24 hour period is presented. The total valid hours of measurement are shown for each 24 hour period.

Table 2-4 Baseline Monitoring Results – Daytime, Nighttime, and Day-Night Equivalent Sound Level Summary – 24 Hour Period

Monitoring Location ID	Date (M/D/Y)	Daytime, Nighttime, and Day-Night Equivalent Sound level (dBA)			Valid Daytime Hours	Valid Nighttime Hours
		L_d	L_n	L_{dn}		
1	12/1/2012	45.7	33.0	45.0	(13 of 15)	(6 of 9)
	12/2/2012	46.6	39.1	47.5	(7 of 15)	(3 of 9)
	12/3/2012	42.6	37.7	46.0	(7 of 15)	(8 of 9)
	12/4/2012	42.9	35.8	44.9	(4 of 15)	(7 of 9)
	12/5/2012	41.2	34.6	42.2	(10 of 15)	(3 of 9)
2	12/5/2012	40.3	-	-	(5 of 15)	(0 of 9)
	12/6/2012	38.0	35.8	42.4	(15 of 15)	(8 of 9)
	12/7/2012	42.6	33.6	43.1	(12 of 15)	(9 of 9)
	12/8/2012	39.5	38.4	45.0	(15 of 15)	(9 of 9)
	12/9/2012	35.7	33.7	40.7	(13 of 15)	(9 of 9)
	12/10/2012	38.1	36.6	43.3	(13 of 15)	(8 of 9)
	12/11/2012	35.4	35.5	41.0	(15 of 15)	(6 of 9)
	12/12/2012	-	28.6	-	(0 of 15)	(7 of 9)
3	12/16/2012	49.3	-	-	(3 of 15)	(0 of 9)
	12/17/2012	-	-	-	(0 of 15)	(2 of 9)
	12/18/2012	48.3	43.7	51.1	(15 of 15)	(9 of 9)
	12/19/2012	49.0	41.4	50.1	(15 of 15)	(9 of 9)
	12/20/2012	51.0	42.9	51.5	(14 of 15)	(4 of 9)
	12/21/2012	50.6	42.0	51.4	(6 of 15)	(4 of 9)
4	6/10/2014	36.4	37.5	43.8	(6 of 8)	(8 of 9)
	6/11/2014	36.5	37.2	43.5	(13 of 15)	(8 of 9)
	6/12/2014	38.5	36.1	43.0	(12 of 15)	(8 of 9)
	6/13/2014	43.2	32.9	43.1	(8 of 15)	(8 of 9)
	6/14/2014	36.9	30.4	38.6	(11 of 15)	(7 of 9)
	6/15/2014	34.1	-	-	(3 of 6)	-

Table 2-4 Baseline Monitoring Results – Daytime, Nighttime, and Day-Night Equivalent Sound Level Summary – 24 Hour Period

Monitoring Location ID	Date (M/D/Y)	Daytime, Nighttime, and Day-Night Equivalent Sound level (dBA)			Valid Daytime Hours	Valid Nighttime Hours
		L_d	L_n	L_{dn}		
5	6/10/2014	39.0	33.8	41.4	(5 of 6)	(7 of 9)
	6/11/2014	35.8	33.4	40.2	(10 of 15)	(8 of 9)
	6/12/2014	39.4	36.2	43.3	(10 of 15)	(7 of 9)
	6/13/2014	43.4	31.6	42.8	(6 of 15)	(8 of 9)
	6/14/2014	38.5	33.4	41.1	(11 of 15)	(7 of 9)
	6/15/2014	36.3	-	-	(3 of 15)	-
6	6/10/2014	41.7	34.3	42.9	(5 of 6)	(9 of 9)
	6/11/2014	48.9	45.6	52.7	(13 of 15)	(9 of 9)
	6/12/2014	54.5	44.1	54.4	(12 of 15)	(8 of 9)
	6/13/2014	54.3	47.9	56.0	(7 of 15)	(5 of 9)
	6/14/2014	54.2	44.6	54.3	(6 of 15)	(3 of 9)
	6/15/2014	52.8	-	-	(1 of 8)	-

Table 2-5 summarizes the measured baseline sound level results for the entire measurement period at each location. The results provide a baseline evaluation of the acoustic environment in the area based on measurement. In addition, the recommended baseline sound level from the BC OGC and US EPA are shown in the table for comparison purposes.

Table 2-5 Baseline Monitoring Results – Daytime, Nighttime, and Day-Night Equivalent Sound level Summary – Entire Measurement Period

Monitoring Location ID	Time Period	Measured L_d (dBA)	BC OGC L_d (dBA)	Measured L_n (dBA)	BC OGC L_n (dBA)	Measured L_{dn} (dBA)	US EPA L_{dn} (dBA)
1	December 1 to 5, 2012	44	51	36	41	45	48 to 52
2	December 5 to 12, 2012	39	51	36	41	43	48 to 52
3	December 16 to 21, 2012	50	61	43	51	51	48 to 52
4	June 10 to 15, 2014	39	45	36	35	43	44
5	June 10 to 15, 2014	39	45	34	35	42	44

Table 2-5 Baseline Monitoring Results – Daytime, Nighttime, and Day-Night Equivalent Sound level Summary – Entire Measurement Period

Monitoring Location ID	Time Period	Measured L_d (dBA)	BC OGC L_d (dBA)	Measured L_n (dBA)	BC OGC L_n (dBA)	Measured L_{dn} (dBA)	US EPA L_{dn} (dBA)
6	June 10 to 15, 2014	53	51	45	41	54	53 to 57

Variability in seasonal and meteorological conditions affects the baseline sound level at all the measurement locations. In most rural acoustic environments, the baseline sound level is characterized by natural sounds sources including wind and rain interacting with natural surfaces (e.g., wind noise, vegetation rustling), stream and creek movement, and animal noises (e.g., from birds and insects). These sources are somewhat variable down to the minute because of changing natural forces. In developed areas with more human activities (i.e. suburban areas, business and commercial districts), the acoustic environment may vary from one location to another during different time periods.

It is common to have measurement results that are above or below the prescribed or recommended levels from noise guidelines and guidance. The measured baseline sound levels are based on approximately one week of measurement data. The measurement result may not be identical to values recommended in noise guideline and guidance; however, it provides an indication of the average acoustic environment for the location. Longer monitoring periods (monthly or annually) or a permanent monitoring program would provide a larger statistical sample; however, the week long program is considered sufficient for an evaluation of the existing acoustic environment in most locations. Longer period (monthly or annually) or a permanent monitoring program may provide a larger statistical sample. The BC OGC and Health Canada guideline does not prescribe minimum monitoring duration for baseline sound level program. The Alberta AER Directive 038 noise regulation recommends monitoring period varies from 9 to 24 hours, depending on the type, time, and duration of the noise. A minimum of 3 hours per daytime or nighttime period of acceptable data (by the AER) is required for the baseline monitoring to be considered valid. Based on professional judgement, the 5 to 6 days long program provides reasonable amount of data for an evaluation of the existing acoustic environment at the monitoring locations.

These baseline results were incorporated in the effects assessment to quantify the change in acoustic environment due to Project-related noise. The supporting information from the baseline monitoring program is presented in Appendix A Noise Baseline.

2.2.1.4 Determination of Baseline Sound Level at Receptors

The baseline sound level at different noise receptors listed in Section 2.1.2 can be estimated by using BC OGC prescribed Ambient Sound Level (ASL) or measurement results from the

monitoring program. The measured L_{dn} results at selected monitoring locations (1 to 6) can be used to represent the noise receptor baseline level. Table 2-6 summarizes the acoustic environment for each monitoring location and the noise receptor it represents.

Receptors 14 to 18 are located near the CDB, similar to the monitoring location 2. Receptors 3 and 27 are located near a small rural community. Receptor 23 is located in a trailer park. The baseline sound level at these three locations is expected to be higher than the quiet rural area; correspondingly, baseline sound levels from monitoring location #2 are assumed for these three receptors (3, 27, and 23).

Receptor 28, 37, 44, 52, 74, 169, and 170 are located in busy suburban or urban areas. The acoustic environment at these locations is expected to be similar or noisier than monitoring location 3. In a conservative approach, baseline sound level at all these locations is assumed to be similar to monitoring location 3. Receptor TLU2 is located in the First Nation community, the population density and the proximity to a busy road (Southern Yellowhead Highway) is similar to the monitoring location 6.

Receptor TLU9 is located in the same area as monitoring location 4.

Receptors 1, 2, 4, 8, 9, 11, 12, 21, 24 to 26, TLU1, and TLU3 to TLU8 are considered to be located in a quiet rural environment, similar to monitoring location 5.

Receptor 13 is located on the same street as monitoring location 6.

Table 2-6 Monitoring Location and Noise Receptor Location Comparison

Monitoring Location ID	Acoustic Environment	Applied to Noise Receptor ID
2	City development boundary	3, 23, 27, and 14 to 18
3	Suburban area close to a busy road	28, 37, 44, 52, 74,169, 170, TLU2
4	Jacko Lake area	TLU9
5	Rural area	1, 2, 4, 8, 9, 11, 12, 21, 22, 24 to 26, TLU1, and TLU3 to TLU8
6	Suburban area	13

Table 2-7 summarizes the estimated L_{dn} for each noise receptor based on the measured monitoring results and ASL prescribed in BC OGC. Details on the determination of ASL are presented in Section 3.1.1.1. In comparing the two data source approaches, the lower value baseline L_{dn} will be used. This is considered a more conservative (more protective) approach as a lower baseline value will result in a higher change or noise effect in the assessment. The shaded cells represented the lower baseline L_{dn} for each receptor. The measured sound levels

are used for all receptors with the exception of receptors 13 and TLU2, where the BCOGC ASL baseline sound levels are lower.

Table 2-7 Baseline Sound Level at Noise Receptors

Noise Receptor ID	Receptor Type	Baseline Sound Level				Baseline Sound Level (BC OGC ASL)		
		L_d (dBA)	L_n (dBA)	L_{dn} (dBA)	Monitoring Location	L_d (dBA)	L_n (dBA)	L_{dn} (dBA)
1	Residence	39	34	42	5	45	35	45
2	Residence	39	34	42	5	45	35	45
3	Residence	39	36	43	2	50	40	50
4	Residence	39	34	42	5	45	35	45
8	Residence	39	34	42	5	45	35	45
9	Residence	39	34	42	5	45	35	45
11	Residence	39	34	42	5	45	35	45
12	Residence	39	34	42	5	45	35	45
13	Aberdeen Development	53	45	54	6	51	41	51
14	CDB 1	39	36	43	2	48	38	48
15	CDB 2	39	36	43	2	45	35	45
16	CDB 3	39	36	43	2	45	35	45
17	CDB 4	39	36	43	2	45	35	45
18	CDB 5	39	36	43	2	45	35	45
21	Residence	39	34	42	5	45	35	45
22	Residence	39	34	42	5	45	35	45
23	Residence	39	36	43	2	53	43	53
24	Residence	39	34	42	5	45	35	45
25	Residence	39	34	42	5	45	35	45
26	Residence	39	34	42	5	45	35	45
27	Residence	39	36	43	2	48	38	48
28	Royal Inland Hospital	50	43	51	3	56	46	56
37	Dufferin Elementary	50	43	51	3	53	43	53
44	Pacific Way Elementary	50	43	51	3	56	46	56
52	Sahali Secondary	50	43	51	3	56	46	56
74	Tots & Teddies	50	43	51	3	56	46	56
169	Kamloops Senior Village	50	43	51	3	53	43	53
170	Ridgepointe at Pineview Retirement Home	50	43	51	3	53	43	53
TLU1	Kamloops Lake Pump house	39	34	42	5	45	35	45

Table 2-7 Baseline Sound Level at Noise Receptors

Noise Receptor ID	Receptor Type	Baseline Sound Level				Baseline Sound Level (BC OGC ASL)		
		L_d (dBA)	L_n (dBA)	L_{dn} (dBA)	Monitoring Location	L_d (dBA)	L_n (dBA)	L_{dn} (dBA)
TLU2	T'Kaloops First Nation Reserve	50	43	51	3	48	38	48
TLU3	Inks Lake	39	34	42	5	45	35	45
TLU4	Jacko Creek	39	34	42	5	45	35	45
TLU5	Upper Peterson Creek	39	34	42	5	45	35	45
TLU6	Goose Lake Road	39	34	42	5	45	35	45
TLU7	Peterson Creek Discharge	39	34	42	5	45	35	45
TLU8	Edith Lake	39	34	42	5	45	35	45
TLU9	Jacko Lake Prayer Tree	39	36	43	4	45	35	45

2.2.2 Vibration Baseline

Baseline ground vibration level at all receptors is not quantified. Vibration level is typically assessed for the event (i.e. blasting) without the consideration of a baseline level. The vibration assessment is based on comparing the Project event only (i.e. blasting) effect to a guideline or threshold. Most guidelines and regulatory limits are only applicable to the event only without the consideration of a baseline level. The masking effect from background vibration level or cumulative vibration level from another event is typically not included.

3.0 REGULATORY FRAMEWORK

3.1 NOISE

The noise assessment was performed in accordance with the recommendations and requirements of the BC Oil & Gas Commission Noise Control Best Practices Guideline (2009) and Health Canada Useful Information for Environmental Assessments document (2010) noise guidance. In areas where the BC OGC noise guideline and Health Canada guidance does not provide any guidance, the following documents were adopted as supplemental guidelines in the assessment:

- American National Standards Institute (ANSI) S12.9-2005 Quantities and Procedures for description and Measurement of Environmental Sound - Part 4: Noise Assessment and Prediction of Long-term Community Response;
- International Organization for Standardization(ISO) 1996-1:2003 Acoustics – Description, measurement and assessment of environmental noise – Part 1: Basic quantities and assessment procedures (ISO 1996-1:2003 Part 1); and
- World Health Organization (WHO) 2009. Night Noise Guidelines for Europe.

3.1.1 BC OGC Noise Control Best Practices Guideline

British Columbia does not have any specific noise regulations directly applicable to mining operations; however, the BC OGC noise guideline applies to oil and gas installations. This guideline is a receptor-oriented regulation, which specifies allowable sound levels from energy-related facilities at designated points of reception (including residences).

In accordance with the BC OGC noise guideline, all new energy-related facilities must meet a daytime (07:00 to 22:00) and nighttime (22:00 to 07:00) PSL at a distance of 1.5 km (criteria boundary) from the facility boundary or at the nearest receptor, whichever is closer. Only dwellings that are permanently or seasonally occupied are defined as receptors. Exceptions to this definition include any employee or worker residence, dormitory, or construction camp located within an industrial plant boundary.

The daytime and nighttime PSLs at a receptor depend on dwelling density and proximity to transportation (i.e., proximity to heavily travelled roadways and rail lines). Daytime PSL is set at 10 dB above the nighttime value to reflect that daytime ambient sound levels are generally higher than nighttime ambient sound levels. When there is no receptor within 1.5 km from a project fence line, the nighttime and daytime PSLs along the 1.5 km criteria boundary are set to 40 dBA and 50 dBA equivalent sound levels (L_{eq}), respectively.

The BC OGC noise guideline does not define a sound-level limit for construction and decommissioning activities. However, the noise guideline requires that reasonable measures be

implemented to limit noise from these activities. Because provincial sound-level limits are not defined, the assessment uses federal guidance (Section 3.1.2) to establish thresholds for construction activities.

3.1.1.1 Permissible Sound Level

The daytime and nighttime PSLs for each receptor were determined in accordance with the BC OGC noise guideline and are summarized in Table 3-1. Details of the determination of PSLs are summarized in Appendix B Permissible Sound Level Determination.

3.1.1.2 Low Frequency Noise

The BC OGC noise guideline also addresses low frequency noise (LFN) concerns. There may be an LFN effect when the following two conditions are met:

1. A clear tonal component exists at a frequency at or below 250 Hz, and
2. The arithmetic difference between the overall C-weighted sound level and the overall A-weighted sound level exceeds 20 dB (i.e., dBC minus dBA is greater than 20 dB).

If either of these conditions is not met, the potential for a LFN effect is low. However, at this point of Project design, there is not sufficient information to assess the tonality component. In cases where the second condition is exceeded, the American National Standards Institute (ANSI) S12.9 standard (ANSI 2005) is adopted as a relevant supplement to access the potential for LFN effect.

The ANSI 12.9 standard assigns acceptable limits on noise (65 dB) in 16 Hz, 31.5 Hz and 63 Hz octave bands. When the cautionary limits are not exceeded, potential adverse LFN effects are deemed as acceptable and no further assessment is required. Generally, annoyance is minimal when octave-band sound pressure levels are less than 65 dB at 16 Hz, 31.5 Hz, and 63 Hz mid-band frequencies. If the predicted noise level exceeds 65 dB at any one of the 16 Hz, 31.5 Hz and 63 Hz band, the resulting overall dBC level will exceed 65 dBC. A conservative equivalent single number threshold to the aforementioned limits at 16 Hz, 31.5 Hz, and 63 Hz is provided by the 65 dBC level.

Table 3-1 Noise Receptor Permissible Sound Level

Noise Receptor ID	Description	Dwelling Unit Density per Quarter Section [1] of land	Proximity to Transportation (Category [2])	Nighttime Basic Sound Level (dBA)	Nighttime Ambient Sound Level [3] (dBA)	Daytime Adjustments (dB)	Class A or B Adjustments[4] (dB)	Daytime Permissible Sound Level (dBA)	Nighttime Permissible Sound Level (dBA)
1	Residence	1 to 8	1	40	35	10	0	50	40
2	Residence	1 to 8	1	40	35	10	0	50	40
3	Residence	1 to 8	2	45	40	10	0	55	45
4	Residence	1 to 8	1	40	35	10	0	50	40
8	Residence	1 to 8	1	40	35	10	0	50	40
9	Residence	1 to 8	1	40	35	10	0	50	40
11	Residence	1 to 8	1	40	35	10	0	50	40
12	Residence	1 to 8	1	40	35	10	0	50	40
13	Aberdeen Development	>160	1	46	41	10	0	56	46
14	CDB 1	9 to 160	1	43	38	10	0	53	43
15	CDB 2	1 to 8	1	40	35	10	0	50	40
16	CDB 3	1 to 8	1	40	35	10	0	50	40
17	CDB 4	1 to 8	1	40	35	10	0	50	40
18	CDB 5	1 to 8	1	40	35	10	0	50	40
21	Residence	1 to 8	1	40	35	10	0	50	40
22	Residence	1 to 8	1	40	35	10	0	50	40
23	Residence	9 to 160	2	48	43	10	0	58	48
24	Residence	1 to 8	1	40	35	10	0	50	40
25	Residence	1 to 8	1	40	35	10	0	50	40
26	Residence	1 to 8	1	40	35	10	0	50	40

Table 3-1 Noise Receptor Permissible Sound Level

Noise Receptor ID	Description	Dwelling Unit Density per Quarter Section [1] of land	Proximity to Transportation (Category [2])	Nighttime Basic Sound Level (dBA)	Nighttime Ambient Sound Level [3] (dBA)	Daytime Adjustments (dB)	Class A or B Adjustments[4] (dB)	Daytime Permissible Sound Level (dBA)	Nighttime Permissible Sound Level (dBA)
27	Residence	9 to 160	1	43	38	10	0	53	43
28	Royal Inland Hospital	>160	2	51	46	10	0	61	51
37	Dufferin Elementary	9 to 160	2	48	43	N/A	N/A	N/A	N/A
44	Pacific Way Elementary	>160	2	51	46	N/A	N/A	N/A	N/A
52	Sahali Secondary	>160	2	51	46	N/A	N/A	N/A	N/A
74	Tots & Teddies	9 to 160	2	48	46	N/A	N/A	N/A	N/A
169	Kamloops Senior Village	9 to 160	2	48	43	10	0	58	48
170	Ridgepointe at Pineview Retirement Home	9 to 160	2	48	43	10	0	58	48
TLU1	Kamloops Lake Pump house	0	1	40	35	10	N/A	N/A	N/A
TLU2	T'Kaloops First Nation Reserve	9 to 160	1	43	38	10	0	53	43
TLU3	Inks Lake	0	1	40	35	10	N/A	N/A	N/A
TLU4	Jacko Creek	0	1	40	35	10	N/A	N/A	N/A

Table 3-1 Noise Receptor Permissible Sound Level

Noise Receptor ID	Description	Dwelling Unit Density per Quarter Section [1] of land	Proximity to Transportation (Category [2])	Nighttime Basic Sound Level (dBA)	Nighttime Ambient Sound Level [3] (dBA)	Daytime Adjustments (dB)	Class A or B Adjustments[4] (dB)	Daytime Permissible Sound Level (dBA)	Nighttime Permissible Sound Level (dBA)
TLU5	Upper Peterson Creek	0	1	40	35	10	N/A	N/A	N/A
TLU6	Goose Lake Road	0	1	40	35	10	N/A	N/A	N/A
TLU7	Peterson Creek Discharge	0	1	40	35	10	N/A	N/A	N/A
TLU8	Edith Lake	0	1	40	35	10	N/A	N/A	N/A
TLU9	Jacko Lake Prayer Tree	0	1	40	35	10	N/A	N/A	N/A

NOTES:

N/A – not applicable

[1] quarter section is an area of one-fourth of a square mile, or 160 acres or 0.65 km^2. It was a common size of a tract under the Dominion Land Survey in Canada.

[2] Definition of transportation proximity category as follows:

Category 1—dwelling units more than 500 m from heavily travelled roads and rail lines and not subject to frequent aircraft flyovers.

Category 2—dwelling units more than 30 m but less than 500 m from heavily travelled roads and rail lines and not subject to frequent aircraft flyovers.

Category 3—dwelling units less than 30 m from heavily travelled roads and rail lines and/or subject to frequent aircraft flyovers.

[3] ASL is 5 dB below the BSL as prescribed in BC OGC Noise Guideline

[4] Class A adjustments are based on the nature of the activity and/or actual ambient sound levels. Class B adjustments are applicable for temporary noise generating activities. Appendix B Permissible Sound Level provides details definition for Class A or B adjustments

3.1.2 Health Canada Noise Guidance

Health Canada does not have a noise regulation and does not mandate specific noise limits. Instead, its approach to noise assessment is based on a number of international standards and technical publications. Health Canada's (2010) Useful Information document summarizes noise-induced health effects and provides recommendations.

Health Canada noise guidance also uses a broader definition of noise sensitive receptors than the BC OGC noise guideline. Health Canada considers the following residential and non-residential locations as noise sensitive receptors:

- permanent and seasonal residences;
- daycare centers;
- nursing homes;
- places of worship;
- schools;
- hospitals; and
- First Nation communities.

Health Canada uses measurable parameters such as daytime (L_d), nighttime (L_n), day-night (L_{dn}) equivalent sound level, and percent highly annoyed (%HA) to quantify noise effects.

The L_d is the 15-hour time average equivalent sound level over the daytime period from 07:00 to 22:00. The L_n is the 9-hour time average equivalent sound level over the nighttime period from 22:00 to 07:00. The L_{dn} is a 24-hour time-averaged L_{eq}, with a 10 dB penalty applied to L_n. The L_{dn} is calculated using the following equation:

$$L_{dn} = 10 \log_{10} [(15 \times 10^{Ld/10}) + (9 \times 10^{(Ln + 10)/10)})/24]$$

The Health Canada guidance recommends an annoyance based criteria where an incremental increase in noise levels is said to incrementally increase the percentage of the highly annoyed population in a community. This percent highly annoyed parameter (%HA) is based on the International Standard Organization (ISO) 1996-1:2003 Acoustics – Description, measurement and assessment of environmental noise – Part 1: Basic quantities and assessment procedures (ISO 1996-1:2003 Part 1). Health Canada advises that noise mitigation measures be considered when a change in the calculated %HA at any given receptor exceeds 6.5%. Change in %HA is quantified by determining the difference between %HA calculated for the baseline condition and %HA calculated with inclusion of the Project's noise contribution using the following equation:

$$\%HA = \frac{100}{1 + e^{[10.4 - 0.132 * Ldn]}}$$

The project is deemed acceptable if an increase in % HA is less than 6.5% at all receptors. Health Canada, however, advises that using this measure alone may not be predictive of possible human health effects, i.e., the change in %HA may not exceed 6.5% but the receptors may experience sleep disturbance. The Health Canada guidance does not provide any recommendations for low frequency noise or sleep disturbance.

3.1.3 World Health Organization Night Noise Guidelines for Europe

The World Health Organization (WHO) Night Noise Guidelines for Europe (2009) report can be used for assessing noise effect on sleep disturbance. The recommended threshold for observed effects in sleep quality, self-reported sleep disturbance, and environmental insomnia is 42 dBA (outside) during the nighttime period. The observed effect threshold is the level above which an effect starts to occur or shows itself to be dependent on the exposure level.

3.2 VIBRATION

3.2.1 Ground Vibration

In blasting activity, the explosive energy is intended to break hard rock. However, some energy travels beyond the intended work zone through the ground. Beyond this work zone, there is no permanent rock displacement. The remaining blast energy, called ground vibration, travels elastically through the ground as rock particles are displaced temporarily and return to their original position. Ground vibration is an oscillatory motion which can be measured in terms of displacement, velocity or acceleration. Because of the oscillatory nature of the vibrating elements, the average of any of the motion descriptors (i.e. displacement, velocity or acceleration) is zero. The ground vibration level in this assessment is defined in terms of peak particle velocity (PPV) and is measured in millimeters per second (mm/s), representing the maximum instantaneous positive or negative peak of the vibration signal.

Table 3-2 summaries the ground vibration criteria used in the assessment for structural damage.

Table 3-2 Ground Vibration Assessment Threshold

Guideline or Guidance	Ground Vibration (mm/s)
The Ontario Ministry of Environment and Climate Change – Guidelines on Information Required for the Assessment of Blasting Noise and Vibration (1985) (MOECC 1985)	10 to 12.5
United States Bureau of Mines RI-8485 and RI-8507	19 to 51
Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters	13
Environment Canada Environmental Code of Practice for Metal Mines (2009)	12.5

Table 3-3 lists general blast vibration damage thresholds for various building materials and conditions, which are commonly accepted worldwide. These were developed over many decades by researchers, regulatory agencies, consultants and educators. The listed thresholds are the absolute minimum vibration levels needed to cause permanent damage. Below the threshold levels, no permanent structural damage is possible. Exceeding the threshold levels does not necessarily guarantee damage, but it exponentially increases the probability of damage. A comparison of the assessment threshold (Table 3-2) and the damage threshold (Table 3-3) indicates that the criteria used are conservative.

The guidelines above focus on structural damage threshold with no guidance on annoyance threshold for blast-related ground vibration. The following two guidelines provide guidance for annoyance threshold due to blast-related ground vibration:

- Australian Department of Environment and Conservation New South Wales (NSW) – Assessing Vibration: A Technical Guideline, 2006
- Australian and New Zealand Environment Council (ANZECC) Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration. Australian and New Zealand Environment Council, Canberra. 1990

Blast related ground vibration events are considered as impulsive vibration event. The NSW vibration guideline is based on guidelines contained in the British Standard (BS) 6472-1992, Evaluation of Human Exposure to Vibration in Buildings. The NSW guideline recommends an annoyance threshold of 8.6 mm/s for residences during the daytime period. The NSW vibration guideline also refers to the ANZECC guideline for blast related impulsive vibration. The ANZECC recommends a lower threshold of 5 mm/s. Based on the NSW and ANZECC guidelines, the more conservative annoyance threshold of 5 mm/s is used to assess blast-related ground vibration effect.

Table 3-3 Damage Thresholds for Different Materials and Conditions

Type of Permanent Damage	Minimum Vibration Levels to Cause Damage (mm/s)
Plaster – hairline cracks.	13
Drywall (Sheetrock) – hairline cracks.	19 - 51
Mortar fill cracks and separations.	52 - 76
Ground settlement, depending on depth, type of soil and dry or wet conditions.	51 - 500
Brick cracks.	77 - 102
Cracks in fully cured concrete.	103 - 203
Cracks and or joint separations in buried pressurized water, gas and fuel lines, etc.	125 - 635

Table 3-3 Damage Thresholds for Different Materials and Conditions

Type of Permanent Damage	Minimum Vibration Levels to Cause Damage (mm/s)
Separation of ceiling and wall corner junctions, door and window frame offsets, floors off level, etc.	204 - 508
Structural distortions (window and door frames, corner junction separations, and sagging floors, etc.)	250 - 1000
Major structural distortions for building frames, beam supports, floors, ceilings, walls, misaligned shafts, etc.	1016 - 1524

In addition to structure damage and human receptors, the blast effect on aquatic life is considered using the assessment. The DFO currently does not provide any quantitative vibration thresholds for aquatic life. In the past, the DFO referred to a guideline which prescribes quantitative vibration limits for aquatic life during blast activities. In absences of any quantitative vibration guideline for aquatic life from the DFO, the 1998 vibration guideline (Wright and Hopky 1998) is adapted as the best available guideline.

Ground vibration effect related to other non-blast related activities (drilling and heavy equipment) will be based on the City of Toronto Construction Vibration Limit (ByLaw-514) of 8 mm/s to 25 mm/s.

Table 3-4 summarizes the ground vibration threshold used for the vibration receptors. Each receptor type has been assigned ground vibration thresholds based on the location classification. The restrictive damage threshold of 13 mm/s is applied at receptor #1a and #1b. The MOECC damage threshold of 10 mm/s is applied to all residential locations, below the minimum vibration levels to cause hairline crack damage on drywall. The annoyance threshold of 5 mm is applicable to residential location, recreation area, and public area with human activities.

Table 3-4 Ground Vibration Threshold at Receptor

Vibration Receptor ID	Receptor Type	Structural Damage Threshold (mm/s)	Annoyance threshold (mm/s)	Fish Habitat Protection Threshold (mm/s)	Classification
1a	Jacko Lake Sensitive Fish Habitat Area #1	NA	NA	13	Sensitive Fish Habitat Area
1b	Jacko Lake Sensitive Fish Habitat Area #2	NA	NA	13	Sensitive Fish Habitat Area
2	Jacko Lake boat launch area	100	5	NA	Open Recreation Area

Table 3-4 Ground Vibration Threshold at Receptor

Vibration Receptor ID	Receptor Type	Structural Damage Threshold (mm/s)	Annoyance threshold (mm/s)	Fish Habitat Protection Threshold (mm/s)	Classification
3	Urban Growth Boundary	10	5	NA	Kamloops City Boundaries
4	Residence 1	10	5	NA	Residences and similar structures
5	Cell Tower 1	25	NA	NA	Commercial Utility Structures
6	Cell Tower 2	25	NA	NA	Commercial Utility Structures
7	Residence 2	51	5	NA	Log Cabin
8	City of Kamloops residences	10	5	NA	Kamloops City Boundaries
9	Elementary Pacific Way School	10	5	NA	Industrial Grade Structure
10	Residence 3	10	5	NA	Residences and similar structures
11	Site 1	10	5	NA	Residences and similar structures
12	Inks Lake	100	5	NA	Open Recreation Area
13	Residence 3	10	5	NA	Residences and similar structures
14	Site 2	100	5	NA	Open Recreation Area
15	Residence 4	10	5	NA	Residences and similar structures
16	Site 3	100	5	NA	Open Recreation Area
17	Site 4	10	5	NA	Residences and similar structures
18	Python Minifile historic underground	250	NA	NA	Historic Underground Workings
19	Residence 5	10	5	NA	Residences and similar structures
20	Residence 6	10	5	NA	Residences and similar structures
21	Residence 7	10	5	NA	Residences and similar structures
22	Galaxy historic underground	250	NA	NA	Historic Underground Workings
23	Royal Inland Hospital	10	5	NA	Industrial Grade Structure

Table 3-4 Ground Vibration Threshold at Receptor

Vibration Receptor ID	Receptor Type	Structural Damage Threshold (mm/s)	Annoyance threshold (mm/s)	Fish Habitat Protection Threshold (mm/s)	Classification
24	Roadcut Failure Zone (Kamloops)	100	NA	NA	Kamloops City Boundaries
25	Pet Boarding	10	5	NA	Residences and similar structures
26	Proposed bike trail (Official)	100	5	NA	Open Recreation Area
27	Wedding event site location	10	5	NA	Industrial Grade Structure
28	Surface storage tank 1	51	NA	NA	Commercial Utility Structures
29	Iron Mask historic underground	250	NA	NA	Historic Underground Workings
20	Surface storage tank 2	51	NA	NA	Commercial Utility Structures
31	Surface storage tank 3	51	NA	NA	Commercial Utility Structures
TLU1	Kamloops Lake Pump house	51	5	NA	Traditional land use area and Commercial Utility Structures
TLU2	T'Kaloops First Nation Reserve	10	5	NA	Residences and similar structures
TLU3	Inks Lake	100	5	NA	Traditional land use area
TLU4	Jacko Creek	100	5	NA	Traditional land use area
TLU5	Upper Peterson Creek	100	5	NA	Traditional land use area
TLU6	Goose Lake Road	100	5	NA	Traditional land use area
TLU7	Peterson Creek Discharge	100	5	NA	Traditional land use area
TLU8	Edith Lake	100	5	NA	Traditional land use area
TLU9	Jacko Lake Prayer Tree	100	5	NA	Traditional land use area

NOTE:
NA – not applicable

3.2.2 Air Blast Overpressure

In blast activity, any blast energy that liberates into the atmosphere generates air overpressures or air blasts. Air blast overpressure is measured in decibels (dBL). Air blast overpressure is the additional pressure above normal atmospheric pressure that is generated from a blast. Air blast often feels like a gust of wind by a receptor as confined blast will generally result in inaudible air blast. Air blast overpressure and sound are different in terms of frequency although both are measured in the units of decibels (dBL or dBA). An event with an air blast overpressure value of 115 dBL, which is inaudible due to the low frequency content, is entirely different from a sound event with the level of 115 dBA. The usual rating terms associated with community noise standards are based on A-weighted noise (dBA), an adjustment scale that accounts for the human ear sensitivity to different frequencies (i.e. less at lower frequencies). This A-weight noise unit does not apply to air blast overpressure.

The MOECC vibration guideline recommends a standard and cautionary limit of 128 dBA and 120 dBL, respectively. Standard limit is applicable to operations subjected to routine monitoring while cautionary limit is applicable to operations not subjected to routine monitoring. The USBM vibration guideline recommends the structural and annoyance threshold of 133 dBL and 120 dBL, respectively. The ANZECC vibration guideline recommends 115 dBL as the annoyance threshold.

Table 3-5 summarizes the air blast overpressure criteria used in the assessment. Table 3-6 lists examples of air blast overpressure effects.

Table 3-5 Air Blast Overpressure Assessment Threshold

Guideline or Guidance	Air blast Overpressure (dBL or kPa)
The Ontario Ministry of Environment – Guidelines on Information Required for the Assessment of Blasting Noise and Vibration (1985) (MOECC 1985)	128 dBL (Standard limit) 120 dBL (Cautionary limit)
United States Bureau of Mines RI-8485 and RI-8507	133 dBL (structural) 120 dBL (annoyance)
Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters (The Federal Fisheries Act)	100 kPa (194 dBL) (swim bladder of fish)
Environment Canada Environmental Code of Practice for Metal Mines (2009)	128 dBL
ANZECC vibration guideline	115 dBL (annoyance)

Table 3-6 Air blast Overpressure Effects on People, Windows, and Structures

Air Blast Overpressure (dBL)	Source, Activity, Response and Damage
110 - 115	Blast effects are barely perceptible, with very few or no complaints.
115 - 120	Could be felt or sensed, but are mostly tolerated depending on the ambient levels inside the home and community.
120 - 125	Blasts are felt or sensed more frequently, and they could be annoying to some people, but no damages occur.
125 - 130	Sounds very loud from rattling effects inside home, but no damage.
133	USBM-recommended safe blast damage limit for homes.
150	Some loose, single pane glass in windows begins to break.
160 - 170	Majority of window pane glass breaks.
180+	Major structural damage equivalent to a very strong earthquake.

The ANZECC annoyance threshold of 115 dBA was used for all receptor locations with human activities. The most conservative MOECC 120 dBL cautionary limit was used for the structural damage threshold. In the fish habitat area, the air blast overpressure limit of 100 kPa was used. The overpressure limit of 100 kPa is equivalent to 194 dBL. Table 3-7 summarizes the air blast overpressure threshold used for the vibration receptors.

Table 3-7 Air Blast Overpressure Threshold at Receptor

Vibration Receptor ID	Receptor Type	Structural Damage Threshold (mm/s)	Annoyance Threshold (mm/s)	Fish Habitat Protection Threshold (mm/s)	Classification
1a	Jacko Lake Sensitive Fish Habitat Area #1	NA	NA	194	Sensitive Fish Habitat Area
1b	Jacko Lake Sensitive Fish Habitat Area #2	NA	NA	194	Sensitive Fish Habitat Area
2	Jacko Lake boat launch area	120	115	NA	Open Recreation Area
3	Urban Growth Boundary	120	115	NA	Kamloops City Boundaries
4	Residence 1	120	115	NA	Residences and similar structures
5	Cell Tower 1	120	NA	NA	Commercial Utility Structures
6	Cell Tower 2	120	NA	NA	Commercial Utility Structures
7	Residence 2	120	115	NA	Log Cabin

Table 3-7 Air Blast Overpressure Threshold at Receptor

Vibration Receptor ID	Receptor Type	Structural Damage Threshold (mm/s)	Annoyance Threshold (mm/s)	Fish Habitat Protection Threshold (mm/s)	Classification
8	City of Kamloops residences	120	115	NA	Kamloops City Boundaries
9	Elementary Pacific Way School	120	115	NA	Industrial Grade Structure
10	Residence 3	120	115	NA	Residences and similar structures
11	Site 1	120	115	NA	Residences and similar structures
12	Inks Lake	120	115	NA	Open Recreation Area
13	Residence 3	120	115	NA	Residences and similar structures
14	Site 2	120	115	NA	Open Recreation Area
15	Residence 4	120	115	NA	Residences and similar structures
16	Site 3	120	115	NA	Open Recreation Area
17	Site 4	120	115	NA	Residences and similar structures
18	Python Minifile historic underground	120	NA	NA	Historic Underground Workings
19	Residence 5	120	115	NA	Residences and similar structures
20	Residence 6	120	115	NA	Residences and similar structures
21	Residence 7	120	115	NA	Residences and similar structures
22	Galaxy historic underground	120	NA	NA	Historic Underground Workings
23	Royal Inland Hospital	120	115	NA	Industrial Grade Structure
24	Roadcut Failure Zone (Kamloops)	120	NA	NA	Kamloops City Boundaries
25	Pet Boarding	120	115	NA	Residences and similar structures

Table 3-7 Air Blast Overpressure Threshold at Receptor

Vibration Receptor ID	Receptor Type	Structural Damage Threshold (mm/s)	Annoyance Threshold (mm/s)	Fish Habitat Protection Threshold (mm/s)	Classification
26	Proposed bike trail (Official)	120	115	NA	Open Recreation Area
27	Wedding event site location	120	115	NA	Industrial Grade Structure
28	Surface storage tank 1	120	NA	NA	Commercial Utility Structures
29	Iron Mask historic underground	120	NA	NA	Historic Underground Workings
20	Surface storage tank 2	120	NA	NA	Commercial Utility Structures
31	Surface storage tank 3	120	NA	NA	Commercial Utility Structures
TLU1	Kamloops Lake Pump house	120	115	NA	Traditional land use area and Commercial Utility Structures
TLU2	T'Kaloops First Nation Reserve	120	115	NA	Residences and similar structures
TLU3	Inks Lake	NA	115	NA	Traditional land use area
TLU4	Jacko Creek	NA	115	NA	Traditional land use area
TLU5	Upper Peterson Creek	NA	115	NA	Traditional land use area
TLU6	Goose Lake Road	NA	115	NA	Traditional land use area
TLU7	Peterson Creek Discharge	NA	115	NA	Traditional land use area
TLU8	Edith Lake	NA	115	NA	Traditional land use area
TLU9	Jacko Lake Prayer Tree	NA	115	NA	Traditional land use area

NOTE:
NA – not applicable

4.0 ASSESSMENT APPROACH

4.1 NOISE

The following list outlines the noise assessment approach:

- Conduct noise baseline study at selected locations.
- Review information provided by KGHM including mine and site plans, equipment lists; information from major equipment vendors; and topographical data for the area around the mine.
- Establish LSA and RSA including the urban and sub-urban residential area in the City of Kamloops, rural and remote residences surrounding the Project, First Nation Communities, and traditional land use areas.
- Identify all noise sensitive receptors within the study area.
- Establish noise assessment criteria and targets for all noise receptors.
- Identify modelling scenarios (operation and construction) that will predictably reflect worst case scenario in terms of noise emissions.
- Identify noise sources for the modelling scenarios and establish corresponding sound power levels.
- Develop an acoustic model for each modelling scenario and predict sound level within the RSA including all noise sensitive receptors.
- Compare the prediction results with applicable regulatory guidelines and guidance.
- If required or warranted, provide noise mitigation and noise management recommendations for the dominant noise sources.

The following sections present the noise modelling method and noise emission data used in the assessment.

4.1.1 Modelling

The BC OGC noise guideline and Health Canada noise guidance does not endorse any specific standards or modelling software; however, international calculation standards are recommended. Sound modelling in this assessment is based on sound propagation calculations in accordance with ISO Standards 9613 Part 1 and Part 2 (ISO 9613-1 1993, ISO 9613-2 1996), which are commonly used by noise practitioners and are accepted by BC OGC and Health Canada.

The latest version of the Cadna/A computer modelling program (Version 4.5.145) from DataKustik (2015), which incorporates ISO 9613 algorithms, was used for the noise assessment. The software model accounts for the following factors:

- geometric spreading;

- screening effects;
- atmospheric absorption;
- source size, location, and elevation;
- mild downwind from the Project to the dwelling(s) and or temperature inversion condition;
- source directivity.

Table 4-1 lists the modelling parameters used in the assessment.

Table 4-1 Noise Modelling Parameters

Item	Model Parameters	Model Setting
1	Temperature	10°C
2	Relative humidity	70%
3	Wind speed	Downwind condition, wind speed of 1 to 5 m/s
4	Noise source identification	Refer to Sections 4.1.2 and 4.1.3
5	Noise source data in octave-band center frequency	Refer to Appendix C
6	Acoustic modelling software	Cadna/A (DataKustik 2015)
7	Noise Propagation Standard	ISO 9613
8	Ground conditions and attenuation factor	• Ground absorption (G) of 0.6 for the Project site and surrounding area with predominantly soil with short grass • Ground absorption (G) of 0.1 for Jacko Lake area
9	Terrain Parameters (terrain resolution)	Ground terrain incorporated in model
10	Reflection parameters	1 order reflection

4.1.2 Construction

Construction activities at the Project site will include typical machinery such as backhoes, bulldozers, front end loaders, excavators, and haul trucks. Most construction activities will occur during both daytime and nighttime.

The noise models include the “worst case” construction phase (i.e. site preparation, infrastructure, structural installation, mechanical installation) noise sources at the proposed KGHM mine. Based on the review of the mine plan and equipment list, the Year -1 construction scenario is considered representative of the worst case scenario. The Year -1 scenario represents a year with a great deal of earth moving and handling, mobile equipment hauls, and hauling of overburden and topsoil material. The processing plant will be in operation during Year -1. Therefore, noise emission associated with the processing facility will be included as well. The

assessment also considers sheet piling activities near the east arm of Jacko Lake as a separate scenario.

Sound power levels for all mobile and stationary noise sources for the construction scenario have been established. Whenever possible, vendor data was used. When vendor data was not available, past measurement of similar equipment in combination with commonly accepted engineering calculations was used. Where appropriate, source directivity patterns were defined and input into the model. The mobile equipment was modelled as line (i.e. truck routes) and area (i.e. stockpiles) sources. The sound power levels for mobile equipment were appropriately time averaged and equally distributed over the extent of the particular source.

Tables 4-2 and 4-3 present a summary of construction equipment sound power levels. Details of the equipment sound power level in full octave band frequency are presented in Appendix C. The sound power levels for the plant are presented in Section 4.1.3.1, Table 4-4 to Table 4-6.

Table 4-2 Construction Scenario Year -1 Primary Equipment Noise Emission

Item	Description	Quantity	Sound Power Level (dBA) per Unit
1	300 Ton Class Haul Truck	5	120
2	Mining Shovel	1	122
3	Loader	1	116
4	Drilling Truck	1	117
5	Track Dozers	4	110
6	Rubber Tire Dozers	1	113
7	Graders	3	114
8	Water Trucks	3	112
9	Piling (Hydraulic Hammer Type)	1[1]	129
10	Backup Alarm	6[2]	113
11	Warning Horn	6[2]	129

NOTES:
1. Piling activities will occur prior to the Construction phase
2. Equipped on dozers and shoveling equipment

Table 4-3 Construction Scenario Year -1 Support Equipment Noise Emission

Item	Description	Quantity	Sound Power Level (dBA) per Unit
1	Excavator	2	108
2	Cable Reeler – FEL mounted	1	103
3	Truck mounted cable reel c/w hydraulic arm Ground Force	1	103
4	Mobile Cable Repair Station	1	94
5	Shovel Lube truck	1	90
6	Pickup Trucks	35	105
7	Fire truck	1	91
8	Ambulance	1	81
9	100 ton tow truck and lowbed trailer	1	111
10	Loader for the load-out	2	92
11	Extend a-boom loader	1	89
12	Crane for the Tailings	1	89
13	Dump Truck	1	103
14	Backhoe Extend Hoe Cat It420e	1	88
15	Forklift, Cat DP30	1	92
16	Forklift, Cat DP60	1	96
17	Forklift Dynalift Reachfork	1	96
18	Hyster 80 Forklift	1	96
19	Cat Mc30 Forklift	3	97
20	Crane, Mobile Rt528c, 28 Ton	1	95
21	Wacker Yard Light Model Ltc4c	8	97
22	Mechanic's Service Truck	2	97
23	Cat Skid Steer 246b	3	94
24	Boom Truck	1	101
25	Boom Truck W/Manbasket	1	101
26	Crane, Boom Truck	1	99
27	Boom Truck	1	101
28	Crane, Jlg	1	89
29	2008 Genie 45' Man Lift	1	90
30	Knuckle Boom, F800, N-50	1	90
31	Miller Big Blue Air Pac Welder	2	96
32	Welder 400amp	1	93
33	Welder 600 Amp	4	99
34	Lube Truck	1	96

Table 4-3 Construction Scenario Year -1 Support Equipment Noise Emission

Item	Description	Quantity	Sound Power Level (dBA) per Unit
35	Carry Deck Crane 15 Ton	1	89
36	Loader For Ball Mill Media & Miscellaneous Work Cat 966	1	95
37	Explosives Transport truck	1	95
38	Compressors	3	105
30	Concentrate 40 t Freight Truck	18	113

The following assumptions were used in the noise model of the construction Year -1 scenario:

- Since the primary and supporting equipment will not be running at full load for 24 hours per day, the utilization and load factors based on the equipment operating time and non-road engine load factors are included in the noise model, which are presented in Tables C-7 and C-8 of Appendix C.
- The plant facility for full built-out phase is assumed to be operating continuously 24 hours at full load.

4.1.3 Operation

Based on the review of the mine plan and equipment list, the two operating scenarios that are considered representative of the worst case scenario will be modeled. These are the Year 2 Project and the Years 4 and 8 Project.

Year 2 operation phase was chosen because it represents the production year with in-pit equipment operating at higher elevation. Thus, noise is subjected to lower screening effects from pit walls and subsequently greater potential noise effects at the receptors.

A combination of Years 4 and 8 of Operation was chosen for assessment. This scenario took aspects from both Year 4 and Year 8 of the Operation phase that contribute to a worst case possible mine year. This is based on the quantity of the equipment fleet, the haulage lengths, the total amount of material moved, and the location of the active mine rock storage facilities.

4.1.3.1 Plant Facility

The noise assessment of the plant facility considers the full built-out phase (i.e., all equipment in operation). The facility will operate continuously during a 24-hour period. The plant facility sound power levels are based on a combination of theoretical calculations and past project experiences for similar facilities. The major components of the plant facility are listed as follows:

- Mill building;
- Crusher building;

- Coarse Ore Stockpile Substation;
- Screeners;
- Feeders;
- Rock Breaker;
- Ball mills;
- Conveyors;
- Dust collectors;
- HVAC Units;
- Water Pump Stations.

Tables 4-4 to 4-6 present a summary of plant facility equipment sound power levels. Table 4-4 summarizes the noise emission level inside the building. Table 4-5 summarizes the noise emission from building roof, walls, and outdoor ventilation equipment. Noise attenuation effects due to roof and walls sound transmission loss is considered in the sound power level. Table 4-6 summarizes the noise emission of outdoor equipment that is not enclosed within a building. The noise attenuation of the building wall and roof is considered in the noise model.

Detail of the equipment sound power level in full octave band frequency is presented in Appendix C. The sound power levels presented are applicable to both Year 2 and Years 4 and 8 scenarios.

Table 4-4 Building Interior Noise Emissions

Building Name	Sound Power Level (dBA)
Coarse Ore Stockpile	116
Central Warehouse	115
HPGR And Secondary Crushing Building	126
Mill Building Section 1 – 7 [1]	113
Section 8 – 23 [1]	123
Section 24 – 34 [1]	123
Water Intake Pump Station	104
Fresh Water Booster Station 1	111
Fresh Water Booster Station 2	111
Fresh Water Booster Station 3	111

NOTE:
[1] Sound power level does not include the building wall and roof transmission. However, the attenuation effect of building walls and roof is included in the noise model

Table 4-5 Building Exterior Noise Sources

Building Name	Description	Quantity	Sound Power Level (dBA)
Coarse Ore Stockpile	Coarse Ore Conveyor	1	119
	Coarse Ore Reclaim Area Dust Collector	1	103
	Coarse Ore Reclaim Tunnel Ventilation Fan	1	103
	Coarse Ore Stockpile Wall	1	92
HPGR And Secondary Crushing Building	HPGR Electrical Rooms Supply Fan / Filter	2	81
	HPGR And Secondary Crushing Building Rollup Door	1	82
	HPGR And Secondary Crushing Building Rollup Door	1	85
	HPGR And Secondary Crushing Building Rollup Door	1	84
	HPGR & Secondary Crushing Building Roof	1	99
	HPGR & Secondary Crushing Building Wall	1	104
	HPGR Area Dust Collector	1	105
	HPGR Feed Bin Vent	1	92
	HPGR Feed Conveyor	1	91
	HPGR Screen Feed Bin Vent	1	92
	HPGR Screen Feed Conveyor	1	89
	HPGR Screen Feed Conveyor	1	90
	HPGR Screen Oversize Transfer Conveyor	1	89
	HPGR Stockpile Wall	1	92
	Building HVAC	1	90
	Building Upblast Roof Exhaust Fan	2	97
Mill Building	Mill Building 1 - 7 Bays Roof	1	87
	Mill Building 1 - 7 Bays Wall	1	88
	Mill Building 23-34 Roof	1	95
	Mill Building 7-23 Roof	1	91
	Mill Building 23-34 Wall	1	100
	Mill Building 7-23 Wall	1	94
	Mill Building E Operating Floor Electrical Room Air Conditioning Unit	2	94
	Mill Building E Operating Floor Electrical Room Air Cooled Condensing Unit	2	92
	Mill Building E Operating Floor Electrical Room Supply Fan / Filter Unit	2	86
	Mill Building Control Room Air Cooled Condensing Unit	1	90

Table 4-5 Building Exterior Noise Sources

Building Name	Description	Quantity	Sound Power Level (dBA)
	Mill Building Control Room Grinding & Classification Air Conditioning Unit - Fan Coil	1	91
	Mill Building Control Room Grinding & Classification Supply Fan / Filter Unit	1	86
	Mill Building Flotation & Regrind Exhaust/Heat Recovery Fan - Compressor /Blower Room	2	95
	Mill Building Flotation & Regrind Roof Upblast Exhaust Fan	8	101
	Mil Building Grinding & Classification Air Cooled Condensing Unit - Offices	1	90
	Mill Building Grinding & Classification Supply Air Fan - No Heat	2	100
	Process Plant Building Grinding & Classification Roof Upblast Exhaust Fan	1	101
	Mill Building HVAC	1	90
Central Warehouse	Central Warehouse Axial Exhaust Fan - Lube Oil Storage	1	87
	Central Warehouse Roof Exhaust Fan - Machine Shop	4	92
	Central Warehouse Roof Exhaust Fan - Repair Bay	4	98
	Warehouse Truck Shop / Mine Dry Roof	1	96
	Warehouse Truck Shop / Mine Dry Wall	1	96
Administration Building	Air Conditioning Unit - Office North and South Zone	4	90
	Air Conditioning Unit - Server and UPS Room	2	87
	Administration Building Exhaust Fan - ENV Lab	2	90
	Remote Air Cooled Condensing Unit - Core	1	94
	Remote Air Cooled Condensing Unit - Offices North Zone	1	87
	Remote Air Cooled Condensing Unit - Offices North and South Zone	2	90
Assay Laboratory	Exhaust Fan - Dust Collector Lab	1	95
	EXHAUST FAN - PERCHLORIC SCRUBBER	1	89
Ball Mill Electrical Room	Air Handling Unit	1	98
BHPGR & Secondary Crushing Electrical Rooms	Air Cooled Condensing Unit 2	2	92

Table 4-5 Building Exterior Noise Sources

Building Name	Description	Quantity	Sound Power Level (dBA)
Main Substation E-House	Air Conditioning Units	12	90
Primary Crusher E-House	Air Conditioning Units	2	91
Tailings Facilities E-House	Air Conditioning Units	2	91

Table 4-6 Outdoor Noise Sources

Description	Quantity	Sound Power Level (dBA)
Main Conveyor	1	100
Rock Breaker	1	103
Primary Crusher Air Compressor System	1	99
Primary Crusher Discharge Apron Feeder	1	107
Primary Crusher Maintenance Crane	1	63
Transformer	4	94
Concentrate Area Dust Collector	1	108
Cone Crusher And HPGR Screen Area Dust Collector	1	106
Cone Crusher Area Dust Collector	1	97
Cone Crusher Feed Bin Vent	2	92
Cone Crusher Screen Feed Conveyor 1	1	84
Cone Crusher Screen Feed Conveyor 2	1	90

4.1.3.2 Mine Fleet

Mine fleet activities at the Project site include machinery such as shovels, loaders, drills, tractor dozers, front end loaders, graders, water trucks, haul trucks, and supporting equipment. The mine fleet's operation will occur during both daytime and nighttime period.

Tables 4-7 presents a summary of mine fleet equipment sound power levels. Details of the equipment sound power levels in full octave band frequency are presented in Appendix C. Based on the Project design information, different equipment quantities are used to represent Year 2 and Years 4 and 8 scenarios.

Table 4-7 Operation Scenarios Year 2 and Years 4 and 8 Primary Equipment Noise Emission

Item	Description	Quantity (Year 2)	Quantity (Years 4 and 8)	Sound Power Level (dBA) per Unit
1	Haul Trucks	17	28	120
2	Mining Shovel	3	3	122
3	Loaders	1	1	116
4	Drilling Trucks	3	3	117
5	Pre-shear Drilling Trucks 152mm	2	2	117
6	Track Dozers	6	6	110
7	Rubber Tire Dozers	3	3	113
8	Graders	4	4	114
9	Water Trucks	4	5	112
10	Back Alarm	11	11	113
11	Warning Horn	11	11	129

4.1.3.3 Support Equipment

The supporting equipment for Year 2 operation and Years 4 and 8 operation are same as the Year -1 construction phase. A summary of supporting equipment sound power levels is shown in Section 4.1.2, Table 4-3. Detail of the equipment sound power level in full octave band frequency is presented in Appendix C.

4.1.4 Decommissioning, Closure, and Post Closure

Decommissioning, Closure, and Post Closure activities are expected to have no interaction or negligible to minor interaction with the noise effect. The quantity of equipment required for the decommissioning is expected to be below the requirement for the construction phase, thus noise effects exceeding acceptable levels are not expected. Noise effects during dismantling, site cleanup and reclamation activities can be managed to acceptable levels by implementation of best practices, standard mitigation and management measures used for the construction phase.

4.2 VIBRATION

The following list outlines the vibration assessment approach:

- Establish LSA and RSA including the urban and sub-urban residential area in the City of Kamloops, rural and remote residences surrounding the Project, open recreation areas, First Nation Communities, and traditional land use areas.
- Identify all vibration receptors within the study area.
- Establish vibration assessment criteria and targets for all vibration receptors
- Review blast design information provided by KGHM;
- Predict the air overpressure and ground vibration effects of blasting activities at vibration receptors based on established methods;
- Compare prediction results with applicable vibration guideline and guidance;
- If required or warranted, provide vibration mitigation and vibration management plan for the blasting activities;
- Assess ground vibration effects associated with heavy construction equipment and permanent machinery at the mine site.

The following sections present the prediction method used in the vibration assessment.

4.2.1 Prediction Method

4.2.1.1 Ground Vibration

A commonly used and accepted equation from the ISEE technical literature Blasters Handbook 2011 was used to predict vibration levels. The equation is listed as follows:

$$PPV = 1143(D/W^{1/2})^{-1.60}$$

Where:

PPV = Peak particle velocity (mm/s).
D = Distance from the blast to nearest inhabited residential dwelling (m).
W = Maximum weight of explosives fired per delay (Kg)

4.2.1.2 Air Blast Overpressure

An equation commonly accepted by the industry to predict air blast overpressure levels at any point of concern was developed by the USBM.

$$\text{Air blast overpressure} = C\ (D/W^{1/3})^{-1.10}$$

Where:

Air blast overpressure = Overpressure (psi)
C = Confinement constant
D = Distance from blast to point of concern (ft.)
W = Weight of explosives per delay (lbs.)

The confinement constant, C, refers to how well the blast is confined in terms of the blowout potential from the top stemming and along the bench face. C = 1.0 for normal explosive confinement, C = 0.10 for very heavy explosive confinement, and C = 10 for very little explosive confinement. In all of the air blast overpressure predictions, a normal explosive confinement of C = 1.0 was used. Converting the overpressure from pound per square inch (psi) to dBL uses the following equation:

$$\text{Air blast overpressure \{dBL\}} = 20\ \text{LOG}\ (\text{Air blast overpressure \{psi\}}/2.9 \times 10^{-9})$$

A maximum air blast overpressure level at 120 dBL is the cautionary limit MOECC recommended to all homes beyond the final pit limit. To minimize the air blast overpressure annoyance complaints, the maximum air blast overpressure level should be kept below 115 dBL.

4.2.2 Construction

The order of magnitude of blast effect during construction is expected to be far less than during the operation phase. Quantitative blast assessment was conducted for the operation phase rather than the construction phase.

Quantitative assessment of vibration effect during construction includes earthworks, construction of facility and road, piling, and drilling activities.

4.2.3 Operation

The blast-related vibration sources are quantified by blast design parameters such as blast charge, blast bore holes diameter, and delay time.

The mitigating avenues to minimize blasting impacts would primarily be driven by the maximum amount of explosives fired per delay. The closest vibration receptor to the blast activity during operation is Jacko Lake. The aquatic life protection vibration threshold of 13 mm/s (Table 3-2) is

the most stringent design criteria. As the blasts get closer to Jacko Lake, the maximum amount of explosives per delay will need to be reduced.

In the blast design, three blast zones (Z1, Z2, and Z3) are proposed. The three zones are shown in Appendix D (Figure 3.23). Zone 3 (Z3) is closest to Jacko Lake and Zone 1 (Z1) is furthest from Jacko Lake. The maximum explosives mass per delay for the different blast zones are:

1. Up to blast zone Z1 = 1020 Kg with a full column load, plus a stem charge in 311 mm holes.
2. Between blast zones Z1 and Z2 = 328 Kg with two explosive decks, plus a stem charge in 311 mm holes.
3. Between blast zones Z2 and Z3 = 127.5 Kg with two explosive decks in 152 mm holes.
4. Beyond blast zone Z3 = 68 Kg with three explosive decks in 152 mm holes.

The maximum amount of explosives per delay decreases substantially from 1020 Kg to 68 Kg as the blasts approach Jacko Lake. The use of lower explosives per delay in Z3 enables the blast effect to be in compliance with the aquatic life protection thresholds at Jacko Lake. Detailed discussion of blast plan and blast procedure modification to address the vibration effect at Jacko Lake is presented in the Noise and Vibration TDR Appendix D Ajax Mine Blast Review. Appendix D also presents details on the blast zones, hole loads, and cautionary notes when using explosive decking and stem charges.

In addition to the maximum amount of explosives per delay, blast design parameters used in the assessment were based on the following assumptions:

- The explosive used in dry holes will be Anfo (94% Ammonium Nitrate and 6% No. 2 diesel fuel, at a density ranging from 0.80 g/cc to 0.85 g/cc.
- The explosive used in wet holes will be an emulsion/Anfo blend in the ratio of 60% Emulsion/ 40% Anfo or 70% Emulsion/30% Anfo, at densities ranging from 1.15 g/cc to 1.25 g/cc.
- Hole diameters could range from 152 mm (6 in) to 311 mm (12 ¼ in) to accommodate the vibration/airblast controls at Jacko Lake, and to accommodate the presplit, buffer and production holes. The largest hole diameter used is 311 mm (12 ¼ in), with a maximum weight of explosives per delay = 1,020 kg.
- The bench height is 15 m, subgrade is between 1.0 m and 2.0 m and the top stemming in 311 mm holes could be between 5 and 7 m, depending on the rock type in the collar zone.
- All distances to a point of concern in the nearby communities were taken from the final pit boundary, even though the early blasts will be much farther away.
- The weakest structural component member in residential homes is usually drywall, which can withstand vibration levels from 19 – 52 mm/s, depending on the associated predominant frequencies.
- Only one hole per delay will be fired on the blasts.
- The minimum delay between holes in all blasts blast will not be less than 8 ms, and the row delays will be incremented from the front of the blast towards the back within 100 – 300 ms.

In addition to the blast induced vibration effect, quantitative assessment includes drilling activities during the operation phase.

4.2.4 Decommissioning, Closure, and Post Closure

Decommissioning, Closure, and Post Closure activities are expected to have less interaction with the vibration effect. Drilling and blasting will be required to construct the channel between the TSF and Humphrey Creek that allows the TSF surface to drain at closure. The blasting that will occur in decommissioning will be much less than the blasting during both construction and operation phases. The quantity of equipment required for the decommissioning is expected to be well below the requirement for the construction phase, thus vibration effects exceeding acceptable levels are not expected.

4.3 PREDICTION CONFIDENCE

Overall, accuracy of predictions for the noise assessment depends on several factors, including the accuracy of the Project design information, noise source data, and the sound propagation algorithm. The latest Project design information available at the time of this assessment was used. The sound power levels of the noise sources were established with field measurements of similar equipment or vendor sound emission data, where available. Acoustic models can be revised (if necessary) when final design information is available.

The Cadna/A model predicts outdoor noise in accordance with ISO 9613. The ISO 9613 sound propagation algorithms have a published accuracy of ±3 dB over source receiver distances between 100 m and 1,000 m. The accuracy for distances up to or over 1.5 km is not stated. The ISO 9613 model also produces results representative of meteorological conditions enhancing sound propagation (e.g., downwind and temperature inversion conditions). These conditions do not occur all the time; therefore, model predictions are expected to be conservative.

To account for the level of uncertainty in the noise predictions, conservative assumptions regarding the Project have been made. These include the assumptions that downwind conditions exist 100% of the time and that the maximum number of equipment operates at rated capacity for each scenario assessed.

Confidence in the ground vibration/airblast predictions is high, since the analytical approach and methodology used in this assessment have been tested and verified in thousands of blast audits worldwide.

5.0 RESULTS

5.1 NOISE

5.1.1 Construction

Noise sources described in Section 4.1.2 were used as inputs in the noise model to assess Project noise effects during construction (Year -1) at the identified noise receptors. Figure 5-1 shows the predicted noise contour maps for construction activities during Year -1 within the RSA. Table 5-1 summarizes the modelling results at all the noise receptors for the construction phase.

Table 5-1 Construction Phase (Year -1) Noise Modelling Results

Noise Receptor ID	Receptor Description	L_d (dBA)	L_n (dBA)	L_{dn} (dBA)
1	Residence	23.5	23.5	29.9
2	Residence	23.6	23.6	30.0
3	Residence	26.2	26.2	32.6
4	Residence	33.0	33.0	39.4
8	Residence	33.6	33.6	40.0
9	Residence	35.1	35.1	41.5
11	Residence	24.3	24.3	30.7
12	Residence	26.9	26.9	33.3
13	Aberdeen Development	29.0	29.0	35.4
14	CDB 1	19.4	19.4	25.8
15	CDB 2	25.7	25.7	32.1
16	CDB 3	30.2	30.2	36.6
17	CDB 4	31.4	31.4	37.8
18	CDB 5	33.3	33.3	39.7
21	Residence	32.3	32.3	38.7
22	Residence	25.6	25.6	32.0
23	Residence	28.0	28.0	34.4
24	Residence	25.1	25.1	31.5
25	Residence	25.7	25.7	32.1
26	Residence	21.6	21.6	28.0
27	Residence	20.9	20.9	27.3
28	Royal Inland Hospital	17.4	17.4	23.8

Table 5-1 Construction Phase (Year -1) Noise Modelling Results

Noise Receptor ID	Receptor Description	L_d (dBA)	L_n (dBA)	L_{dn} (dBA)
37	Dufferin Elementary	22.7	22.7	29.1
44	Pacific Way Elementary	26.9	26.9	33.3
52	Sahali Secondary	20.2	20.2	26.6
74	Tots & Teddies	23.0	23.0	29.4
169	Kamloops Senior Village	21.9	21.9	28.3
170	Ridgepointe at Pineview Retirement Home	23.5	23.5	29.9
TLU1	Kamloops Lake Pump house	7.9	7.9	14.3
TLU2	T'Kaloops First Nation Reserve	17.1	17.1	23.5
TLU3	Inks Lake	48.0	48.0	54.4
TLU4	Jacko Creek	29.6	29.6	36.0
TLU5	Upper Peterson Creek	28.8	28.8	35.2
TLU6	Goose Lake Road	30.3	30.3	36.7
TLU7	Peterson Creek Discharge	38.4	38.4	44.8
TLU8	Edith Lake	30.7	30.7	37.1
TLU9	Jacko Lake Prayer Tree	40.2	40.2	46.6

In addition to the construction phase during Year -1, the noise effect of piling at Jacko Lake is presented in Table 5-2. For highly impulsive sounds such as piling activities, there is ample evidence that for comparable equivalent continuous sound pressure levels, the annoyance caused by the impulsive sounds is higher. An adjustment of +12 dB was added to the predicted sound level, based on recommendations in the Canadian Standard Association CSA-ISO 1996-1:05 standards "Acoustics — Description, measurement and assessment of environmental noise - Part 1: Basic quantities and assessment procedures". Figure 5-2 shows the predicted noise contour maps (L_d before 12 dB adjustment) for piling activities within the RSA.

Table 5-2 Construction Phase Piling Noise Modelling Results

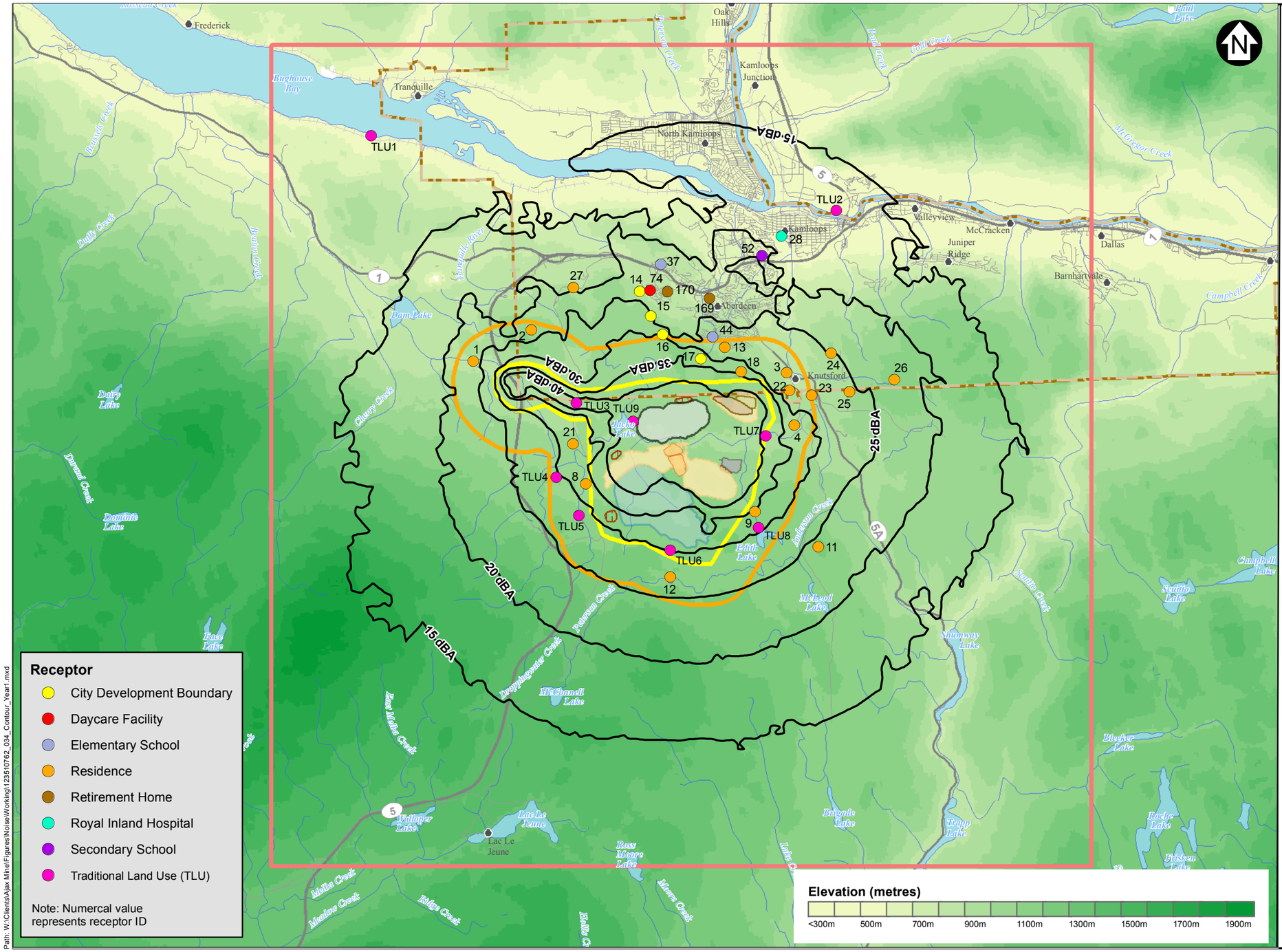
Noise Receptor ID	Receptor Description	L_d (dBA)	L_d With +12 dB adjustment (dBA)	L_{dn} (dBA)
1	Residence	20.6	32.6	30.6
2	Residence	24.6	36.6	34.6
3	Residence	11.3	23.3	21.4
4	Residence	21.7	33.7	31.7
8	Residence	34.5	46.5	44.5

Table 5-2 Construction Phase Piling Noise Modelling Results

Noise Receptor ID	Receptor Description	L_d (dBA)	L_d With +12 dB adjustment (dBA)	L_{dn} (dBA)
9	Residence	23.1	35.1	33.1
11	Residence	15.3	27.3	25.3
12	Residence	22.2	34.2	32.2
13	Aberdeen Development	18.7	30.7	28.7
14	CDB 1	7.3	19.3	17.6
15	CDB 2	23.9	35.9	33.9
16	CDB 3	30.9	42.9	40.9
17	CDB 4	22.8	34.8	32.8
18	CDB 5	17.4	29.4	27.4
21	Residence	42.3	54.3	52.3
22	Residence	8.3	20.3	18.5
23	Residence	18.7	30.7	28.7
24	Residence	16.4	28.4	26.4
25	Residence	15.6	27.6	25.6
26	Residence	11.6	23.6	21.7
27	Residence	21.1	33.1	31.1
28	Royal Inland Hospital	1.9	13.9	12.8
37	Dufferin Elementary	21.1	33.1	31.1
44	Pacific Way Elementary	14.8	26.8	24.8
52	Sahali Secondary	7.6	19.6	17.8
74	Tots & Teddies	14.4	26.4	24.4
169	Kamloops Senior Village	13	25	23.0
170	Ridgepointe at Pineview Retirement Home	17.7	29.7	27.7
TLU1	Kamloops Lake Pump house	2.6	14.6	13.4
TLU2	T'Kaloops First Nation Reserve	9.2	21.2	19.4
TLU3	Inks Lake	37.9	49.9	47.9
TLU4	Jacko Creek	31.4	43.4	41.4
TLU5	Upper Peterson Creek	29.3	41.3	39.3
TLU6	Goose Lake Road	25.5	37.5	35.5
TLU7	Peterson Creek Discharge	25	37	35.0
TLU8	Edith Lake	21.6	33.6	31.6
TLU9	Jacko Lake Prayer Tree	71.6	83.6	81.6

Figure 5-1
Noise Contour for Construction Activities (Year -1) during Daytime or Nighttime Period

Stantec



Legend

- Noise Contour Line dBA
- Noise Local Study Area
- Noise Regional Study Area
- Plant Boundary

Base Data

- Community
- Highway
- Paved Road
- Railway
- Watercourse
- Waterbody

Proposed Structure

- Mine Rock Storage Facility (MRSF)
- Ore Stockpile
- Overburden Stockpile
- Pit Outline
- Plant Site
- Reclamation Stockpile
- Tailings Storage Facility (TSF)
- Topsoil Stockpile

Receptor

- City Development Boundary
- Daycare Facility
- Elementary School
- Residence
- Retirement Home
- Royal Inland Hospital
- Secondary School
- Traditional Land Use (TLU)

Note: Numerical value represents receptor ID

NOTES:
1. BASE MAP: DEM (55m)
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD83 UTM, ZONE 10 NORTH, METER.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:150,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
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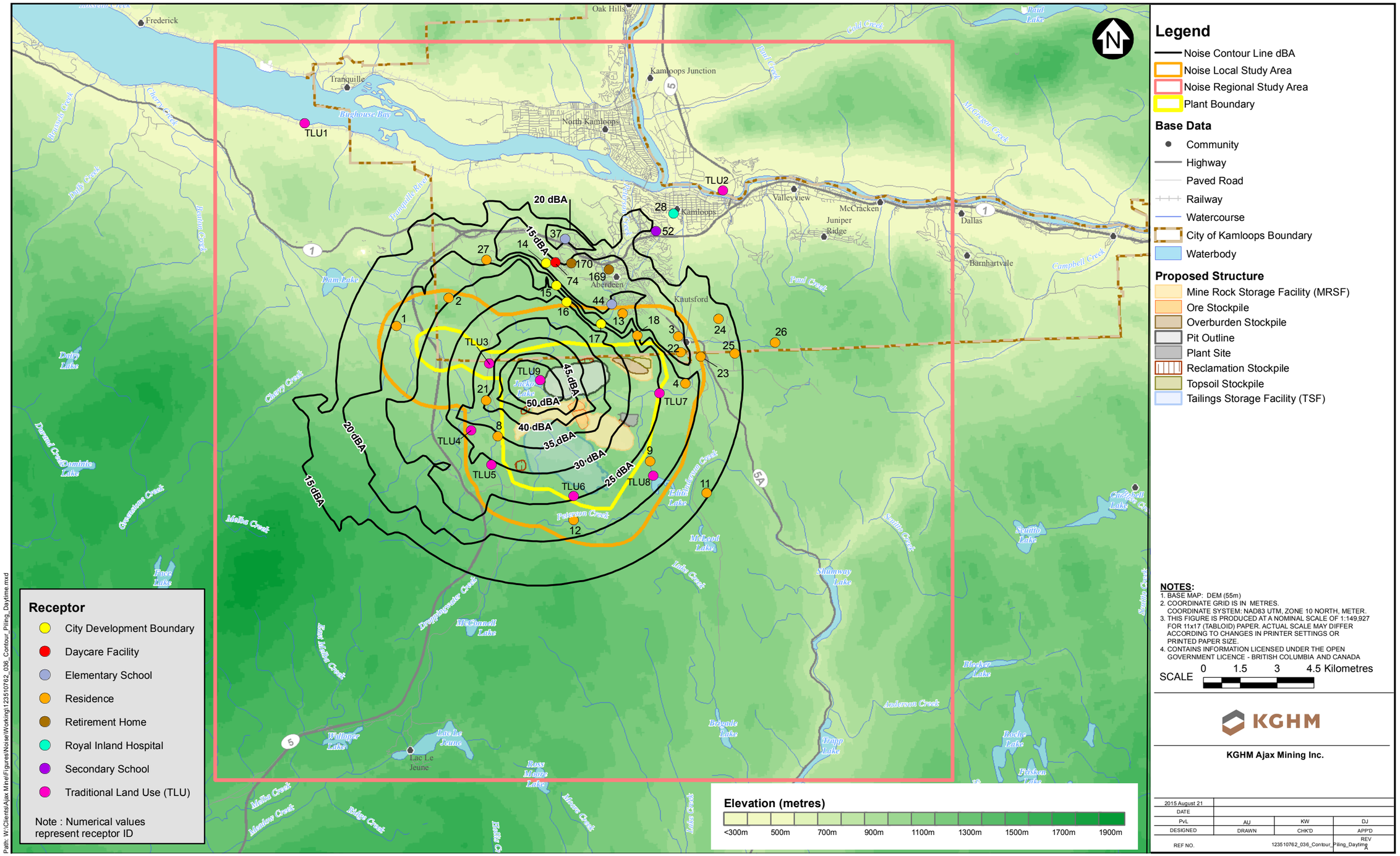
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KGHM

KGHM Ajax Mining Inc.

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Oak Hills
Frederick
Tranquille
Kamloops Junction
North Kamloops
Brigade Bay
TLU1
TLU2
Valleyview
McCracken
Juniper Ridge
Dallas
Barnhartvale
Kamloops
Aberdeen
Knutsford
Pann Lake
Dairy Lake
Dominic Lake
Jacko Lake
Ellis Lake
Pete Lake
Mellas Creek
Meadow Creek
Ross Moore Lake
Lac Le Jeune
Willapper Lake
McConnell Lake
McLeod Lake
Shumway Lake
Briggale Lake
Tripp Lake
Bachet Lake
Fishem Lake
Scottie Lake
Campbell Lake
Paul Creek
Gold Creek
Peterson Creek
Cherry Creek
Dunn Peak Creek
Guerard Creek
Dry Creek
Bonaparte Creek
Tranquille River
Deep Lake Creek
Anderson Creek
Lake Creek
Moore Creek
Riley Creek
Eagle Creek
20 dBA
15 dBA
50 dBA
45 dBA
40 dBA
35 dBA
30 dBA
25 dBA
15 dBA
TLU3
TLU4
TLU5
TLU6
TLU7
TLU8
TLU9
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74
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170
5
5A
1
Receptor
City Development Boundary
Daycare Facility
Elementary School
Residence
Retirement Home
Royal Inland Hospital
Secondary School
Traditional Land Use (TLU)
Note : Numerical values represent receptor ID
Elevation (metres)
<300m
500m
700m
900m
1100m
1300m
1500m
1700m
1900m
Legend
Noise Contour Line dBA
Noise Local Study Area
Noise Regional Study Area
Plant Boundary
Base Data
Community
Highway
Paved Road
Railway
Watercourse
City of Kamloops Boundary
Waterbody
Proposed Structure
Mine Rock Storage Facility (MRSF)
Ore Stockpile
Overburden Stockpile
Pit Outline
Plant Site
Reclamation Stockpile
Topsoil Stockpile
Tailings Storage Facility (TSF)
NOTES:
1. BASE MAP: DEM (55m)
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD83 UTM, ZONE 10 NORTH, METER.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:149,927 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA AND CANADA
SCALE 0 1.5 3 4.5 Kilometres
KGHM
KGHM Ajax Mining Inc.
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5.1.2 Operation

Noise sources described in Section 4.1.3 were used as inputs in the noise model to assess Project noise effects during operation at the identified noise receptors. Figures 5-3 and 5-4 show the modelled daytime or nighttime noise contour map for Year 2 and year 4/8 within the RSA, respectively. The daytime and nighttime noise levels are the same for the operation phase. Table 5-3 summarizes the modelling results at all the noise receptors for Year 2 and Years 4 and 8 during the operation phase.

Table 5-3 Operation Phase (Year 2 and Years 4 and 8) Noise Modelling Results

Noise Receptor ID	Receptor Description	Year 2			Years 4 and 8		
		L_d (dBA)	L_n (dBA)	L_{dn} (dBA)	L_d (dBA)	L_n (dBA)	L_{dn} (dBA)
1	Residence	26.3	26.3	32.7	26.2	26.2	32.6
2	Residence	26.7	26.7	33.1	26.8	26.8	33.2
3	Residence	28.9	28.9	35.3	28.8	28.8	35.2
4	Residence	35.3	35.3	41.7	34.5	34.5	40.9
8	Residence	37.4	37.4	43.8	36.7	36.7	43.1
9	Residence	36.1	36.1	42.5	37.7	37.7	44.1
11	Residence	27.5	27.5	33.9	27.2	27.2	33.6
12	Residence	30.0	30.0	36.4	30.0	30.0	36.4
13	Aberdeen Development	31.0	31.0	37.4	31.5	31.5	37.9
14	CDB 1	21.4	21.4	27.8	23.8	23.8	30.2
15	CDB 2	27.9	27.9	34.3	28.9	28.9	35.3
16	CDB 3	32.2	32.2	38.6	33.1	33.1	39.5
17	CDB 4	33.3	33.3	39.7	33.9	33.9	40.3
18	CDB 5	34.5	34.5	40.9	35.1	35.1	41.5
21	Residence	36.1	36.1	42.5	35.9	35.9	42.3
22	Residence	27.9	27.9	34.3	27.7	27.7	34.1
23	Residence	30.4	30.4	36.8	30.0	30.0	36.4
24	Residence	28	28	34.4	27.5	27.5	33.9
25	Residence	28.4	28.4	34.8	27.9	27.9	34.3
26	Residence	24.4	24.4	30.8	24.4	24.4	30.8
27	Residence	23.2	23.2	29.6	23.7	23.7	30.1
28	Royal Inland Hospital	19.6	19.6	26.0	20.1	20.1	26.5
37	Dufferin Elementary	25.4	25.4	31.8	25.6	25.6	32.0
44	Pacific Way Elementary	29	29	35.4	29.6	29.6	36.0

Table 5-3 Operation Phase (Year 2 and Years 4 and 8) Noise Modelling Results

Noise Receptor ID	Receptor Description	Year 2			Years 4 and 8		
		L_d (dBA)	L_n (dBA)	L_{dn} (dBA)	L_d (dBA)	L_n (dBA)	L_{dn} (dBA)
52	Sahali Secondary	22.5	22.5	28.9	22.7	22.7	29.1
74	Tots & Teddies	25.4	25.4	31.8	26.2	26.2	32.6
169	Kamloops Senior Village	24.2	24.2	30.6	25.0	25.0	31.4
170	Ridgepointe at Pineview Retirement Home	26.2	26.2	32.6	26.9	26.9	33.3
TLU1	Kamloops Lake Pump house	10.8	10.8	17.2	11.7	11.7	18.1
TLU2	T'Kaloops First Nation Reserve	20.5	20.5	26.9	20.1	20.1	26.5
TLU3	Inks Lake	50.1	50.1	56.5	50.1	50.1	56.5
TLU4	Jacko Creek	33.1	33.1	39.5	32.7	32.7	39.1
TLU5	Upper Peterson Creek	32.8	32.8	39.2	33.8	33.8	40.2
TLU6	Goose Lake Road	33.7	33.7	40.1	34.2	34.2	40.6
TLU7	Peterson Creek Discharge	40.9	40.9	47.3	39.5	39.5	45.9
TLU8	Edith Lake	33.6	33.6	40.0	33.7	33.7	40.1
TLU9	Jacko Lake Prayer Tree	46.7	46.7	53.1	49.2	49.2	55.6

Figure 5.3
Noise Contour for Operation (Year 2) during Daytime or Nighttime Period

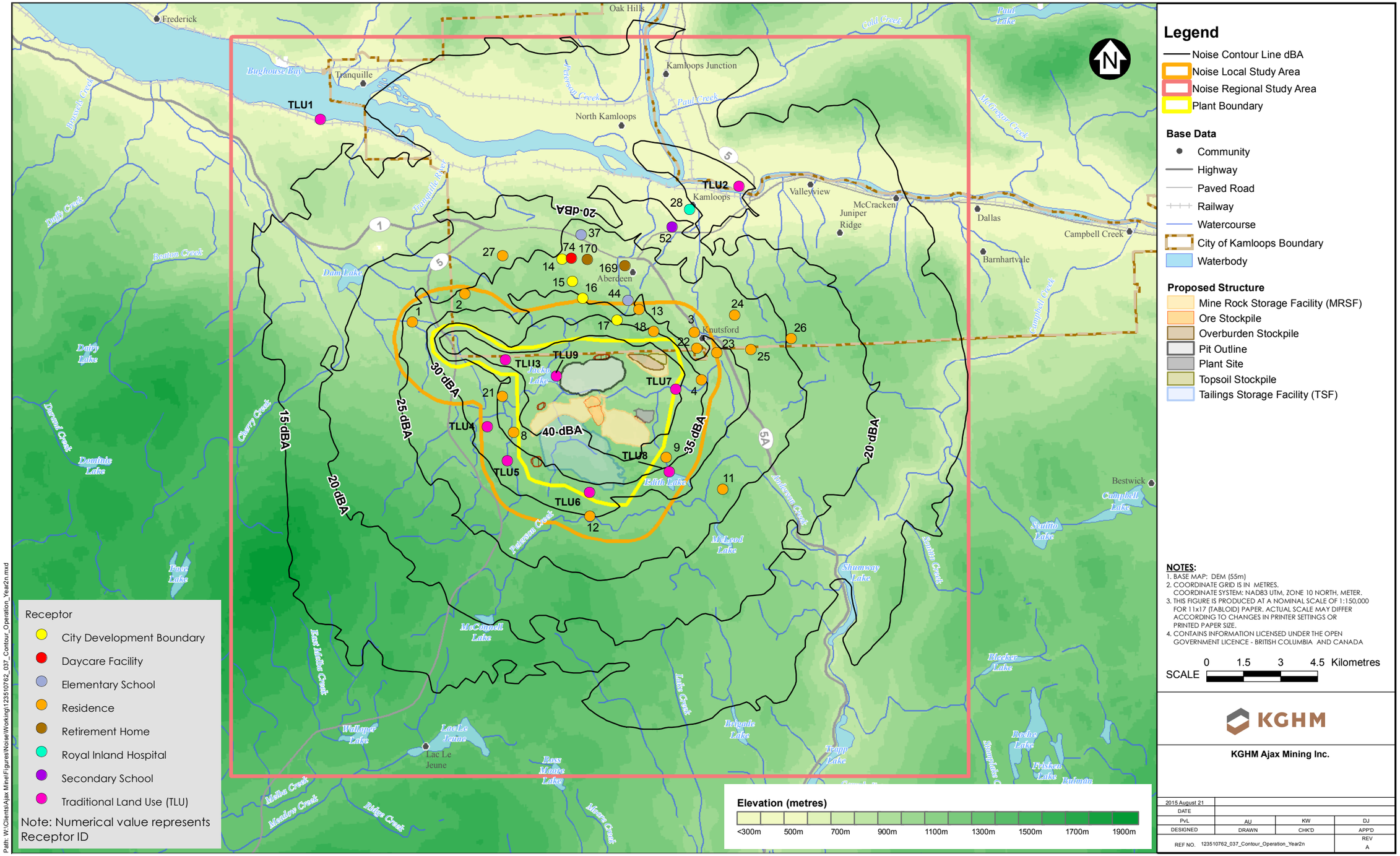
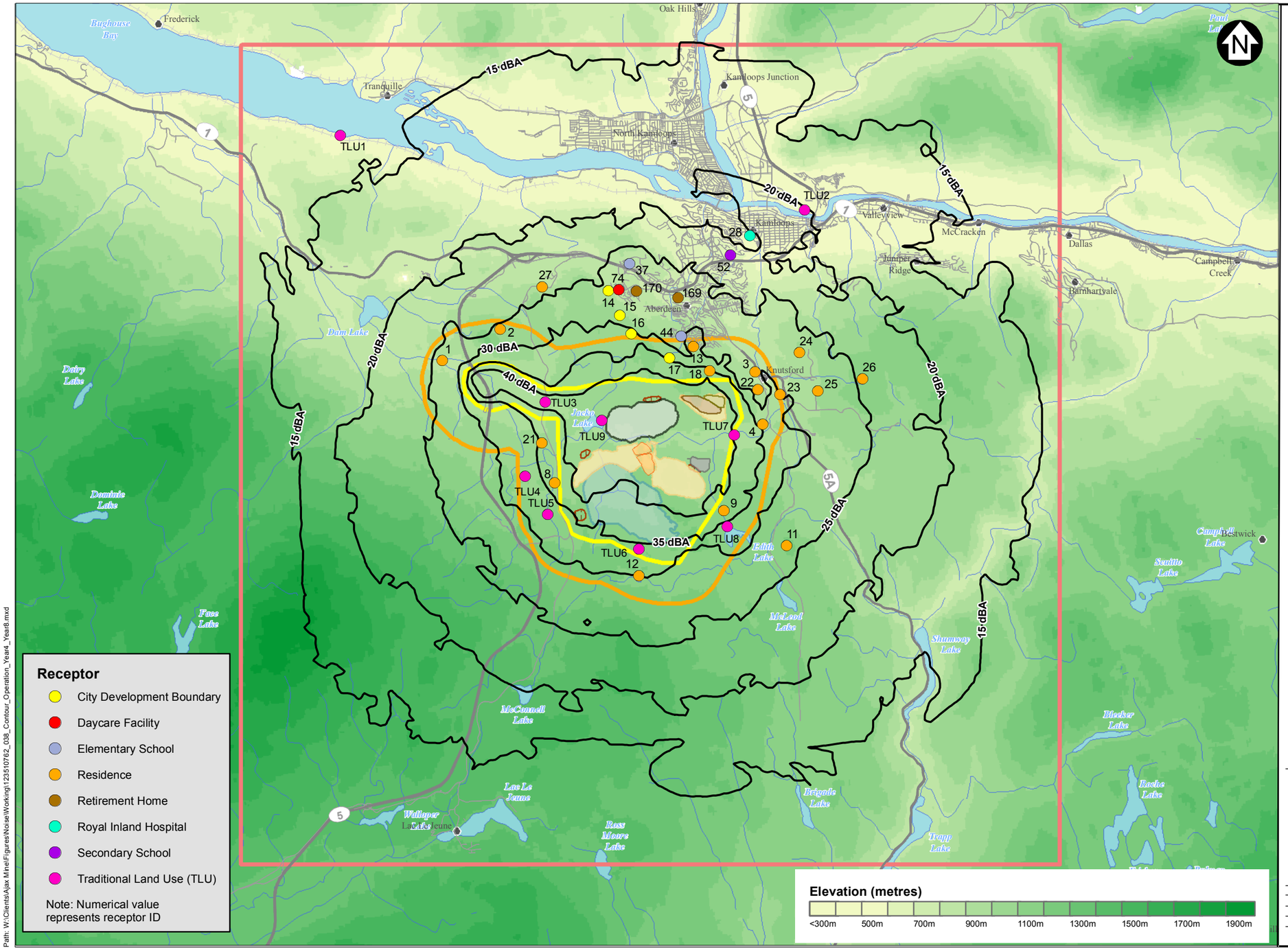


Figure 5-4
Noise Contour for Operation (Years 4 and 8) during Daytime or Nighttime Period



NOTES:
1. BASE MAP: DEM (55m)
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD83 UTM, ZONE 10 NORTH, METER.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:150,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA AND CANADA

SCALE 0 1.5 3 4.5 Kilometres

KGHM

KGHM Ajax Mining Inc.

2015 August 20			
DATE			
PVL	AU	KW	DJ
DESIGNED	DRAWN	CHK'D	APP'D
REF NO.	123510762_038_Contour_Operation_Year4_Year8		REV A

Path: W:\Clients\Ajax Mine\Figures\Noise\Working\123510762_038_Contour_Operation_Year4_Year8.mxd

5.1.3 Compliance with BC OGC Noise Limits

5.1.3.1 Permissible Sound Level

Compliance with the BC OGC noise guideline PSL was assessed for the operation phase at the residential receptors. Noise receptors such as school and daycare are non-residential dwellings. They are not classified as BC OGC receptors. Therefore, these receptors do not have a PSL limit and they are excluded in the result table. The BC OGC Noise Control Guideline does not have a noise limit on construction or decommissioning activities.

The cumulative sound level is compared to the PSL at the residential receptors in Table 5-4. The cumulative sound levels are determined by logarithmically adding the predicted sound level (Table 5-3) for Project operation (Year 2 and Years 4 and 8) to the BC OGC prescribed ambient sound level (ASL) for the daytime and nighttime periods. BC OGC noise guideline prescribes that ASL can be estimated to be 5 dB below the Basic Sound Level (BSL). Table 3-1 in Section 3.1.1.1 presents the BSL for all the residential receptors. The nighttime ASL is determined by subtracting 5 dB from the nighttime BSL and the daytime ASL is 10 dB higher than the nighttime ASL.

The cumulative predicted sound levels comply with the PSL at all residential receptors for both Year 2 and Years 4 and 8 scenarios.

Table 5-4 Operation Phase (Year 2 and Years 4 and 8) Noise Modelling Results

Receptor Location ID	Receptor Description	Project Only (Year 2)		Project Only (Year 4 and 8)		BC OGC ASL[1]		Cumulative Sound Level (Year 2)		Cumulative Sound Level (Years 4 and 8Years 4 and 8)		PSL		Meet PSL Limit?
		L_d (dBA)	L_n (dBA)	L_d (dBA)	L_n (dBA)	L_d (dBA)	L_n (dBA)	L_d (dBA)	L_n (dBA)	L_d (dBA)	L_n (dBA)	L_d (dBA)	L_n (dBA)	
1	Residence	26.3	26.3	26.2	26.2	45	35	45.1	35.5	45.1	35.5	50	40	Yes
2	Residence	26.7	26.7	26.8	26.8	45	35	45.1	35.6	45.1	35.6	50	40	Yes
3	Residence	28.9	28.9	28.8	28.8	50	40	50.0	40.3	50.0	40.3	55	45	Yes
4	Residence	35.3	35.3	34.5	34.5	45	35	45.4	38.2	45.4	37.8	50	40	Yes
8	Residence	37.4	37.4	36.7	36.7	45	35	45.7	39.4	45.6	38.9	50	40	Yes
9	Residence	36.1	36.1	37.7	37.7	45	35	45.5	38.6	45.7	39.6	50	40	Yes
11	Residence	27.5	27.5	27.2	27.2	45	35	45.1	35.7	45.1	35.7	50	40	Yes
12	Residence	30.0	30.0.	30.0	30.0	50	40	45.1	36.2	45.1	36.2	50	40	Yes
13	Aberdeen Development	31.0	31.0	31.5	31.5	51	41	51.0	41.4	51.0	41.5	56	46	Yes
14	CDB1	21.4	21.4	23.8	23.8	48	38	48.0	38.1	48.0	38.2	53	43	Yes
15	CDB2	27.9	27.9	28.9	28.9	45	35	45.1	35.8	45.1	36.0	50	40	Yes
16	CDB3	32.2	32.2	33.1	33.1	45	35	45.2	36.8	45.3	37.2	50	40	Yes
17	CDB4	33.3	33.3	33.9	33.9	45	35	45.3	37.2	45.3	37.5	50	40	Yes
18	CDB5	34.5	34.5	35.1	35.1	45	35	45.4	37.8	45.4	38.1	50	40	Yes
21	Residence	36.1	36.1	35.9	35.9	45	35	45.5	38.6	45.5	38.5	50	40	Yes
22	Residence	27.9	27.9	27.7	27.7	45	35	45.1	35.8	45.1	35.7	50	40	Yes
23	Residence	30.4	30.4	30.0	30.0	53	43	53.0	43.2	53.0	43.2	58	48	Yes
24	Residence	28.0	28.0	27.5	27.5	45	35	45.1	35.8	45.1	35.7	50	40	Yes
25	Residence	28.4	28.4	27.9	27.9	45	35	45.1	35.9	45.1	35.8	50	40	Yes

Table 5-4 Operation Phase (Year 2 and Years 4 and 8) Noise Modelling Results

Receptor Location ID	Receptor Description	Project Only (Year 2)		Project Only (Year 4 and 8)		BC OGC ASL[1]		Cumulative Sound Level (Year 2)		Cumulative Sound Level (Years 4 and 8Years 4 and 8)		PSL		Meet PSL Limit?
		L_d (dBA)	L_n (dBA)	L_d (dBA)	L_n (dBA)	L_d (dBA)	L_n (dBA)	L_d (dBA)	L_n (dBA)	L_d (dBA)	L_n (dBA)	L_d (dBA)	L_n (dBA)	
26	Residence	24.4	24.4	24.4	24.4	45	35	45.0	35.4	45.0	35.4	50	40	Yes
27	Residence	23.2	23.2	23.7	23.7	48	38	48.0	38.1	48.0	38.2	53	43	Yes
28	Royal Inland Hospital	19.6	19.6	20.1	20.1	56	46	56.0	46.0	56.0	46.0	61	51	Yes
37	Dufferin Elementary	25.4	25.4	25.6	25.6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
44	Pacific Way Elementary	29.0	29.0	29.6	29.6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
52	Sa-Hali Secondary	22.5	22.5	22.7	22.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
74	Tots & Teddies	25.4	25.4	26.2	26.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
169	Kamloops Senior Village	24.2	24.2	25.0	25.0	53	43	53.0	43.1	53.0	43.1	58	48	Yes
170	Ridgepointe at Pineview Retirement Home	26.2	26.2	26.9	26.9	53	43	53.0	43.1	53.0	43.1	58	48	Yes
TLU1	Kamloops Lake Pump house	10.8	10.8	11.7	11.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TLU2	T'Kaloops First Nation Reserve	20.5	20.5	20.1	20.1	48	38	48.0	38.1	48.0	38.1	53	43	Yes

Table 5-4 Operation Phase (Year 2 and Years 4 and 8) Noise Modelling Results

Receptor Location ID	Receptor Description	Project Only (Year 2)		Project Only (Year 4 and 8)		BC OGC ASL[1]		Cumulative Sound Level (Year 2)		Cumulative Sound Level (Years 4 and 8Years 4 and 8)		PSL		Meet PSL Limit?
		L_d (dBA)	L_n (dBA)	L_d (dBA)	L_n (dBA)	L_d (dBA)	L_n (dBA)	L_d (dBA)	L_n (dBA)	L_d (dBA)	L_n (dBA)	L_d (dBA)	L_n (dBA)	
TLU3	Inks Lake	50.1	50.1	50.1	50.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TLU4	Jacko Creek	33.1	33.1	32.7	32.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TLU5	Upper Peterson Creek	32.8	32.8	33.8	33.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TLU6	Goose Lake Road	33.7	33.7	34.2	34.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TLU7	Peterson Creek Discharge	40.9	40.9	39.5	39.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TLU8	Edith Lake	33.6	33.6	33.7	33.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

NOTES:
N/A – not applicable
[1] Based on the ASL established in Table 3-1

5.1.3.2 Low-Frequency Noise Assessment

Table 5-5 summarizes the LFN assessment results for the Project operation during Year 2 and Years 4 and 8.

The BC OGC noise guideline advises that potential adverse LFN effects should be assessed. The assessment is based on an evaluation of the difference between the C-weighted and A-weighted sound levels, the overall C-weighted sound levels, and presence of low frequency tones at the residential receptors. BC OGC place cautionary limits of 20 dB on the difference between the C-weighted and the A-weighted levels. When the actual difference exceeds the cautionary limit, further evaluation is recommended. Under the BC OGC noise guideline, the evaluation considers low frequency tones. If no low frequency tonality is present or expected, potential adverse LFN effects are deemed as acceptable even if the cautionary limit is exceeded.

The dBC minus dBA results at most receptors are below 20 dB. During the operation phase Year 2, the results at six receptors (receptor #ID 14, 26, 28, 52, TLU1, and TLU2) equal to or exceeding the BC OGC limit of a 20 dB difference between the C-weighted and A-weighted sound levels. During the operation phase Years 4 and 8, there are four receptors (noise receptor ID# 26, 28, TLU1, and TLU2) with dBC minus dBA level equal to or exceeding 20 dB. These receptors and the dBC minus dBA values are highlighted in Table 5-5. Further evaluation of LFN effects is required for these receptors (receptors #ID 14, 26, 28, 52, TLU1, and TLU2).

The ANSI 12.9 standard is used to assess potential LFN effects once the difference between the C-weighted and A-weighted Project noise levels exceed the 20 dB cautionary limit. The ANSI 12.9 standard assigns acceptable limits on noise (65 dB) in 16 Hz, 31.5 Hz and 63 Hz octave bands. When the cautionary limit of 20 dB is not exceeded, potential adverse LFN effects are deemed as acceptable and no further assessment is required. Generally, annoyance is minimal when octave-band sound pressure levels are less than 65 dB at 16 Hz, 31.5 Hz, and 63 Hz mid-band frequencies. If the predicted sound level exceeds 65 dB at any one of the 16Hz, 31.5Hz and 63 Hz band, the resulting overall dBC level will exceed 65 dBC. A conservative equivalent single number threshold to the aforementioned limits at 16 Hz, 31.5 Hz, and 63 Hz is provided by the 65 dBC level. The predicted levels at all six receptors (receptors ID # 14, 26, 28, 52, TLU1, and TLU2) and all other receptors are well below 65 dBC.

Based on the BC OGC noise guideline and the ANSI 12.9 standard method, the results indicate no potential LFN effect at the all receptors.

Table 5-5 Low Frequency Noise Assessment

Noise Receptor ID	Receptor Description	Year 2			Years 4 and 8		
		L_n (dBC)	L_n (dBA)	dBC minus dBA	L_n (dBC)	L_n (dBA)	dBC minus dBA
1	Residence	26.3	45.4	19.1	26.2	45.2	19.0
2	Residence	26.7	45.9	19.2	26.8	45.9	19.1
3	Residence	28.9	47.2	18.3	28.8	47.0	18.2
4	Residence	35.3	52.4	17.1	34.5	51.7	17.2
8	Residence	37.4	51.7	14.3	36.7	50.8	14.1
9	Residence	36.1	52.3	16.2	37.7	52.8	15.1
11	Residence	27.5	46.1	18.6	27.2	45.7	18.5
12	Residence	30.0	47.7	17.7	30.0	47.5	17.5
13	Aberdeen Development	31.0	48.6	17.6	31.5	48.6	17.1
14	**CDB 1**	21.4	41.9	20.5	23.8	43.3	**19.5**
15	CDB 2	27.9	46.2	18.3	28.9	46.7	17.8
16	CDB 3	32.2	49.2	17.0	33.1	49.5	16.4
17	CDB 4	33.3	50.2	16.9	33.9	50.3	16.4
18	CDB 5	34.5	50.4	15.9	35.1	50.1	15.0
21	Residence	36.1	51.3	15.2	35.9	50.8	14.9
22	Residence	27.9	47.0	19.1	27.7	46.8	19.1
23	Residence	30.4	48.1	17.7	30.0	47.5	17.5
24	Residence	28.0	47.0	19.0	27.5	46.5	19.0
25	Residence	28.4	47.8	19.4	27.9	47.4	19.5
26	**Residence**	24.4	44.9	20.5	24.4	45.0	**20.6**
27	Residence	23.2	42.9	19.7	23.7	43.1	19.4
28	**Royal Inland Hospital**	19.6	40.4	20.8	20.1	40.7	**20.6**
37	Dufferin Elementary	25.4	44.4	19.0	25.6	44.3	18.7
44	Pacific Way Elementary	29.0	47.3	18.3	29.6	47.5	17.9
52	**Sahali Secondary**	22.5	42.5	20.0	22.7	42.5	**19.8**
74	Tots & Teddies	25.4	44.5	19.1	26.2	44.8	18.6
169	Kamloops Senior Village	24.2	44.0	19.8	25.0	44.4	19.4
170	Ridgepointe at Pineview Retirement Home	26.2	45.1	18.9	26.9	45.3	18.4
TLU1	**Kamloops Lake Pump house**	10.8	33.8	23.0	11.7	34.2	**22.5**
TLU2	**T'Kaloops First Nation Reserve**	20.5	40.9	20.4	20.1	40.5	**20.4**

Table 5-5 Low Frequency Noise Assessment

Noise Receptor ID	Receptor Description	Year 2			Years 4 and 8		
		L_n (dBC)	L_n (dBA)	dBC minus dBA	L_n (dBC)	L_n (dBA)	dBC minus dBA
TLU3	Inks Lake	50.1	60.5	10.4	50.1	60.5	10.4
TLU4	Jacko Creek	33.1	49.5	16.4	32.7	48.8	16.1
TLU5	Upper Peterson Creek	32.8	49.1	16.3	33.8	49.7	15.9
TLU6	Goose Lake Road	33.7	50.5	16.8	34.2	50.7	16.5
TLU7	Peterson Creek Discharge	40.9	56.1	15.2	39.5	54.9	15.4
TLU8	Edith Lake	33.6	50.4	16.8	33.7	50.2	16.5
TLU9	Jacko Lake Prayer Tree	46.7	58.6	11.9	49.2	59.8	10.6

5.1.4 Compliance with Health Canada Noise Guidance

For the construction and operation phases, change in %HA associated with the Project is compared with the threshold advised by Health Canada. Impulsive characteristics of source noise are accounted for with adjustments in the prediction results (Table 5-2) from the Project because the presence of impulsive noise can increase the potential annoyance of sound.

5.1.4.1 Baseline %HA

The determination of baseline %HA at a receptor is based on the baseline L_{dn} sound level, by an equation shown in Section 3.1.2. The baseline sound level at a receptor can be estimated by two different approaches. The first approach uses the prescribed ASL in the BC OGC noise guideline. The ASL is 5 dB below the BSL as determined in Table 3-1 of Section 3.1.1.1 (also summarized in Table 2-7). The second approach uses the baseline sound level estimated from the baseline monitoring program as presented in Table 2-7 of Section 2.2.1.4.

Table 5-6 below summarizes the baseline sound level and the corresponding %HA for the two different approaches. In comparing the two approaches, the lower value %HA will be used as the baseline %HA. This is considered a more conservative approach as a lower baseline %HA will result in a higher change in %HA when compared to the Project %HA.

Table 5-6 Determination of Baseline %HA

Noise Receptor ID	Receptor Description	BC OGC ASL		Baseline Monitoring Program		Baseline L_{dn} used in Compliance (dBA)	Baseline %HA used in Compliance (%)
		Baseline L_{dn} (dBA)	Baseline %HA (%)	Baseline L_{dn} (dBA)	Baseline %HA (%)		
1	Residence	45	1.14	42	0.73	42	0.73
2	Residence	45	1.14	42	0.73	42	0.73
3	Residence	50	2.19	43	0.88	43	0.88
4	Residence	45	1.14	42	0.73	42	0.73
8	Residence	45	1.14	42	0.73	42	0.73
9	Residence	45	1.14	42	0.73	42	0.73
11	Residence	45	1.14	42	0.73	42	0.73
12	Residence	45	1.14	42	0.73	42	0.73
13	Aberdeen Development	51	2.49	54	3.59	51	2.49
14	CDB 1	48	1.69	43	0.88	43	0.88
15	CDB 2	45	1.14	43	0.88	43	0.88
16	CDB 3	45	1.14	43	0.88	43	0.88
17	CDB 4	45	1.14	43	0.88	43	0.88
18	CDB 5	45	1.14	43	0.88	43	0.88
21	Residence	45	1.14	42	0.73	42	0.73
22	Residence	45	1.14	42	0.73	42	0.73
23	Residence	53	3.22	43	0.88	43	0.88
24	Residence	45	1.14	42	0.73	42	0.73
25	Residence	45	1.14	42	0.73	42	0.73
26	Residence	45	1.14	42	0.73	42	0.73
27	Residence	48	1.69	43	0.88	43	0.88
28	Royal Inland Hospital	56	4.71	51	2.61	51	2.61
37	Dufferin Elementary	53	3.22	51	2.61	51	2.61
44	Pacific Way Elementary	56	4.71	51	2.61	51	2.61
52	Sahali Secondary	56	4.71	51	2.61	51	2.61
74	Tots & Teddies	56	4.71	51	2.61	51	2.61
169	Kamloops Senior Village	53	3.22	51	2.61	51	2.61

Table 5-6 Determination of Baseline %HA

Noise Receptor ID	Receptor Description	BC OGC ASL		Baseline Monitoring Program		Baseline L_{dn} used in Compliance (dBA)	Baseline %HA used in Compliance (%)
		Baseline L_{dn} (dBA)	Baseline %HA (%)	Baseline L_{dn} (dBA)	Baseline %HA (%)		
170	Ridgepointe at Pineview Retirement Home	53	3.22	51	2.61	51	2.61
TLU1	Kamloops Lake Pump house	45	0.73	42	0.73	42	0.73
TLU2	T'Kaloops First Nation Reserve	48	1.69	51	2.61	48	1.69
TLU3	Inks Lake	45	0.73	42	0.73	42	0.73
TLU4	Jacko Creek	45	0.73	42	0.73	42	0.73
TLU5	Upper Peterson Creek	45	0.73	42	0.73	42	0.73
TLU6	Goose Lake Road	45	0.73	42	0.73	42	0.73
TLU7	Peterson Creek Discharge	45	0.73	42	0.73	42	0.73
TLU8	Edith Lake	45	0.73	42	0.73	42	0.73
TLU9	Jacko Lake Prayer Tree	45	1.14	43	0.88	43	0.88

5.1.4.2 Construction

The change in %HA results during the construction phase Year -1 and piling activity at all receptors is summarized in Table 5-7. The change in %HA at all receptors is below the limit of 6.5% during the construction phase Year -1.

Piling activities are expected prior to the construction phase, resulting in a noise emission that is considered highly impulsive. The impulsive sound adjustment of 12 dB was applied to the results presented in Table 5-2 of Section 5.1.1. The change in %HA at all receptors is below the limit of 6.5% during the pilling activities; the only exception is at the Jacko Lake Prayer Tree (ID# TLU9) traditional land use location with the change in %HA value of 58.17%.

5.1.4.3 Operation

The change in %HA results during the Year 2 and Years 4 and 8 operation phase for all receptors is summarized in Table 5-8. The change in %HA at all receptors is below the limit of 6.5%.

Table 5-7 Construction Phase (Piling Activity and Year -1) Change in %HA Results

Noise Receptor ID	Receptor Description	Baseline %HA (%)	Piling Activity			Year -1			Exceed 6.5%
			Project L_{dn} (dBA)	Project %HA (%)	Change in %HA (%)	Project L_{dn} (dBA)	Project %HA (%)	Change in %HA (%)	
1	Residence	0.73	42	0.76	0.03	42	0.76	0.03	No
2	Residence	0.73	42	0.81	0.08	42	0.76	0.03	No
3	Residence	0.88	43	0.88	0.00	43	0.92	0.04	No
4	Residence	0.73	42	0.77	0.04	44	0.96	0.23	No
8	Residence	0.73	46	1.35	0.62	44	0.99	0.26	No
9	Residence	0.73	42	0.79	0.06	45	1.08	0.35	No
11	Residence	0.73	42	0.74	0.01	42	0.76	0.03	No
12	Residence	0.73	42	0.78	0.05	42	0.79	0.06	No
13	Aberdeen Development	2.49	51	2.50	0.01	51	2.53	0.04	No
14	CDB 1	0.88	43	0.88	0.00	43	0.89	0.01	No
15	CDB 2	0.88	43	0.94	0.06	43	0.92	0.04	No
16	CDB 3	0.88	45	1.15	0.27	44	0.99	0.11	No
17	CDB 4	0.88	43	0.93	0.05	44	1.02	0.14	No
18	CDB 5	0.88	43	0.89	0.01	45	1.09	0.21	No
21	Residence	0.73	53	3.06	2.33	43	0.93	0.20	No
22	Residence	0.73	42	0.73	0.00	42	0.78	0.04	No
23	Residence	0.88	43	0.90	0.02	44	0.95	0.07	No
24	Residence	0.73	42	0.74	0.01	42	0.77	0.04	No
25	Residence	0.73	42	0.74	0.01	42	0.78	0.05	No
26	Residence	0.73	42	0.73	0.00	42	0.75	0.02	No
27	Residence	0.88	43	0.91	0.03	43	0.89	0.01	No

Table 5-7 Construction Phase (Piling Activity and Year -1) Change in %HA Results

Noise Receptor ID	Receptor Description	Baseline %HA (%)	Piling Activity			Year -1			Exceed 6.5%
			Project L_{dn} (dBA)	Project %HA (%)	Change in %HA (%)	Project L_{dn} (dBA)	Project %HA (%)	Change in %HA (%)	
28	Royal Inland Hospital	2.61	51	2.61	0.00	51	2.62	0.00	No
37	Dufferin Elementary	2.61	51	2.63	0.01	51	2.62	0.01	No
44	Pacific Way Elementary	2.61	51	2.62	0.00	51	2.64	0.02	No
52	Sahali Secondary	2.61	51	2.61	0.00	51	2.62	0.00	No
74	Tots & Teddies	2.61	51	2.62	0.00	51	2.62	0.01	No
169	Kamloops Senior Village	2.61	51	2.62	0.00	51	2.62	0.01	No
170	Ridgepointe at Pineview Retirement Home	2.61	51	2.62	0.01	51	2.62	0.01	No
TLU1	Kamloops Lake Pump house	0.73	42	0.73	0.00	42	0.73	0.00	No
TLU2	T'Kaloops First Nation Reserve	1.69	48	1.69	0.00	48	1.69	0.00	No
TLU3	Inks Lake	0.73	49	1.87	1.14	55	3.96	3.23	No
TLU4	Jacko Creek	0.73	44	1.07	0.34	43	0.84	0.11	No
TLU5	Upper Peterson Creek	0.73	44	0.95	0.22	42	0.82	0.09	No
TLU6	Goose Lake Road	0.73	43	0.83	0.10	43	0.86	0.13	No
TLU7	Peterson Creek Discharge	0.73	42	0.82	0.09	46	1.39	0.66	No
TLU8	Edith Lake	0.73	42	0.77	0.04	43	0.87	0.14	No
TLU9	Jacko Lake Prayer Tree	0.88	82	59.05	58.17	48	1.73	0.85	Yes

Table 5-8 Operation Phase (Year 2 and Years 4 and 8) Change in %HA Results

Noise Receptor ID	Receptor Description	Baseline %HA (%)	Year 2			Years 4 and 8			Exceed 6.5%
			Project L_{dn} (dBA)	Project %HA (%)	Change in %HA (%)	Project L_{dn} (dBA)	Project %HA (%)	Change in %HA (%)	
1	Residence	0.73	42	0.78	0.05	42	0.78	0.05	No
2	Residence	0.73	42	0.79	0.06	42	0.79	0.06	No
3	Residence	0.88	44	0.96	0.08	44	0.96	0.08	No
4	Residence	0.73	45	1.09	0.36	44	1.04	0.31	No
8	Residence	0.73	46	1.28	0.55	45	1.21	0.48	No
9	Residence	0.73	45	1.15	0.42	46	1.31	0.58	No
11	Residence	0.73	42	0.80	0.07	42	0.79	0.06	No
12	Residence	0.73	43	0.85	0.12	43	0.85	0.12	No
13	Aberdeen Development	2.49	51	2.55	0.06	51	2.56	0.07	No
14	CDB 1	0.88	43	0.89	0.02	43	0.90	0.03	No
15	CDB 2	0.88	44	0.94	0.07	44	0.96	0.08	No
16	CDB 3	0.88	44	1.05	0.17	45	1.08	0.21	No
17	CDB 4	0.88	45	1.09	0.21	45	1.12	0.24	No
18	CDB 5	0.88	45	1.16	0.28	45	1.19	0.31	No
21	Residence	0.73	45	1.15	0.42	45	1.14	0.41	No
22	Residence	0.73	42	0.81	0.08	42	0.80	0.07	No
23	Residence	0.88	44	0.99	0.11	44	0.98	0.11	No
24	Residence	0.73	42	0.81	0.08	42	0.80	0.07	No
25	Residence	0.73	42	0.81	0.08	42	0.81	0.08	No
26	Residence	0.73	42	0.76	0.03	42	0.76	0.03	No
27	Residence	0.88	43	0.90	0.02	43	0.90	0.03	No

Table 5-8 Operation Phase (Year 2 and Years 4 and 8) Change in %HA Results

Noise Receptor ID	Receptor Description	Baseline %HA (%)	Year 2			Years 4 and 8			Exceed 6.5%
			Project L_{dn} (dBA)	Project %HA (%)	Change in %HA (%)	Project L_{dn} (dBA)	Project %HA (%)	Change in %HA (%)	
28	Royal Inland Hospital	2.61	51	2.62	0.00	51	2.62	0.00	No
37	Dufferin Elementary	2.61	51	2.63	0.02	51	2.63	0.02	No
44	Pacific Way Elementary	2.61	51	2.65	0.04	52	2.66	0.04	No
52	Sahali Secondary	2.61	51	2.62	0.01	51	2.62	0.01	No
74	Tots & Teddies	2.61	51	2.63	0.02	51	2.63	0.02	No
169	Kamloops Senior Village	2.61	51	2.63	0.01	51	2.63	0.01	No
170	Ridgepointe at Pineview Retirement Home	2.61	51	2.63	0.02	51	2.64	0.02	No
TLU1	Kamloops Lake Pump house	0.73	42	0.73	0.00	42	0.73	0.00	No
TLU2	T'Kaloops First Nation Reserve	1.69	48	1.70	0.01	48	1.70	0.01	No
TLU3	Inks Lake	0.73	57	5.10	4.37	57	5.10	4.37	No
TLU4	Jacko Creek	0.73	44	0.96	0.23	44	0.94	0.21	No
TLU5	Upper Peterson Creek	0.73	44	0.95	0.22	44	1.00	0.27	No
TLU6	Goose Lake Road	0.73	44	0.99	0.26	44	1.02	0.29	No
TLU7	Peterson Creek Discharge	0.73	48	1.76	1.03	47	1.54	0.81	No
TLU8	Edith Lake	0.73	44	0.99	0.26	44	0.99	0.26	No
TLU9	Jacko Lake Prayer Tree	0.88	54	3.43	2.56	56	4.61	3.73	No

5.1.5 Sleep Disturbance

The sleep disturbance noise guideline of 42 dBA (outside during nighttime) was used for this assessment based on the World Health Organization Night Guidelines for Europe (WHO 2009). The results in Tables 5-1 and 5-3 indicate that the nighttime equivalent sound level from the Project is below 42 dBA at all residential receptors for both construction and operation Project phases. No sleep disturbance noise effect is expected from the Project.

5.1.6 Comparison to Baseline Sound Level during Construction and Operation Phase

Tables 5-9 and 5-10 compare the modelling results to the baseline sound level at the noise receptors for Construction and Operation phases, respectively. The maximum level difference represents the highest arithmetic difference between the predicted and the baseline sound level at a receptor. The noise effect is considered perceptible when the predicted noise level is the same or higher than baseline sound level (i.e. maximum level difference equals or greater than zero). A perceptible noise event does not indicate that noise guideline limits are exceeded.

During the piling activities, the predicted Ld level of 71.6 dBA is 32.6 dB above the baseline daytime sound level of 39 dBA at the Jacko Lake Prayer Tree (ID# TLU#9) traditional land use receptor location. Other traditional land use receptor locations such as Inks Lake (ID# TLU3) and Peterson Creek Discharge (ID# TLU7) will have perceptible noise effect from the piling activities. In addition, noise effect at receptors ID# 4, 8, 9, 16, 17, 18 and 21 is predicted to be perceptible.

During Operation Phase, the predicted Ln level of 50.1 dBA is 16.1 dB above the baseline nighttime sound level of 34 dBA at the Inks Lake (ID# TLU3) traditional land use receptor location. The dominate noise source is from the haul truck traffic along the access road. Other traditional land use locations such as Goose Lake Road (Id# TLU6), Peterson Creek Discharge (ID# TLU7), and Jacko Lake Prayer Tree (ID# TLU#9) are predicted to have perceptible noise effect from the operation. In addition, the noise effect at receptors ID#4, 8, 9 and 21 is predicted to be perceptible during the Operation phases.

Table 5-9 Comparison to Baseline Sound Level Construction Phase and Piling Activities

ID	Receptor Type	Construction Phase Year -1, L_d or L_n (dBA)	Piling Activities, L_d (dBA)	Baseline Sound Level used in Health Canada Noise Guideline		Maximum Level Differences[1] (dB)
				L_d (dBA)	L_n (dBA)	
1	Residence	29.9	20.6	39	34	-4.1
2	Residence	30.0	24.6	39	34	-4
3	Residence	32.6	11.3	39	36	-3.4
4	Residence	39.4	21.7	39	34	5.4 *

Table 5-9 Comparison to Baseline Sound Level Construction Phase and Piling Activities

ID	Receptor Type	Construction Phase Year -1, L_d or L_n (dBA)	Piling Activities, L_d (dBA)	Baseline Sound Level used in Health Canada Noise Guideline		Maximum Level Differences[1] (dB)
				L_d (dBA)	L_n (dBA)	
8	Residence	40.0	34.5	39	34	6 *
9	Residence	41.5	23.1	39	34	7.5 *
11	Residence	30.7	15.3	39	34	-3.3
12	Residence	33.3	22.2	39	34	-0.7
13	Aberdeen Development	35.4	18.7	51	41	-5.6
14	CDB 1	25.8	7.3	39	36	-10.2
15	CDB 2	32.1	23.9	39	36	-3.9
16	CDB 3	36.6	30.9	39	36	1.9 *
17	CDB 4	37.8	22.8	39	36	1.8 *
18	CDB 5	39.7	17.4	39	36	3.7 *
21	Residence	38.7	42.3	39	34	13.3 *
22	Residence	32.0	8.3	39	34	-2
23	Residence	34.4	18.7	39	36	-1.6
24	Residence	31.5	16.4	39	34	-2.5
25	Residence	32.1	15.6	39	34	-1.9
26	Residence	28.0	11.6	39	34	-6
27	Residence	27.3	21.1	39	36	-7.9
28	Royal Inland Hospital	23.8	1.9	50	43	-19.2
37	Dufferin Elementary	29.1	21.1	50	43	-13.9
44	Pacific Way Elementary	33.3	14.8	50	43	-9.7
52	Sa-Hali Secondary	26.6	7.6	50	43	-16.4
74	Tots & Teddies	29.4	14.4	50	43	-13.6
169	Kamloops Senior Village	28.3	13	50	43	-14.7
170	Ridgepointe at Pineview Retirement Home	29.9	17.7	50	43	-13.1
TLU1	Kamloops Lake Pump house	14.3	2.6	39	34	-26.1
TLU2	T'Kaloops First Nation Reserve	23.5	9.2	48	38	-20.9
TLU3	Inks Lake	54.4	37.9	39	34	14 *
TLU4	Jacko Creek	36.0	31.4	39	34	-4.4
TLU5	Upper Peterson Creek	35.2	29.3	39	34	-5.2

Table 5-9 Comparison to Baseline Sound Level Construction Phase and Piling Activities

ID	Receptor Type	Construction Phase Year -1, L_d or L_n (dBA)	Piling Activities, L_d (dBA)	Baseline Sound Level used in Health Canada Noise Guideline		Maximum Level Differences[1] (dB)
				L_d (dBA)	L_n (dBA)	
TLU6	Goose Lake Road	36.7	25.5	39	34	-3.7
TLU7	Peterson Creek Discharge	44.8	25	39	34	4.4 *
TLU8	Edith Lake	37.1	21.6	39	34	-3.3
TLU9	Jacko Lake Prayer Tree	46.6	71.6	39	36	32.6 *

NOTES:
[1] The maximum arithmetic difference between the prediction results and baseline level during the nighttime period
* Perceptible noise effect

Table 5-10 Comparison to Baseline Sound Level Operation Phase

ID	Receptor Type	Operation Year 2, L_d or L_n (dBA)	Operation Year 4 and 8, L_d or L_n (dBA)	Baseline Sound Level used in Health Canada Noise Guideline		Maximum level differences[1] (dB)
				L_d (dBA)	L_n (dBA)	
1	Residence	26.3	26.2	39	34	-7.7
2	Residence	26.7	26.8	39	34	-7.2
3	Residence	28.9	28.8	39	36	-7.1
4	Residence	35.3	34.5	39	34	1.3 *
8	Residence	37.4	36.7	39	34	3.4 *
9	Residence	36.1	37.7	39	34	3.7 *
11	Residence	27.5	27.2	39	34	-6.5
12	Residence	30	30	39	34	-4
13	Aberdeen Development	31	31.5	51	41	-9.5
14	CDB 1	21.4	23.8	39	36	-12.2
15	CDB 2	27.9	28.9	39	36	-7.1
16	CDB 3	32.2	33.1	39	36	-2.9
17	CDB 4	33.3	33.9	39	36	-2.1
18	CDB 5	34.5	35.1	39	36	-0.9
21	Residence	36.1	35.9	39	34	2.1 *
22	Residence	27.9	27.7	39	34	-6.1

Table 5-10 Comparison to Baseline Sound Level Operation Phase

ID	Receptor Type	Operation Year 2, L_d or L_n (dBA)	Operation Year 4 and 8, L_d or L_n (dBA)	Baseline Sound Level used in Health Canada Noise Guideline		Maximum level differences[1] (dB)
				L_d (dBA)	L_n (dBA)	
23	Residence	30.4	30	39	36	-5.6
24	Residence	28	27.5	39	34	-6
25	Residence	28.4	27.9	39	34	-5.6
26	Residence	24.4	24.4	39	34	-9.6
27	Residence	23.2	23.7	39	36	-12.3
28	Royal Inland Hospital	19.6	20.1	50	43	-22.9
37	Dufferin Elementary	25.4	25.6	50	43	-17.4
44	Pacific Way Elementary	29	29.6	50	43	-13.4
52	Sa-Hali Secondary	22.5	22.7	50	43	-20.3
74	Tots & Teddies	25.4	26.2	50	43	-16.8
169	Kamloops Senior Village	24.2	25	50	43	-18
170	Ridgepointe at Pineview Retirement Home	26.2	26.9	50	43	-16.1
TLU1	Kamloops Lake Pump house	10.8	11.7	39	34	-22.3
TLU2	T'Kaloops First Nation Reserve	20.5	20.1	48	38	-17.5
TLU3	Inks Lake	50.1	50.1	39	34	16.1*
TLU4	Jacko Creek	33.1	32.7	39	34	-0.9
TLU5	Upper Peterson Creek	32.8	33.8	39	34	-0.2
TLU6	Goose Lake Road	33.7	34.2	39	34	0.2 *
TLU7	Peterson Creek Discharge	40.9	39.5	39	34	6.9 *
TLU8	Edith Lake	33.6	33.7	39	34	-0.3
TLU9	Jacko Lake Prayer Tree	46.7	49.2	39	36	13.2 *

NOTES:

[1] The maximum arithmetic difference between the prediction results and baseline level during the nighttime period

* Perceptible noise effect

5.2 VIBRATION

5.2.1 Construction

During the construction phase, the following activities may cause vibration:

- earthworks;
- site road construction, use and maintenance;
- open pit development; and
- drilling and blasting.

As presented in the method section above, the vibration effects from different activities are compared to the City of Toronto construction vibration of 8 mm/s. These activities are expected to occur at different time and locations, vibration from multiple concurrent sources are not expected to interactively cumulatively for the same receptor.

The heavy construction equipment associated with earthworks during construction at the plant facilities are expected to generate ground vibration up to 1 mm/s at a distance of 25 m (FTA 1995 and ASCE 2000). The closest residences are located more than 600 m away from the plant facilities. Vibration level from the source decrease with increasing distance. Therefore, vibration levels the closest residences are expected to be below the construction vibration limit of 8 mm/s.

Typical ground vibration from site road construction equipment (i.e. grader, compactor) can generate vibration up to 2 mm/s at a distance of 25 m (Stantec 2012). Road construction along a portion of the access is expected during the construction phase. The access road is at least 100 m away from the closest vibration receptor (Jacko Lake Boat Launch Area) and 1500 m away from the closest residential receptor. The vibration effect at this residential receptor from road construction equipment is expected to be well below the construction vibration limit of 8 mm/s.

Open pit development includes piling operation for the dam development near Jacko Lake east arm. Piling operations typically generate ground vibration levels up to 3 mm/s at a distance of 25 m (FTA 1995). Most of the vibration receptor (Jacko Lake Boat Launch Area) is at least 500 m from the piling operation. Vibration effect at these vibration receptors is expected to be below the construction vibration limit of 8 mm/s. The only exception is the Jacko Lake Prayer Tree (ID# TLU9) location. This location is in close proximity to the piling activities. The ground vibration level could exceed 3 mm/s in close proximity to the piling equipment; however, accessibility near the dam will be limited during the piling activities.

Quantitative blast assessment is conducted for the operation phase rather than the construction phase as the order of magnitude of blast effect during construction is expected to be far less.

Drilling typically generates a ground vibration level of up to 0.4 mm/s at a distance of 25 m (FTA 1995). The nearest vibration receptor is located more than 1000 m from the pit area with drilling activities. At this distance, the vibration level from drilling activities is expected to be well below the construction threshold of 8 mm/s.

5.2.2 Operation

The distance between the plant facility and the closest residence is over 600 m. There are no dominant vibration sources during operation of the plant facility that will induce a vibration level over this distance.

During the Operation phase, the primary vibration effects are ground vibration and air blast due to blast activities in the pit. Table 5-11 lists the predicted ground vibration and air blast levels for the vibration receptors of interest. The blasts plan divides the pit into three progressive zones (Zone 1 – Z1, Zone 2 – Z2, and Zone 3 – Z3) based on distance from Jacko Lake. Z1 is furthest and Z3 is closest to Jacko Lake. Different blast parameters are used in different zones.

To be conservative in all of the predictions, the distance to each point of concern was always taken from the final pit boundary, and all blasts were assumed to be fired with 1,020 kg of explosives, except for the blasts approaching Jacko Lake (Z3).

Detailed discussion of blast plan and blast procedure modification to address the vibration effect at Jacko Lake is presented in the Noise and Vibration TDR Appendix D Ajax Mine Blast Review. Appendix D also presents details on the blast zones, hole loads, and cautionary notes when using explosive decking and stem charges.

Table 5-11 Predicted Ground Vibration and Air Blast Overpressure Results at Receptor Locations

Vibration Receptor ID	Receptor Type	Predicted Ground Vibration Amplitude (mm/s)	Predicted Air blast overpressure (dBL)
1a	Jacko Lake Sensitive Fish Habitat Area #1	12.31[1]	128[1]
1b	Jacko Lake Sensitive Fish Habitat Area #2	6.96[1]	125[1]
2	Jacko Lake boat launch area	4.41	118
3	Urban Growth Boundary	2.09	113
4	Residence 1	1.70	112
5	Cell Tower 1	1.66	112
6	Cell Tower 2	1.38	111
7	Residence 2	1.21	110
8	City of Kamloops residences	1.15	110
9	Elementary Pacific Way School	1.09	109
10	Residence 3	1.09	109

Table 5-11 Predicted Ground Vibration and Air Blast Overpressure Results at Receptor Locations

Vibration Receptor ID	Receptor Type	Predicted Ground Vibration Amplitude (mm/s)	Predicted Air blast overpressure (dBL)
11	Site 1	1.02	109
12	Inks Lake	0.99	109
13	Residence 3	0.95	108
14	Site 2	0.91	108
15	Residence 4	0.88	108
16	Site 3	0.88	108
17	Site 4	0.82	108
18	Python Minifile historic underground	0.76	107
19	Residence 5	0.74	107
20	Residence 6	0.74	107
21	Residence 7	0.65	106
22	Galaxy historic underground	0.63	106
23	Royal Inland Hospital	0.51	105
24	Roadcut Failure Zone (Kamloops)	0.47	104
25	Pet Boarding	0.46	104
26	Proposed bike trail (Official)	0.45	104
27	Wedding event site location	0.39	103
28	Surface storage tank 1	0.37	103
29	Iron Mask historic underground	0.34	102
20	Surface storage tank 2	0.33	102
31	Surface storage tank 3	0.30	102
TLU1	Kamloops Lake Pump house	0.07	93
TLU2	T'Kaloops First Nation Reserve	0.15	97
TLU3	Inks Lake	1.17	110
TLU4	Jacko Creek	0.63	106
TLU5	Upper Peterson Creek	0.56	105
TLU6	Goose Lake Road	0.50	105
TLU7	Peterson Creek Discharge	1.36	111
TLU8	Edith Lake	0.47	104
TLU9	Jacko Lake Prayer Tree	11.96	124

NOTE:
[1] Zone 3 blasting

Table 5-12 lists the predicted ground vibration and air blast levels in increments of 100 m to 3000 m for the Zone 1 and Zone 3 blasts, starting at 100 m from the final pit boundary. Figures 5-5 and 5-6 present the Zone 1 blasting ground vibration level and air blast overpressure, respectively. Figures 5-7 and 5-8 present the Zone 3 blasting ground vibration level and air blast overpressure, respectively. Details on the blast plan design for each zone are presented in the Noise and Vibration Technical Data Report (Appendix D).

Table 5-12 Predicted Ground Vibration and Air blast Overpressure Results For Zone 1 and Zone 3 Blasts

Distance from Final Pit Boundary (m)	Zone 1		Zone 3	
	Ground Vibration Amplitude (mm/s)	Air Blast Overpressure (dBL)	Ground Vibration Amplitude (mm/s)	Air Blast Overpressure (dBL)
100	184.05	140	21.09	131
200	60.71	133	6.96	125
245 [1]	43.88	131	5.03	123
300	31.73	129	3.64	121
400	20.03	127	2.29	118
500	14.01	125	1.61	116
550 [2]	12.03	124	1.38	115
600	10.47	123	1.20	114
700	8.18	121	0.94	113
800	6.61	120	0.76	111
900	5.47	119	0.63	110
950 [3]	5.02	118	0.58	110
1000	4.62	118	0.53	109
1100	3.97	117	0.45	108
1200	3.45	116	0.40	108
1300	3.04	115	0.35	107
1400 [4]	2.70	115	0.31	106
1500	2.42	114	0.28	105
1600	2.18	113	0.25	105
1700	1.98	113	0.23	104
1800	1.81	112	0.21	104
1900	1.66	112	0.19	103
2000	1.53	111	0.17	103
2100	1.41	111	0.16	102

Table 5-12 Predicted Ground Vibration and Air blast Overpressure Results For Zone 1 and Zone 3 Blasts

Distance from Final Pit Boundary (m)	Zone 1		Zone 3	
	Ground Vibration Amplitude (mm/s)	Air Blast Overpressure (dBL)	Ground Vibration Amplitude (mm/s)	Air Blast Overpressure (dBL)
2200	1.31	110	0.15	102
2300	1.22	110	0.14	101
2400	1.14	110	0.13	101
2500	1.07	109	0.12	101
2600	1.00	109	0.11	100
2700	0.94	108	0.11	100
2800	0.89	108	0.10	100
2900	0.84	108	0.10	99
3000	0.80	107	0.09	99
4000	0.50	105	0.06	96

NOTE:

[1] Zone 1 blast - distance from Z1 area boundary meeting ground vibration annoyance threshold of 5 mm/s

[2] Zone 1 blast - distance from Z1 area boundary meeting air blast overpressure annoyance threshold of 115 dBL

[3] Zone 3 blast - distance from Z3 area boundary meeting ground vibration annoyance threshold of 5 mm/s

[4] Zone 3 blast - distance from Z3 area boundary meeting air blast overpressure annoyance threshold of 115 dBL

Figure 5-5
Ground Vibration Level for Zone 1 Blasting

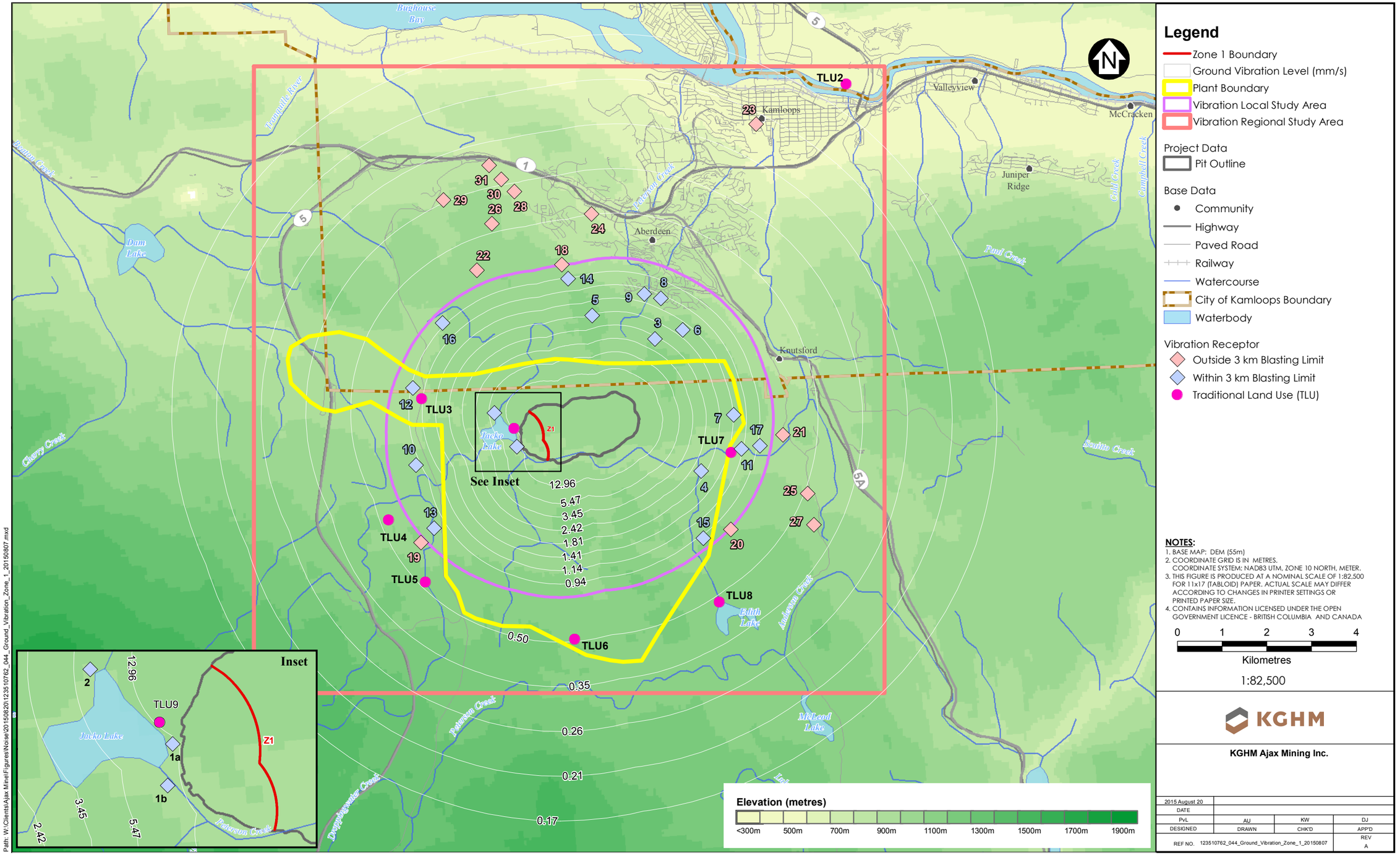
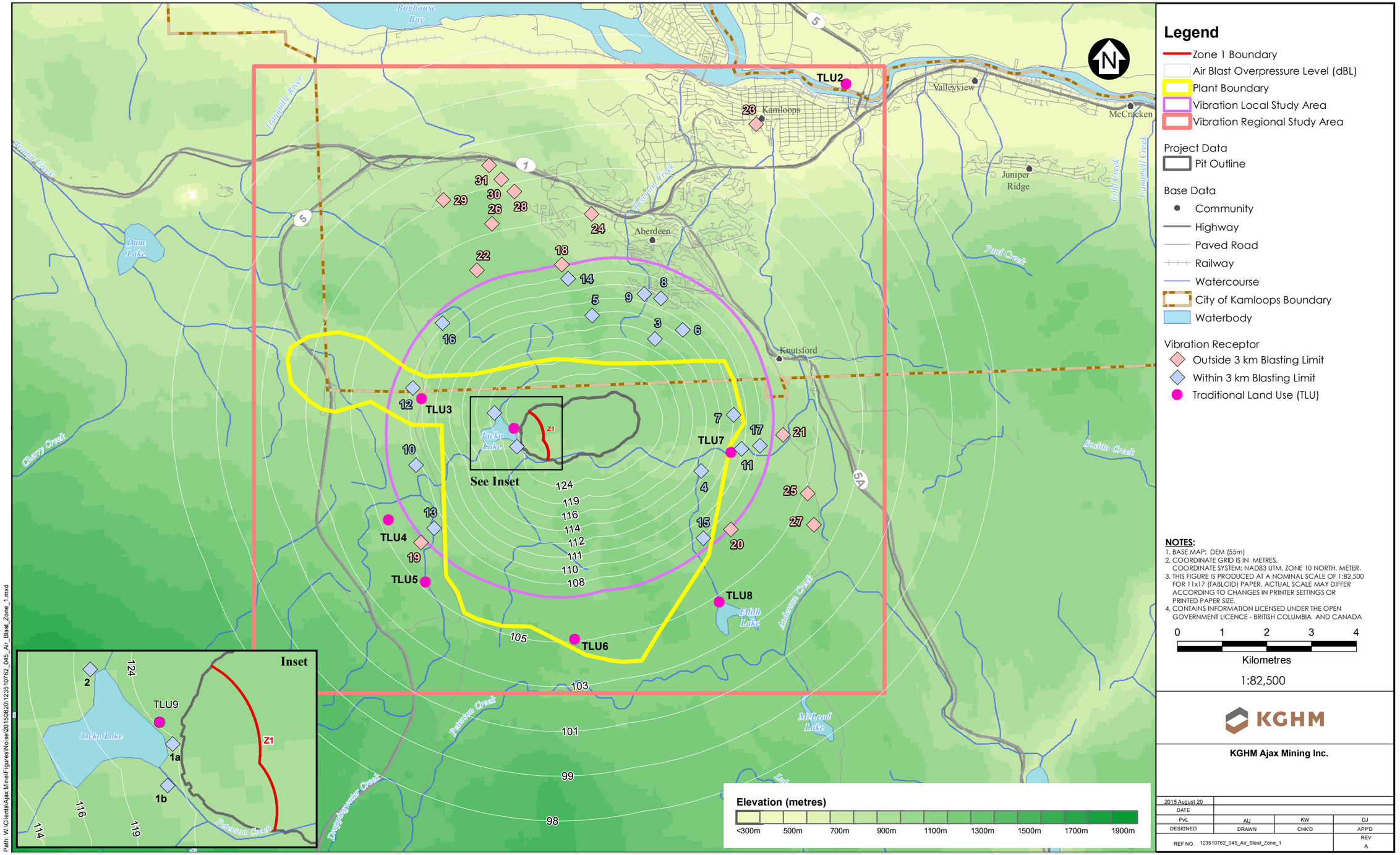


Figure 5-6
Air Blast Overpressure Level for Zone 1 Blasting



NOTES:
1. BASE MAP: DEM (55m)
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD83 UTM, ZONE 10 NORTH, METER.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:82,500 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
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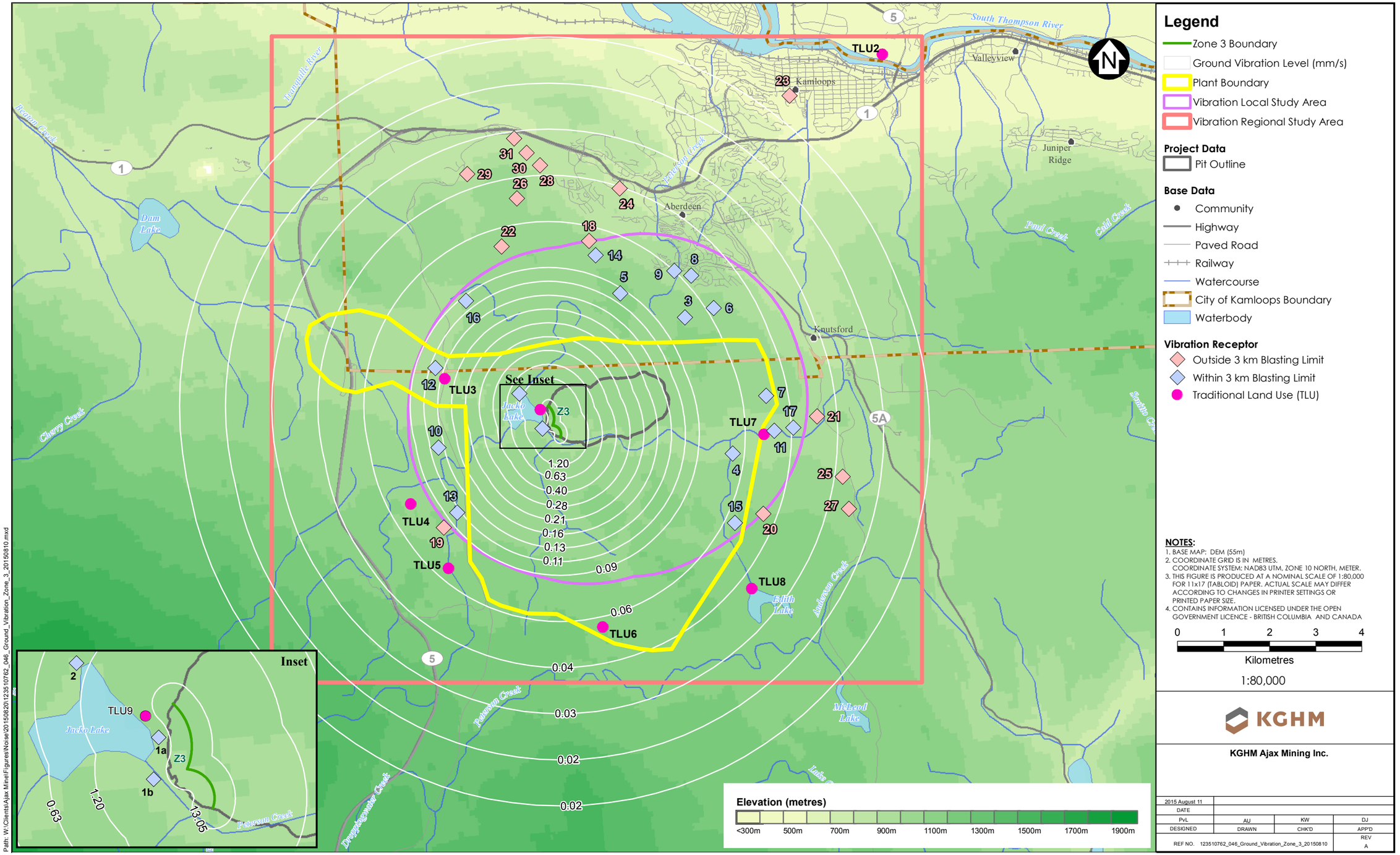
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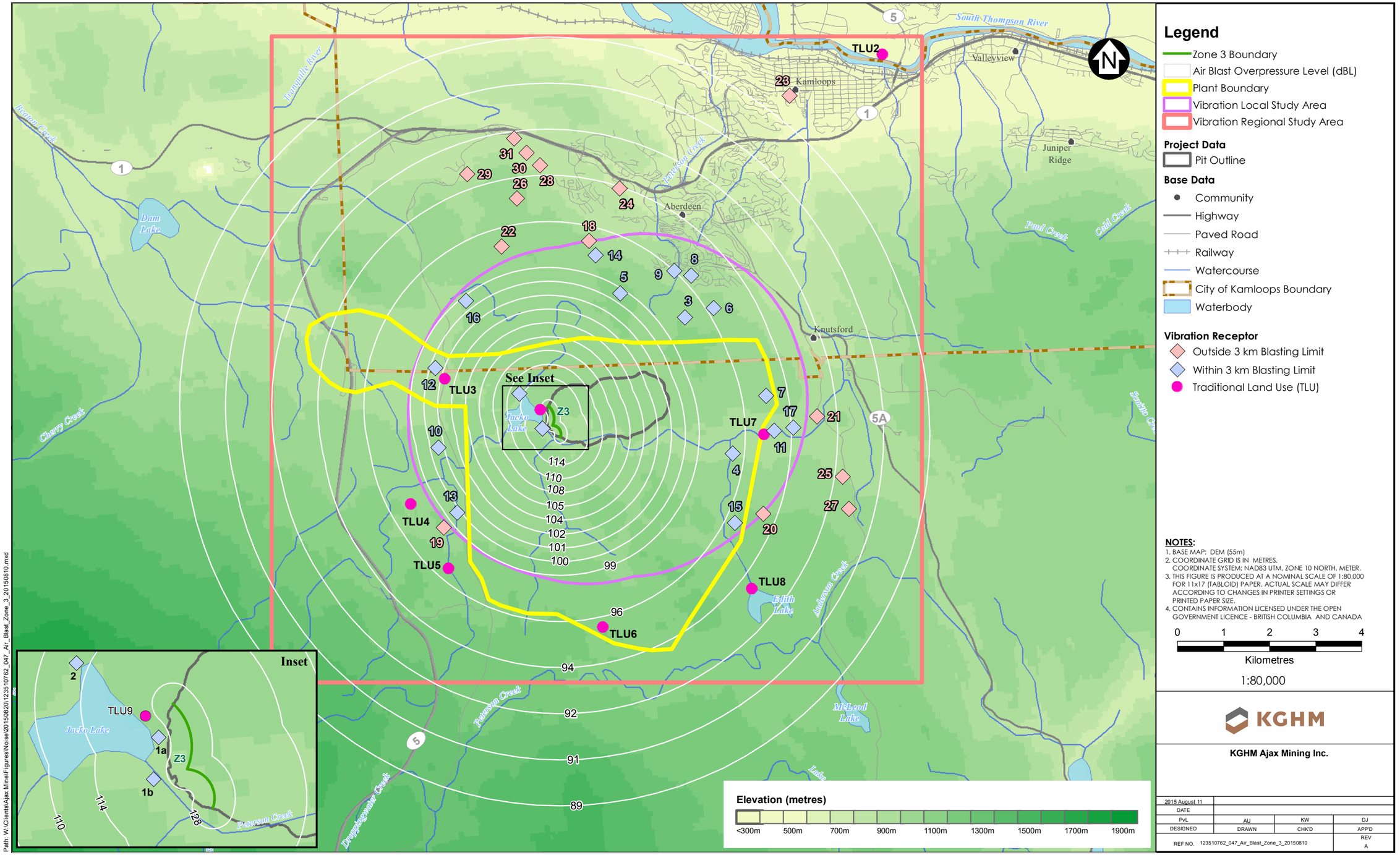
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Figure 5-7
Ground Vibration Level for Zone 3 Blasting



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5.2.2.1 Comparison to Human Annoyance Guideline

The predicted blast-related vibration results are compared to the human annoyance threshold of 5 mm/s for ground vibration and 115 dBL for air blast overpressure. The results in Table 5-12 indicate that at Jacko Lake Fish Habitat Area (ID# 1a and 1b) and Jacko Lake Prayer Tree (ID# TLU9) locations, the predicted levels exceed the annoyance thresholds. Results in Table 5-12 indicate that 1400 m and 550 m is the minimum buffer distance from the blasting zone area boundary for annoyance threshold compliance during Zone 1 and Zone 3 blast, respectively. Prediction results at all other receptors are below the annoyance thresholds.

5.2.2.2 Comparison to Ontario Ministry of Environment and Climate Change Vibration Threshold and United State Bureau of Mining

The predicted ground vibration level at the urban growth boundary is 2.09 mm/s. At the closest residential receptor, the predicted level is 1.70 mm/s. These levels (i.e. 1 to 2 mm/s) are an order of magnitude lower than 19 mm/s, the minimum vibration level required to cause cracks in drywall (USBM); it is highly unlikely that blasting can cause structural damage to any of the free standing structures in the surrounding communities. A 1 to 2 mm/s vibration level is equivalent to an adult walking briskly across an uncarpeted floor. The results indicate that blast-induced ground vibration effect is expected to be well below the MOECC NPC119 limit of 10 mm/s, Environment Canada limit of 12.5 mm/s, and USBM limit of 19 mm/s.

The predicted air blast levels for all homes, industrial structures and towers were all well below the USBM structural damage threshold (133 dBL) and MOECC cautionary limit (120 dBL). The predicted air blast level at the closest residential structure is 112 dBL. Thus, it is also highly unlikely that any air blast can cause any cosmetic or structural damage for this receptor and other similar receptors at further distance. Damage from air blast overpressure usually starts with cracked window glass panes. At 150 dBL, some single pane glass windows will begin to crack.

A legitimate concern, which often comes up with homeowners, is that of repeated blasting. Even when ground vibration levels are very low, could repeated blasting over the 20 – 23 year mine life cause fatigue and ultimately structural damage? Based on the USBM data, predicted ground vibration levels of under 2 mm/s, and an average of four blasts per week, fatigue in the residential homes would not set in for at least 622 years.

5.2.2.3 Compliance to Aquatic Life Projection Vibration Guideline

The DFO currently does not provide any quantitative vibration thresholds for aquatic life. In the past, the DFO referred to a guideline which prescribes quantitative vibration limits for aquatic life during blast activities. In absences of any quantitative vibration guideline for aquatic life from the DFO, the 1998 vibration guideline (Wright and Hopky 1998) is adapted as the best available guideline.

The aquatic life vibration guideline (Wright and Hopky 1998) stipulates the most restrictive threshold for vibration at 13 mm/s for protection of aquatic life in Jacko Lake. In order to comply with this threshold, the maximum weight of explosives per delay will be incrementally reduced from 1,020 kg in Zone 1 to 68 kg beyond Zone 3 through the use of explosive decks, smaller diameter 152 mm holes, or both. The vibration guideline for aquatic life at Jacko Lake dictates the blast design because the damage threshold for aquatic life is lower than the residential damage threshold of 19 mm/s and Jacko Lake is closer to the mine pit than other residential receptors. Ground vibration and air blast levels at Jacko Lake are expected to meet the aquatic life vibration guideline threshold.

6.0 SUMMARY AND CONCLUSIONS

The noise assessment focused on the Project noise effect on humans. A total of 37 noise receptors were identified, including residences, traditional land use area, First Nation communities, schools, daycares, hospitals, and potential city development areas. Noise effects from the Construction and Operation and phases were predicted to comply with the applicable noise guideline threshold value (i.e. BC OGC, Health Canada, and WHO) at all receptors. The only exception is a location near east end of Jacko Lake where short term (less than two months duration) daytime piling activities noise effects exceeded the Health Canada noise threshold. Public access to this area is restricted during piling activities.

The vibration effect assessment focused on the blast induced ground vibration and air blast overpressure effects on human habitats and structures. A total of 41 vibration receptors were identified, including residences, traditional land use area, First Nation communities, commercial structures, potential city development areas, Jacko Lake sensitive fish habitat area, and open recreation areas. Blast designs were developed to eliminate structural damage and reduce annoyance effects from blast induced ground vibrations and air blast overpressure. The results were compared to thresholds recommended in provincial, federal, and international vibration guidelines. The vibrations effects at all receptors are below the structural damage threshold and the annoyance threshold. The only exception is Jacko Lake, where the predicted levels exceed the annoyance thresholds when blasting occurs near the western portion of the pit. Public access to this area is restricted during Operational blasting. The predicted vibration effects at Jacko Lake meet the aquatic life protection vibration thresholds.

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8.0 CLOSURE

This report was prepared for the sole benefit of KGHM Ajax Mining Inc. and their representatives. The report may not be relied upon by any other person or entity without the express written consent of Stantec Consulting Ltd. and KGHM Ajax Mining Inc.

Any uses which a third party makes of this report, or any reliance on decisions made based on it, are the responsibilities of such third parties. Stantec Consulting Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Should additional information become available which differs significantly from our understanding of conditions presented in this report, we request that this information be brought to our attention so that we may reassess the conclusions provided herein.

The work was performed and the TDR was prepared by Lina Wang, Acoustic Specialist. The TDR was reviewed and edited by Jonathan Chui Project Technical Lead. We trust that the above information meets with your present requirements. Should you have any questions or require further information, please contact the undersigned.

Respectfully submitted,

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Appendix A NOISE BASELINE

AJAX MINING PROJECT
Noise Baseline Technical Data Report



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Executive Summary

KGHM Ajax Mining Inc. (KAM) proposes to develop the Ajax Project, an open pit copper-gold mine at the historic Afton Mining Camp, partially within the City of Kamloops, British Columbia.

The British Columbia Oil and Gas Commission (BC OGC) Noise Control Best Practices Guideline (2009) and Health Canada (HC) Useful Information for Environmental Assessment (2010) provides guidelines and guidance for the noise impact assessment as well as methods for determining baseline sound levels for areas close to the proposed project.

Baseline (ambient) sound levels that are present in the community and local study area are required to quantify the Project noise effect. The BC OGC Guideline (2009) stipulates that baseline sound levels should be calculated on the basis of dwelling density and proximity to transportation sources. Health Canada recognizes measured or estimated methods in establishing the baseline sound levels for the communities.

Variability in seasonal and meteorological conditions will affect the ambient sound level at a location. In most rural acoustic environments, the ambient sound level is characterized by natural sound sources including insects, animal, wind and rain interacting with natural surfaces. These sources are somewhat variable down to the minute because of changing natural forces. In developed areas with more human activities (i.e. suburban area, business and commercial districts), the acoustic environment may vary from one location to another due to the level of activities during different time periods.

Two multiday noise monitoring programs (December 2012 and June 2014) were conducted for a total of six monitoring locations. The selected locations represent different developed and undeveloped areas within or near the Project. Two locations are in a rural environment within the Project development area. Two locations are at the Aberdeen development boundary, representative of a rural to suburban area transition. Two locations are within the suburban residential community of Aberdeen.

Monitoring programs of this type and duration provide information on daily variability in noise levels as well as average daily sound levels. Longer periods (monthly or annually) or a permanent monitoring program may provide a large statistical sample; however, the week long program is considered sufficient for an evaluation of the existing acoustic environment in most locations. The methods used during the noise monitoring program were consistent with the requirements outlined in Section 4.5 of Alberta Energy Regulator (AER) Directive 038: Noise Control (AER 2007), upon which the BC OGC noise guideline is based.

The measured levels at the six noise monitoring locations provided a baseline evaluation of the acoustic environment in the area. Non-representative data (i.e. periods of high wind, rain, interference with microphone) have been removed from the analysis. The approach of isolating non-representative events is considered conservative as the removal of invalid data results in a lower baseline sound level. A lower baseline sound level will cause a greater change in the acoustic environment when the Project noise effect is assessed

The measured sound levels at the three locations (one in Aberdeen community and two near the development boundary) during the December 2012 monitoring program are generally below the estimated ambient sound levels outlined in the BC OGC noise guideline (see Table 3-1). The potential reason for the lower measured levels could be seasonal variability. Ambient sound levels determination in the BC OGC noise guideline is for summer conditions. During the winter months, decreases in community outdoor activities and natural sound (i.e. birds, insects, leaves rustling) may result in a lower ambient sound level.

The measured sound levels at the three other locations during the June 2014 monitoring program are more comparable with the ambient level suggested in the BC OGC noise guideline. The measured nighttime sound levels at two rural locations are within 1 dB of the BC OGC noise guideline estimated ambient sound level of 35 A-weighted decibels (dBA) sound level in a rural environment. The measured daytime and nighttime sound level at one residential location in the Aberdeen community is comparable to the BC OGC noise guideline estimated ambient sound level for a dwelling in a higher population area.

Health Canada's approach to noise assessment is to consider a variety of internationally recognized standards for acoustics such as the United States Environmental Protection Agency (US EPA 1974). The US EPA noise guideline provides an estimate of baseline sound levels based on a qualitative description of the area. The measured day-night sound levels at two rural locations and two locations within the community of Aberdeen are comparable to the baseline sound level suggested in the US EPA noise guideline.

In assessing the Project noise effect with the BC OGC noise guideline and Health Canada guidance, the measurement results will be incorporated in the environmental assessment to quantify the change in the acoustic environment.

Abbreviations

ASL	ambient sound level
ANSI	American National Standard Institute
BSL	basic sound level
BC	British Columbia
CSL	comprehensive sound level
dB	linear decibel sound level
dBA	A-weighted decibel sound level
dBC	C-weighted decibel sound level
OGC	Oil & Gas Commission
HC	Health Canada
ISO	International Standard Organization
GPS	global positioning system
L_{eq}	continuous equivalent sound level (energy equivalent sound level)
$L_{eq, 1hr}$	Hourly equivalent sound level
$L_{eq, 1min}$	One minute equivalent sound level
L_d	daytime equivalent sound level
L_{dn}	day-night average sound level
L_n	nighttime equivalent sound level
m	meter
MG	wind direction in degrees where North is 0˚ or 360 ˚, East is 90 ˚, South is 180 ˚, West is 270˚

LSA	local study area
RH	relative humidity in percentage (%)
RSA	regional study area
RWIS	road weather information system
TP	temperature in Celsius (C˚)
US EPA	United States Environmental Protection Agent
UTM	Universal Transverse Mercator
WS	Wind speed (km/hr)

1.0 OBJECTIVES

There are developed and undeveloped areas near the Project. Many environmental factors can affect the acoustic environment in both developed and undeveloped areas. These factors can vary to the minute because of changing natural forces and human activities. The existing acoustic environment is quantified by the baseline (ambient) sound level. The baseline sound levels that are present in the community and local study area are required to assess the Project noise effect. The objectives of the baseline sound monitoring study were to quantify the baseline sound level at selected locations within the Project study area through field measurements.

The baseline monitoring program included six locations that represent different developed and undeveloped areas. Two locations are in a rural environment. Two locations are located near the Aberdeen development boundary, representative of a rural to suburban area transition. Two locations are within the suburban residential community of Aberdeen.

The measurement results are compared to the baseline sound level estimation based on the BC OGC and US EPA noise guidelines. In addition, the results will be incorporated in the environment assessment to quantify the change in acoustic environment due to the Project noise effect.

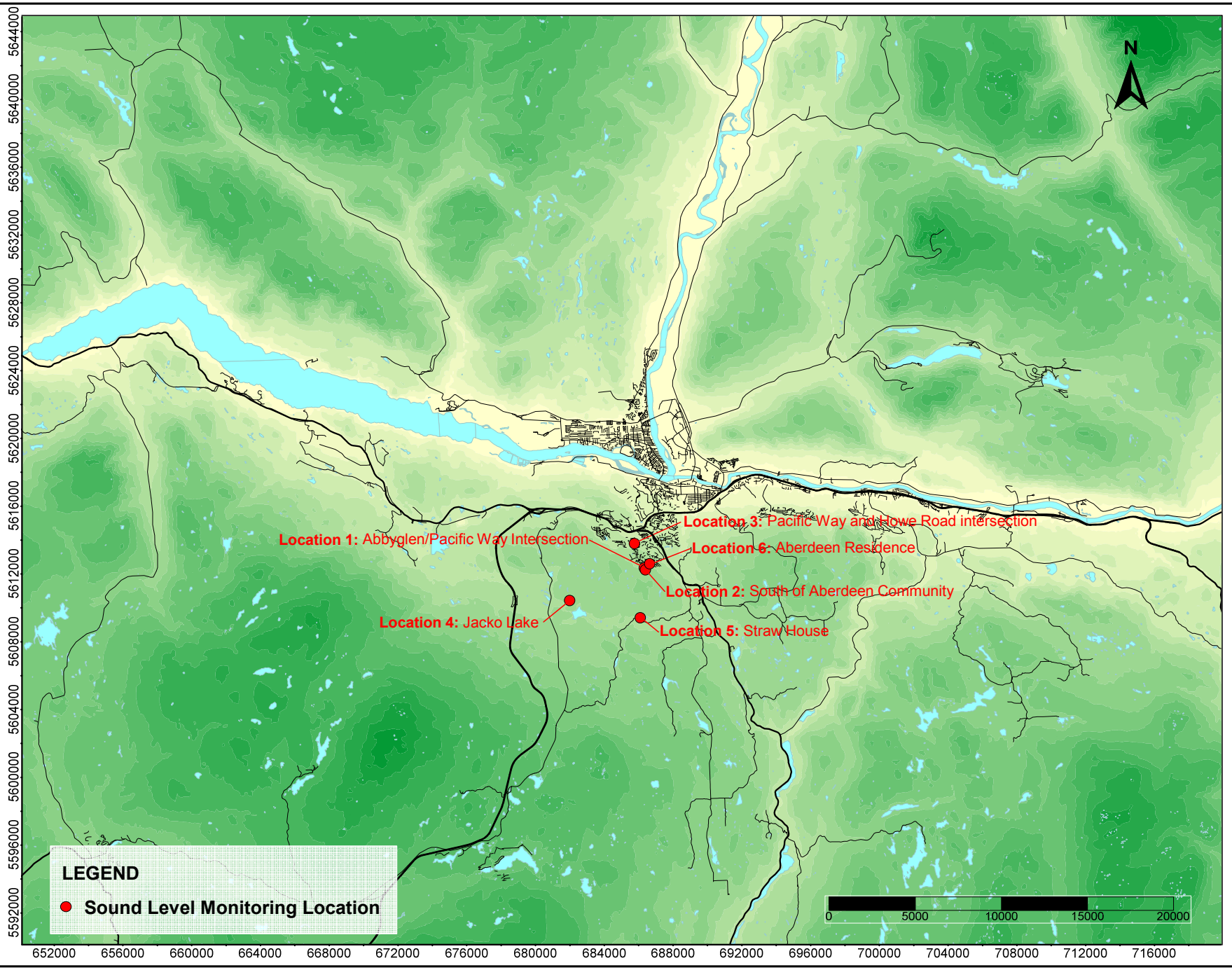
2.0 NOISE MONITORING LOCATIONS

Figure 2-1 shows the six noise monitoring locations chosen for the baseline analysis. Table 2-1 details the six measurement locations including the Universal Transverse Mercator (UTM) coordinates.

Table 2-1 Location coordinates and description

ID	Location	Description	Measurement period	Easting [a] (m)	Northing [a] (m)
1	Abbeyglen/Pacific way intersection	South end of the Aberdeen development, at the intersection of Pacific Way and Abbeyglen Way.	December 1 to 5, 2012	686,325	5,612,358
2	South of the Aberdeen community	South end of the Aberdeen development, at the end of Pacific Way. (south of location 1)	December 5 to 12, 2012	686,390	5,612,252
3	Pacific Way and Howe Road Intersection	Open field at the intersection of Pacific Way and Howe Rd, close to the City of Kamloops road weather information system (RWIS) meteorological station.	December 16 to 21, 2012	685,751	5,613,789
4	Jacko Lake	Location approximately 600 m north west of Jacko Lake, inside the project boundary, north of the main haul road.	June 10 to 15, 2014	681,985	5,610,442
5	Straw House	2560 Goose Lake Rd, Kamloops, BC (~3km NNE of Goose Lake) just outside the project boundary.	June 10 to 15, 2014	686,088	5,609,417
6	Aberdeen Residence	Residential area in the community of Aberdeen, south of Aberdeen Dr. and north of the project boundary	June 10 to 15, 2014	686,639	5,612,604

NOTE:
[a] UTM Zone 10U NAD 83



Stantec	KGHM AJAX MINING	DRAFT DATE August 21, 2015
FIGURE NO. 2-1	Sound Level Monitoring Locations	PREPARED FOR KGHM

3.0 METHODS AND APPROACH

The methods used during the noise monitoring programs were consistent with the requirements outlined in BC OGC Noise Control Best Practices Guideline (2009). Furthermore, where information was not specified, specifications were taken from the Alberta Energy Regulator (AER) Directive 038: Noise Control, which the BC OGC noise guideline is based on. Directive 038 requires that a noise survey be conducted with a minimum Type 2 integrating sound level meter under weather conditions acceptable for noise measurements. Rain precipitation and high wind speed exceeding 15 km/hr are not considered acceptable weather conditions.

Health Canada guidance does not recommend noise monitoring methods; however, the guidance recognizes measurement or estimated methods in establishing the baseline sound levels for the communities.

3.1 ENVIRONMENT NOISE DESCRIPTOR

Environmental noise is generally not steady but varies with time in a somewhat random manner. In order to assign a meaningful measure to such recorded (observed) noise, time-averaging and statistical analyses over a specific time period are performed. “Energy” averaging is by far the most common form of time-averaging for recorded noise. It results in a descriptor known as the continuous equivalent sound level (L_{eq}). L_{eq} represents a steady, continuous sound level that has the same acoustic energy as the original time-varying sound over the same time period. The daytime equivalent sound level (L_d) and nighttime equivalent sound level (L_n) represents the time period of 07:00 to 22:00 and 22:00 to 07:00, respectively. The one minute ($L_{eq,\ 1min}$) and hourly ($L_{eq,\ 1hr}$) equivalent sound level represents the time period of one minute and one hour, respectively.

Another environmental noise descriptor that is commonly used is the day-night average sound level (L_{dn}). L_{dn} is calculated using a time-weighted average of 15-hour A-weighted daytime L_{eq} and 9-hour A-weighted nighttime L_{eq} over a 24-hour period with 10 dB penalty added to the nighttime levels. L_{dn} is used by Health Canada (HC 2010) to assess the noise effects on human health.

Appendix A provides a description of acoustical concepts and definitions used in the assessment.

3.2 BASELINE SOUND LEVEL

The following sections provide information on estimating baseline sound level based on methods prescribed in BC OGC noise guideline and Health Canada referenced standard (US EPA 1974).

3.2.1 BC OGC

The BC OGC noise guideline recommends that baseline sound levels should be calculated on the basis of dwelling density and proximity to transportation sources. Section 2.2 in the BC OGC noise guideline defines the method to estimate ambient sound level. Table 3-1 presents the nighttime ambient sound levels for different area classification based on dwelling unit density and transportation categories. The daytime ambient sound level can be determined by adding an adjustment of 10 dBA above the nighttime basic sound level. In the BC OGC noise guideline, values presented in Table 3-1 are the recommended ambient sound levels to be used in the determination of cumulative sound level.

Table 3-1 Nighttime Ambient Sound Level

Proximity to Transportation	Dwelling unit density per quarter section of land		
	1 - 8 dwellings (dBA L_{eq})	9 - 160 dwellings (dBA L_{eq})	>160 dwellings (dBA L_{eq})
Category 1	35 (Locations 4 and 5)	38	41 (Locations 1, 2, and 6)
Category 2	40	43	46
Category 3	45	48	51 (Location 3)

NOTES:

Category 1—dwelling units more than 500 m from heavily travelled roads and/or rail lines and not subject to frequent aircraft flyovers.

Category 2—dwelling units more than 30 m but less than 500 m from heavily travelled roads and/or rail lines and not subject to frequent aircraft flyovers.

Category 3—dwelling units less than 30 m from heavily travelled roads and/or rail lines and/or subject to frequent aircraft flyovers.

Density per quarter section—refers to a quarter section with the affected dwelling at the centre (a 451 m radius). For quarter sections with various land uses or with mixed densities, the density chosen is then averaged for the area under consideration.

Monitoring locations 1, 2, and 6 are located in areas with higher population density (greater than 160 dwellings per quarter section of land) and a Category 1 proximity to transportation. As per Table 3-1, the estimated ambient sound level is 51 dBA and 41 dBA for the daytime and nighttime periods, respectively.

Monitoring location 3 is located in an area with similar population density as locations 1, 2, and 6. However, the proximity to transportation is considered as Category 3 since the location is less than 30 m from a heavily travelled road (Pacific Way). As per Table 3-1, the estimated ambient sound level is 61 dBA and 51 dBA for the daytime and nighttime periods, respectively.

Monitoring locations 4 and 5 are located in areas with low dwelling units density (between 1 to 8 dwellings per quarter section of land) and a Category 1 proximity to transportation. As per Table 3-1, the estimated ambient sound level is 45 dBA and 35 dBA for the daytime and nighttime periods, respectively.

3.2.2 Health Canada

Health Canada recognizes measured or estimated methods in establishing the baseline sound levels for the communities. Health Canada's approach to noise assessment is to consider a variety of internationally recognized standards for acoustics such as the United States Environmental Protection Agency (US EPA 1974). In Table B-3 of the US EPA noise guideline, baseline sound level can be estimated based on qualitative description of the area. Table 3-2 below presents an estimation of baseline sound level using qualitative descriptions and population densities of average types of communities. The values presented in Table 3-2 are expected noise levels for a certain community type, not the recommended baseline noise level to be used in an assessment.

In reference to Table 3-2 below, monitoring locations 1, 2 and 3 can be considered as part of a quiet suburban residential community. Monitoring location 6 can be considered as part of a normal suburban residential community. The US EPA noise guideline also provides an example of sound level for rural areas. The level is comparable to the L_{dn} value based on BC OGC noise guideline recommended L_d and L_n sound levels.

Table 3-2 US EPA Estimation of Baseline Noise Levels Using Qualitative Descriptions and Population Densities of Average Types of Communities

Type (Qualitative Description)	Average Census Population Density, Number of People Per Square km (Mile)	Estimated Baseline Sound Level, L_{dn} (dBA)[1]
Rural Environment	Not applicable	44
Quiet suburban residential community (remote from large cities, industrial activity and trucking)	249 (630)	48–52 (Location 1, 2, and 3)
Normal suburban residential community (not located near industrial activity)	791 (2000)	53–57 (Location 6)
Urban residential community (not immediately adjacent to heavily travelled roads and industrial areas)	2,493 (6300)	58–62
Noisy urban residential community (near relatively busy roads or industrial areas)	7,913 (20,000)	63–67
Very noisy urban residential community	24,925 (63,000)	68–72

NOTE:

[1] A range of values is provided and that selection of the appropriate estimated value would typically be based on the precautionary principle in the absence of adequate justification for a higher baseline. All L_{dn} values, except that of the quiet rural area community type, are based on the U.S. EPA Levels document (EPA 1974).

3.3 NOISE MONITORING EQUIPMENT

Type 1 integrating sound level meters meeting the American National Standards Institute (ANSI) S1.43-1997 standard were used for the sound monitoring studies. Type 1 sound level meters are certified with higher precision specification than Type 2 sound level meters, and therefore exceed the standard required by the guideline.

Two different manufacturers of sound level meter were used for the December 2012 field study and the June 2014 field study. In December 2012 field study, one “01dB Duo” (Duo) sound level meter was used. The logging rate was set at 1 second. In the June 2014 field study, two Brüel and Kjaer 2250 (B&K 2250) and one Brüel and Kjaer 2270 (B&K 2270) Type 1 sound level meters were used. The meters were set for one-minute logging intervals.

The following data was logged for all locations:

- A-weighted decibel (dBA) continuous equivalent sound levels
- C-weighted decibel (dBC) continuous equivalent sound levels
- linear weighted decibel (dB) full octave band data

Audio sound recordings were made during each 24-hour monitoring period in order to track and identify changes in measured noise levels in order to filter out unrepresentative events. The sound level meter setup photograph (locations 2, 4, 5, and 6) and monitoring locations (locations 1, 2, 3, and 6) within the Aberdeen community are presented in Appendix B.

3.4 CALIBRATION

Each sound level meter was laboratory calibrated within the last 24 months and the calibrator within the last 12 months. Larson Davis Type CAL 200 and B&K Type 4231 calibrators were used to calibrate the sound level meters immediately before and after each measurement series and after any change in equipment conditions (e.g. cable replacement). Discrepancy in calibration level did not exceed +/- 0.5 dB during the measurement period. Both calibrators conform to ANSI S1.40-2006 regulations.

3.5 WEATHER STATION

The BC OGC noise guideline does not prescribe representative weather condition for sound surveys. AER Directive 038 considers wind speeds higher than 15 km/hr and rain precipitation as non-representative weather conditions. Ambient temperatures must also be within the manufacturer's tolerances for instrument operation.

Weather data was collected at monitoring locations indicated below. Table 3-3 summarizes the weather station and weather meter used in collecting the weather information. The weather station or meter recorded wind speed, wind direction, temperature, and humidity data.

Table 3-3 Weather Station Location

Date of field study	Weather Station
December 2012	Pacific Way meteorological station and Environmental Canada Kamloops Airport meteorological station
June 2014	Kestrel 4500 pocket weather meter and Environmental Canada Kamloops Airport meteorological station

During both measurement periods (December 2012 and June 2014), daily meteorological conditions obtained from the Environment Canada Kamloops Airport meteorological station were used to provide general information on conditions in the City of Kamloops.

Weather information during the December 2012 survey was obtained from the Pacific Way meteorological station operated by the City of Kamloops that is situated close to monitoring Location 3. The data showed that the weather varied considerably during the survey with periods of high winds and precipitation (snow and rain) observed. Sound measurements during periods of precipitation (rain and snow) and high wind (audible wind inducted noise from audio recording) were isolated from the data.

Weather information during the June 2014 monitoring event was obtained from the Kestrel 4500 portable weather meter that was included in the monitoring site setup. Sound measurement during periods of high wind and precipitation was filtered out using wind speed data from the Kestrel 4500. Periods of precipitation were determined from qualitative weather information from the Environment Canada data and audible noise recordings during rainfall.

3.6 DATA ANALYSIS APPROACH

The data from the December 2012 field study was processed using "dBTRAIT32" computer software from "01dB Metravib". The data from the June 2014 field study was processed using the Brüel and Kjaer BZ5503 Measurement Partner Suite® software program.

Audio sound recordings were reviewed to identify noise sources for each monitoring period such as natural sounds (i.e. high wind, rain) and local activities. Data that were not representative of normal site activity or measured outside acceptable weather conditions were filtered from the data set prior to the calculation of any averages or other statistics. Hourly ($L_{eq,\ 1hr}$), daytime (L_d), and nighttime (L_n) values were then calculated for the measurement period. As per the BC OGC noise guideline, the daytime period is 7:00 to 22:00 and the nighttime period is from 22:00 to 7:00.

The BC OGC noise guideline does not prescribe a minimum number of hours for a measurement to be considered valid. The AER Directive 038 considers three hours per daytime and nighttime period to be minimum representative sample period. In addition, Directive 038 recommends that invalid or abnormal data not typical of an average ambient sound level should be extracted from the measurement. Invalid data includes periods with non-representative weather condition (rain precipitation and high wind), which are typically associated with higher sound level. Such conditions affect the receptor's perception of noise unless the event occurs with regularity. The approach of isolating non-representative events is considered conservative as the removal of invalid data (i.e. high wind, rain, crew activities) results in a lower baseline sound level. A lower baseline sound level will cause in a greater change in the acoustic environment when the Project noise effect is assessed.

4.0 RESULTS

The hourly, daytime, and nighttime L_{eq} noise levels were calculated for each long-term measurement location. In determining the hourly equivalent sound level ($L_{eq, 1hr}$), a minimum cumulative time period of 30 minutes is required. Graphs showing the sound level measurement time history at each location are presented in Figures 4-1a to 4-6b. The following sections present the measurement results in more details at each location.

4.1 MONITORING LOCATION 1

Noise measurements were collected from December 1 to 5, 2012 at the location south of the Aberdeen development, near the intersection of Pacific Way and Abbeyglen Way. Filtered hourly equivalent sound levels ($L_{eq, 1hr}$) are presented in Table 4-1. The grey shading in the table indicates the nighttime periods. There were a total of 23 and 12 valid measurement hours during the daytime and nighttime periods respectively.

The lowest and highest $L_{eq, 1hr}$ values during the daytime were 34.0 dBA and 49.1 dBA, respectively. During the nighttime period, the lowest and highest $L_{eq, 1hr}$ values were 25.3 dBA and 37.9 dBA, respectively.

The measured sound levels ($L_{eq, 1min}$) time history graph is presented in Figures 4-1a to 4-1e. Non-representative data (anomalous noise events) are shaded in red and defined as "Exclusions" in all figures. These data are isolated from the data analysis of the hourly, daytime, and nighttime equivalent results. Isolated noise events observed at this location were primarily noise due to wind with periods of precipitation. Other isolated events included animal activities and human conversation near the microphone.

The acoustic environment at this location is dominated with natural sound and local activities within the community.

Table 4-1 Monitoring Location 1 $L_{eq, 1hr}$ Sound Level (December 1 to 5, 2012)

Date	Start Hour	$L_{eq, 1hr}$ [dBA]	Valid Minutes (out of 60) [a]
December 1, 2012	2:00	25.3	60
December 1, 2012	3:00	29.8	55
December 1, 2012	4:00	31.2	54
December 1, 2012	8:00	39.2	32
December 1, 2012	14:00	48.0	32
December 1, 2012	15:00	46.0	56
December 1, 2012	16:00	43.9	50
December 1, 2012	17:00	42.0	60
December 1, 2012	18:00	42.4	60
December 1, 2012	19:00	46.8	39
December 1, 2012	20:00	46.1	56
December 1, 2012	21:00	49.1	34
December 2, 2012	0:00	36.8	58
December 2, 2012	21:00	39.1	35
December 3, 2012	5:00	34.6	49
December 3, 2012	18:00	38.1	44
December 3, 2012	19:00	39.1	42
December 3, 2012	20:00	35.8	53
December 3, 2012	21:00	36.0	47
December 3, 2012	22:00	34.8	55
December 3, 2012	23:00	37.2	42
December 4, 2012	0:00	37.9	41
December 4, 2012	1:00	30.6	46
December 4, 2012	3:00	33.9	37
December 4, 2012	16:00	43.3	33
December 5, 2012	7:00	35.2	58
December 5, 2012	8:00	40.5	55
December 5, 2012	9:00	40.5	60
December 5, 2012	10:00	41.3	51
December 5, 2012	11:00	34.0	53
December 5, 2012	12:00	43.9	51
December 5, 2012	13:00	41.7	38

NOTE:

[a] $L_{eq, 1hr}$ with less than 30 minutes of filtered data is not included in this table. However, the filtered data was included in the calculation of overall L_d and L_n. Nighttime period is indicated with grey shading (22:00 – 7:00)

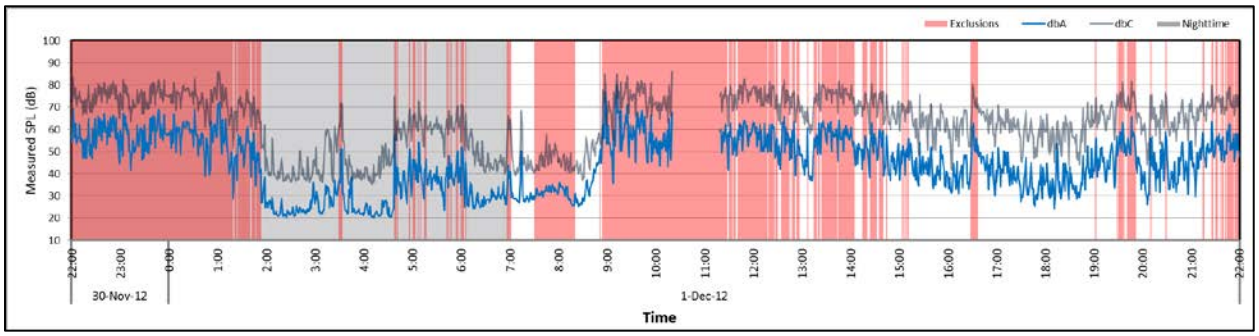


Figure 4-1a Location 1 Measurements - L_{eq} (December 1, 2012)

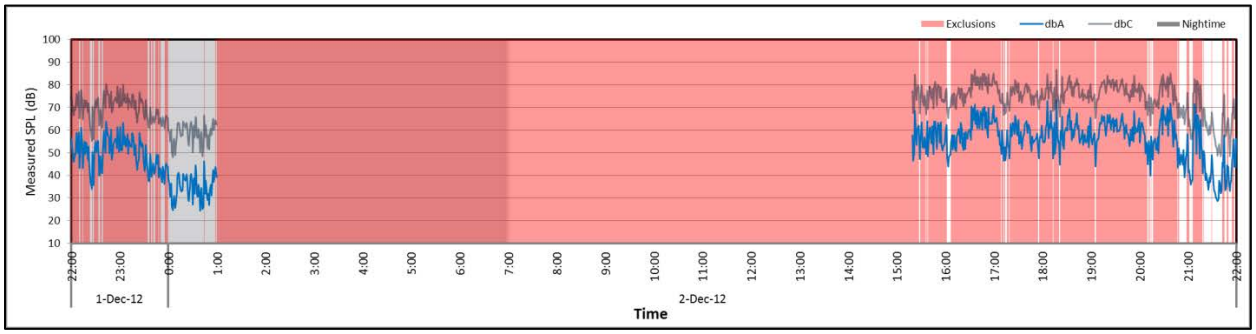


Figure 4-1b Location 1 Measurements - L_{eq} (December 2, 2012)

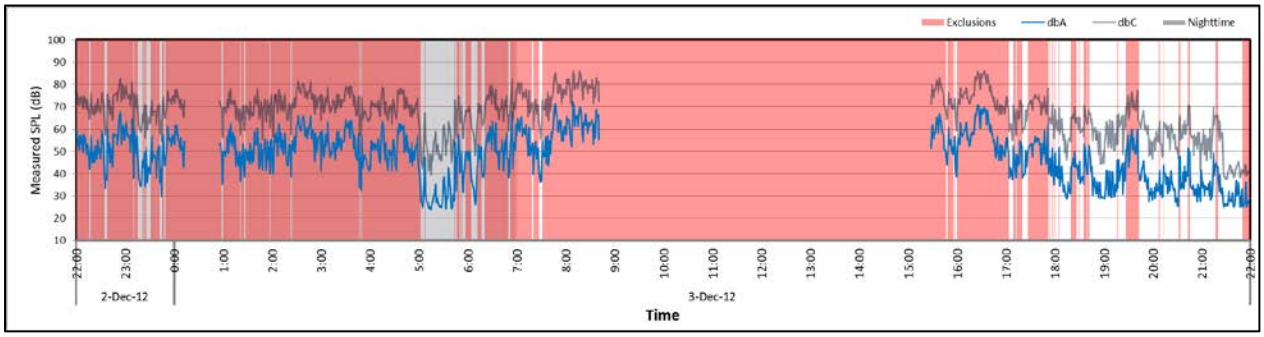


Figure 4-1c Location 1 Measurements - L_{eq} (December 3, 2012)

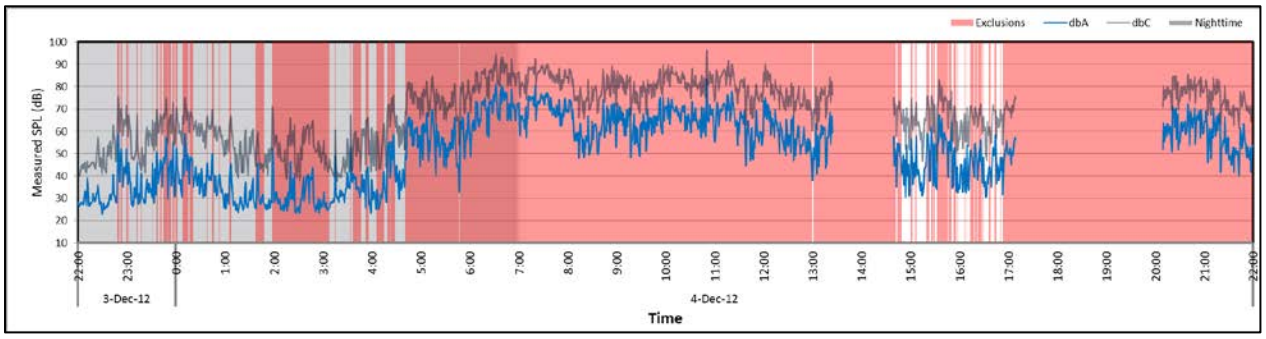


Figure 4-1d Location 1 Measurements - L_{eq} (December 4, 2012)

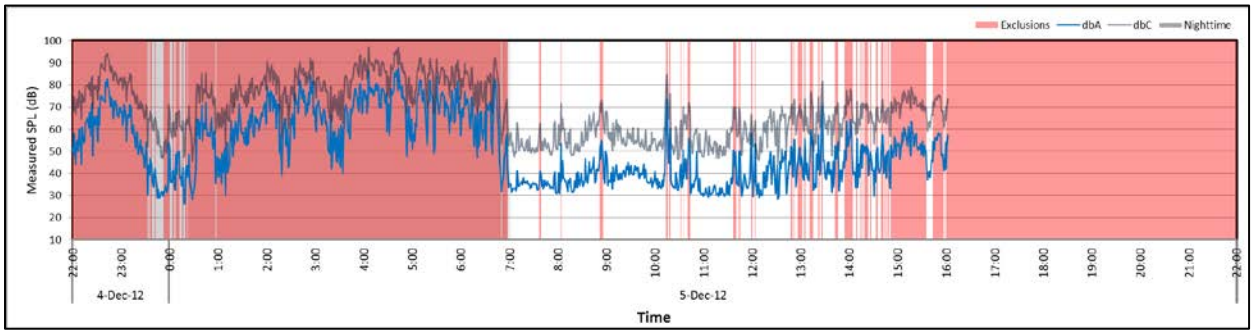


Figure 4-1e Location 1 Measurements - L_{eq} (December 5, 2012)

4.2 MONITORING LOCATION 2

Noise measurements were collected from December 5 to 12, 2012 at location near the end of Pacific Way, south of Location 1. Filtered $L_{eq, 1hr}$ values are presented in Table 4-2. There were a total of 67 and 29 valid measurement hours during the daytime and nighttime periods respectively.

The lowest and highest $L_{eq, 1hr}$ values during the daytime were 24.7 dBA and 44.3 dBA, respectively. During the nighttime period, the lowest and highest $L_{eq, 1hr}$ values were 24.9 dBA and 38.6 dBA, respectively.

The measured $L_{eq, 1min}$ time history graph is presented in Figures 4-2a to 4-2h. Non-representative data (anomalous noise events) are shaded in red. These data are isolated from the data analysis of the hourly, daytime, and nighttime equivalent sound level results. Isolated noise events observed at this location were primarily noise due to wind with periods of precipitation. Other isolated events included vehicle noise in close proximity to the microphone.

Similar to Location 1, the acoustic environment at this location is dominated with natural sound and local activities within the community.

Table 4-2 Monitoring Location 2 $L_{eq, 1hr}$ Sound Level (December 5 to 12, 2012)

Date	Start Hour	$L_{eq, 1hr}$ [dBA]	Valid Minutes (out of 60) [a]
December 5, 2012	17:00	40.5	33
December 5, 2012	18:00	41.3	34
December 5, 2012	23:00	36.7	35
December 6, 2012	0:00	32.6	43
December 6, 2012	7:00	35.2	38
December 6, 2012	8:00	41.3	51
December 6, 2012	9:00	35.8	60
December 6, 2012	10:00	39.1	36
December 6, 2012	14:00	32.9	50
December 6, 2012	15:00	34.0	60
December 6, 2012	17:00	38.0	53
December 6, 2012	18:00	41.4	60
December 6, 2012	19:00	41.8	60
December 6, 2012	20:00	36.4	60

Table 4-2 Monitoring Location 2 $L_{eq, 1hr}$ Sound Level (December 5 to 12, 2012)

Date	Start Hour	$L_{eq, 1hr}$ [dBA]	Valid Minutes (out of 60) [a]
December 6, 2012	21:00	32.8	60
December 6, 2012	22:00	37.1	60
December 6, 2012	23:00	33.2	56
December 7, 2012	0:00	32.5	60
December 7, 2012	1:00	31.2	59
December 7, 2012	2:00	30.9	41
December 7, 2012	3:00	30.2	52
December 7, 2012	6:00	31.7	58
December 7, 2012	7:00	32.7	57
December 7, 2012	8:00	36.8	60
December 7, 2012	9:00	36.4	60
December 7, 2012	10:00	33.6	55
December 7, 2012	11:00	42.6	57
December 7, 2012	12:00	39.3	40
December 7, 2012	13:00	39.0	60
December 7, 2012	14:00	44.3	36
December 8, 2012	3:00	34.7	43
December 8, 2012	4:00	34.5	50
December 8, 2012	7:00	37.1	37
December 8, 2012	8:00	38.8	38
December 8, 2012	9:00	40.9	57
December 8, 2012	10:00	40.6	27
December 8, 2012	11:00	42.2	55
December 8, 2012	12:00	41.3	35
December 8, 2012	14:00	41.1	60
December 8, 2012	15:00	36.2	60
December 8, 2012	16:00	37.6	59
December 8, 2012	17:00	37.8	60
December 8, 2012	18:00	39.4	60
December 8, 2012	19:00	37.4	60
December 8, 2012	20:00	36.7	60

Table 4-2 Monitoring Location 2 $L_{eq, 1hr}$ Sound Level (December 5 to 12, 2012)

Date	Start Hour	$L_{eq, 1hr}$ [dBA]	Valid Minutes (out of 60) [a]
December 8, 2012	21:00	34.3	60
December 8, 2012	22:00	29.9	60
December 8, 2012	23:00	27.1	58
December 9, 2012	0:00	25.0	60
December 9, 2012	1:00	24.9	56
December 9, 2012	2:00	31.5	46
December 9, 2012	3:00	31.5	55
December 9, 2012	6:00	34.9	35
December 9, 2012	12:00	38.8	32
December 9, 2012	14:00	33.1	60
December 9, 2012	15:00	33.3	60
December 9, 2012	16:00	35.2	57
December 9, 2012	17:00	36.4	60
December 9, 2012	18:00	35.7	60
December 9, 2012	19:00	34.0	60
December 9, 2012	20:00	32.1	60
December 9, 2012	21:00	34.1	60
December 9, 2012	22:00	36.9	57
December 9, 2012	23:00	38.6	34
December 10, 2012	0:00	38.3	39
December 10, 2012	2:00	35.7	40
December 10, 2012	3:00	36.5	45
December 10, 2012	4:00	33.7	59
December 10, 2012	10:00	37.5	33
December 10, 2012	11:00	35.7	50
December 10, 2012	12:00	39.4	50
December 10, 2012	13:00	39.1	60
December 10, 2012	16:00	37.8	58
December 10, 2012	17:00	36.6	60
December 10, 2012	18:00	39.9	60
December 10, 2012	19:00	39.5	58

Table 4-2 Monitoring Location 2 $L_{eq, 1hr}$ Sound Level (December 5 to 12, 2012)

Date	Start Hour	$L_{eq, 1hr}$ [dBA]	Valid Minutes (out of 60) [a]
December 10, 2012	20:00	38.6	58
December 10, 2012	21:00	37.8	32
December 11, 2012	5:00	31.3	42
December 11, 2012	8:00	41.9	35
December 11, 2012	9:00	39.2	39
December 11, 2012	11:00	33.4	41
December 11, 2012	12:00	36.3	30
December 11, 2012	13:00	32.3	58
December 11, 2012	14:00	34.5	60
December 11, 2012	15:00	32.5	60
December 11, 2012	16:00	34.3	60
December 11, 2012	17:00	33.8	60
December 11, 2012	18:00	28.3	60
December 11, 2012	19:00	30.1	60
December 11, 2012	20:00	26.0	60
December 11, 2012	21:00	24.7	60
December 11, 2012	23:00	25.6	37
December 12, 2012	2:00	29.8	40
December 12, 2012	3:00	31.3	41
December 12, 2012	4:00	30.0	40

NOTE:

[a] $L_{eq, 1hr}$ with less than 30 minutes of filtered data is not included in this table. However, the filtered data was included in the calculation of L_d and L_n. Nighttime period is indicated with grey shading (22:00 – 7:00)

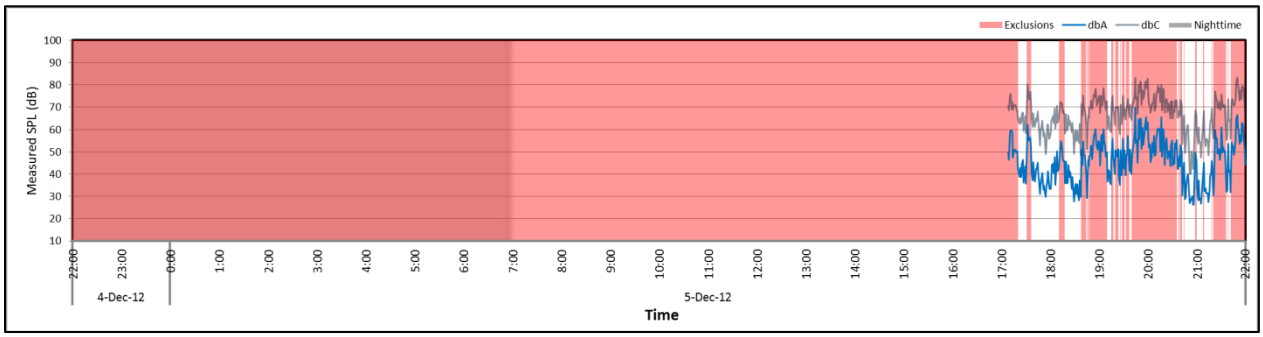


Figure 4-2a Location 2 Measurements - L_{eq} (December 5, 2012)

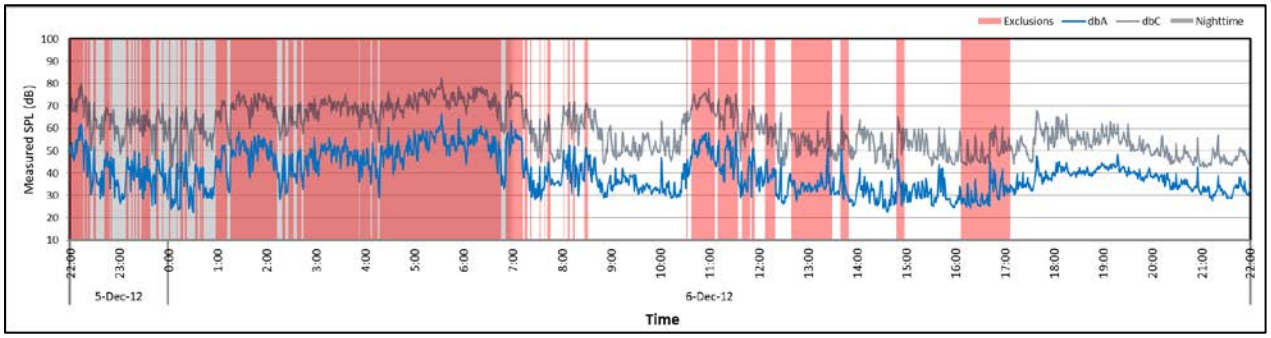


Figure 4-2b Location 2 Measurements - L_{eq} (December 6, 2012)

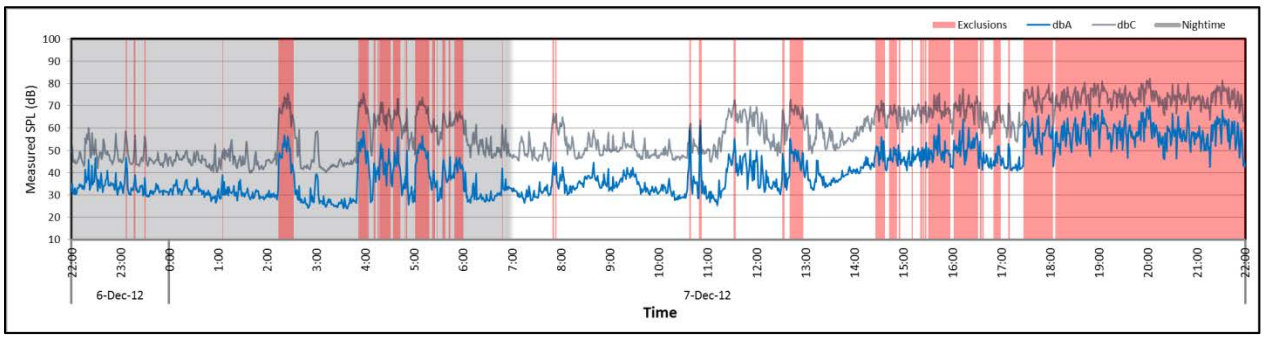


Figure 4-2c Location 2 Measurements - L_{eq} (December 7, 2012)

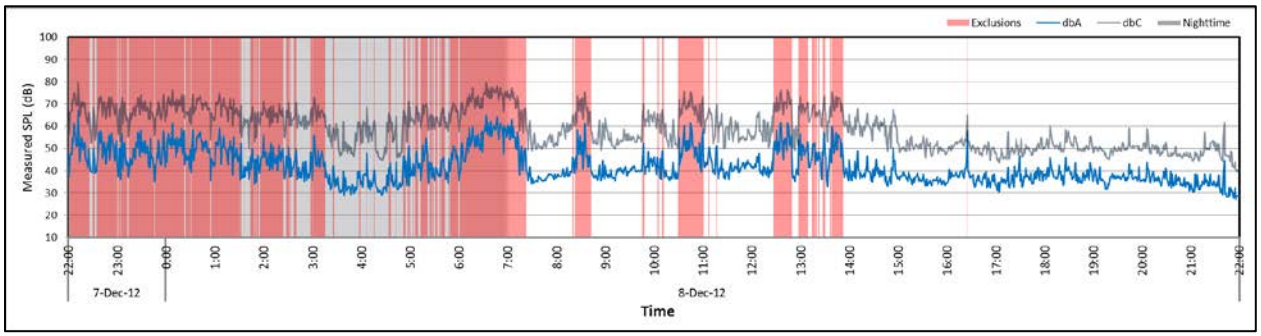


Figure 4-2d Location 2 Measurements - L_{eq} (December 8, 2012)

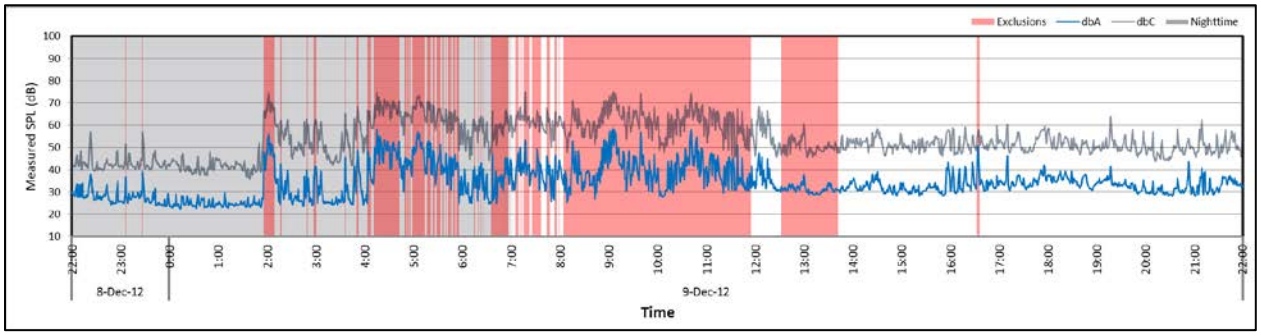


Figure 4-2e Location 2 Measurements - L_{eq} (December 9, 2012)

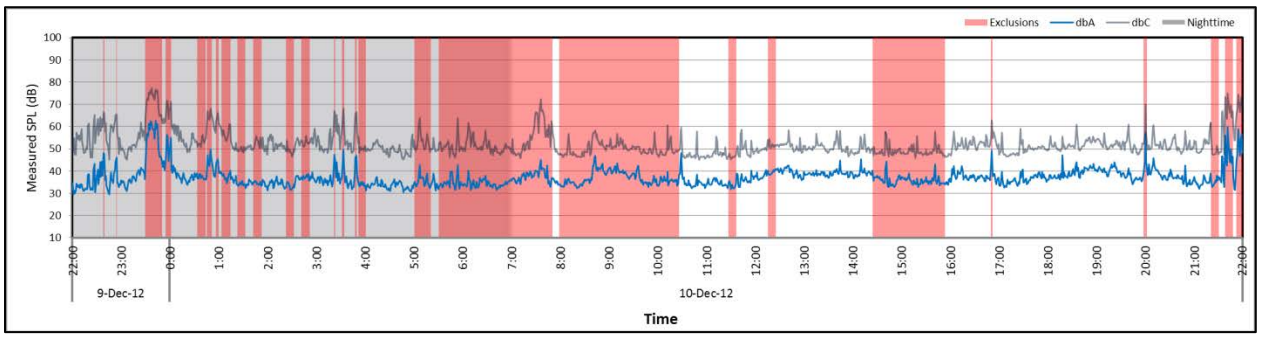


Figure 4-2f Location 2 Measurements - L_{eq} (December 10, 2012)

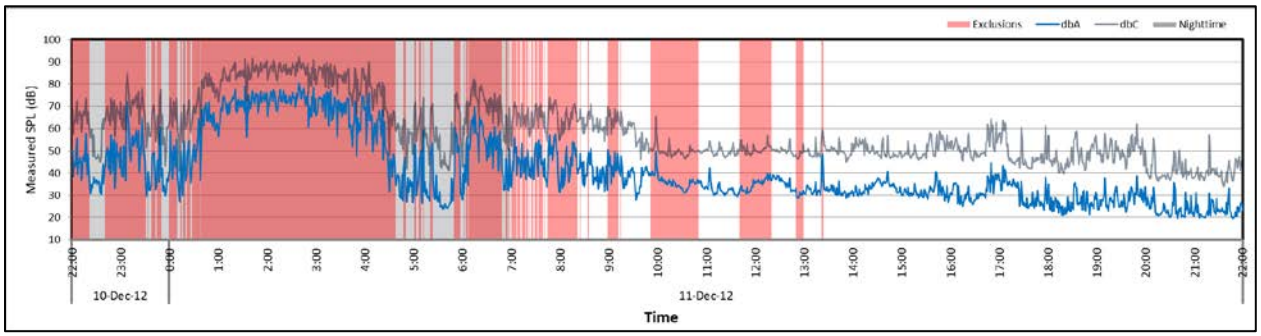


Figure 4-2g Location 2 Measurements - L_{eq} (December 11, 2012)

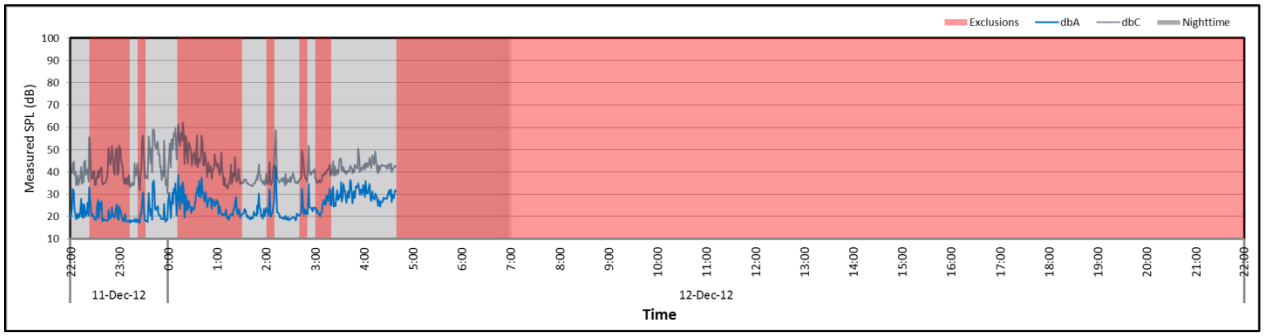


Figure 4-2h Location 2 Measurements - L_{eq} (December 12, 2012)

4.3 MONITORING LOCATION 3

Noise measurements were collected from December 16 to 21, 2012 at a location near the intersection of Pacific Way and Howe Rd, close to the City of Kamloops road weather information system (RWIS) meteorological station. The monitoring location was setup in the open field at the south east corner of the intersection. Filtered $L_{eq, 1hr}$ values are presented in Table 4-3. There were a total of 42 and 21 valid measurement hours during the daytime and nighttime periods respectively.

The lowest and highest $L_{eq, 1hr}$ values during the daytime were 43.2 dBA and 54.4 dBA, respectively. During the nighttime period, the lowest and highest $L_{eq, 1hr}$ values were 36.0 dBA and 46.9 dBA, respectively.

The measured $L_{eq, 1min}$ time history graph is presented in Figures 4-3e to 4-3f. Non-representative data (anomalous noise events) are shaded in red. These data are isolated from the data analysis of the hourly, daytime, and nighttime equivalent sound level results. Isolated noise events observed at this location were primarily noise due to wind with periods of precipitation. Other isolated events included emergency vehicle, human conversation, animal noise, and vehicle engine noise in close proximity to the microphone.

The acoustic environment at this location is dominated with natural sound, local activities within the community, and traffic along Pacific Way.

Table 4-3 Monitoring Location 3 $L_{eq, 1hr}$ Sound Level (December 16 to 21, 2012)

Date	Start Hour	$L_{eq, 1hr}$ [dBA]	Valid Minutes (out of 60) [a]
December 16, 2012	19:00	48.7	53
December 17, 2012	22:00	41.8	51
December 17, 2012	23:00	42.5	59
December 18, 2012	0:00	40.5	60
December 18, 2012	1:00	39.8	60
December 18, 2012	2:00	46.1	60
December 18, 2012	3:00	41.8	60
December 18, 2012	4:00	46.9	60
December 18, 2012	5:00	43.0	60
December 18, 2012	6:00	44.9	60
December 18, 2012	7:00	47.4	60
December 18, 2012	8:00	47.7	60
December 18, 2012	9:00	52.7	60
December 18, 2012	10:00	49.0	60

Table 4-3 Monitoring Location 3 $L_{eq, 1hr}$ Sound Level (December 16 to 21, 2012)

Date	Start Hour	$L_{eq, 1hr}$ [dBA]	Valid Minutes (out of 60) [a]
December 18, 2012	11:00	48.6	60
December 18, 2012	12:00	47.1	60
December 18, 2012	13:00	48.7	60
December 18, 2012	14:00	47.2	60
December 18, 2012	15:00	45.5	60
December 18, 2012	16:00	48.0	60
December 18, 2012	17:00	47.3	60
December 18, 2012	18:00	48.5	60
December 18, 2012	19:00	47.6	60
December 18, 2012	20:00	46.8	60
December 18, 2012	21:00	46.4	60
December 18, 2012	22:00	45.5	60
December 18, 2012	23:00	44.3	60
December 19, 2012	0:00	41.4	60
December 19, 2012	1:00	38.7	60
December 19, 2012	2:00	36.3	60
December 19, 2012	3:00	36.7	60
December 19, 2012	4:00	36.0	59
December 19, 2012	5:00	39.8	60
December 19, 2012	6:00	42.9	57
December 19, 2012	7:00	43.2	60
December 19, 2012	8:00	47.5	60
December 19, 2012	9:00	47.6	60
December 19, 2012	10:00	47.2	60
December 19, 2012	13:00	51.5	59
December 19, 2012	14:00	52.8	40
December 19, 2012	16:00	52.7	56
December 19, 2012	18:00	48.6	36
December 19, 2012	19:00	49.5	47
December 19, 2012	20:00	46.0	42
December 19, 2012	21:00	45.5	53

Table 4-3 Monitoring Location 3 $L_{eq, 1hr}$ Sound Level (December 16 to 21, 2012)

Date	Start Hour	$L_{eq, 1hr}$ [dBA]	Valid Minutes (out of 60) [a]
December 19, 2012	22:00	45.3	60
December 20, 2012	0:00	40.7	46
December 20, 2012	9:00	53.6	39
December 20, 2012	11:00	54.4	35
December 20, 2012	14:00	48.5	36
December 20, 2012	15:00	51.6	39
December 20, 2012	16:00	51.2	60
December 20, 2012	17:00	51.0	51
December 20, 2012	18:00	51.1	54
December 20, 2012	19:00	50.0	30
December 20, 2012	20:00	50.0	42
December 20, 2012	21:00	47.5	37
December 21, 2012	3:00	40.1	36
December 21, 2012	7:00	47.1	47
December 21, 2012	8:00	51.0	60
December 21, 2012	9:00	54.4	58
December 21, 2012	10:00	50.0	60
December 21, 2012	11:00	49.2	50

NOTE:

[a] $L_{eq, 1hr}$ with less than 30 minutes of filtered data is not included in this table. However, the filtered data was included in the calculation of L_d and L_n. Nighttime period is indicated with grey shading (22:00 – 7:00)

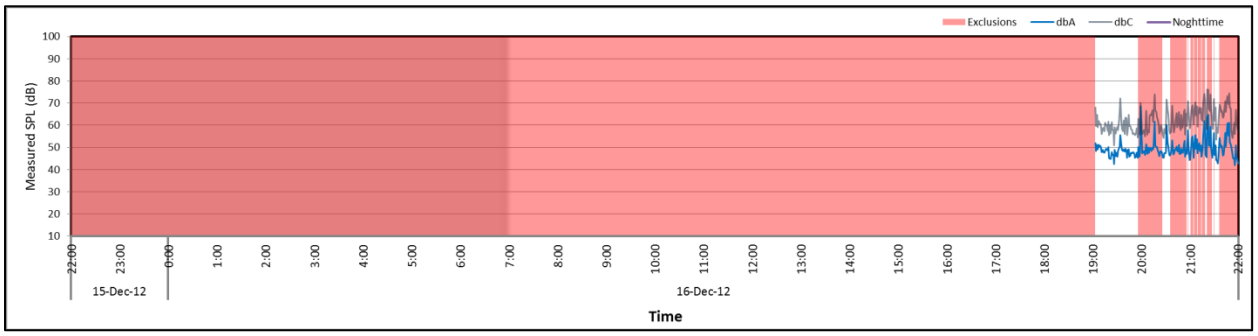


Figure 4-3a Location 3 Measurements - L_{eq} (December 16, 2012)

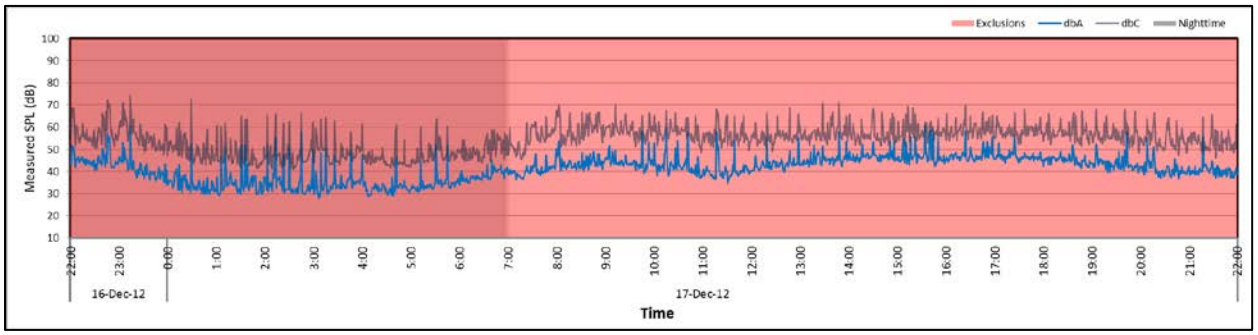


Figure 4-3b Location 3 Measurements - L_{eq} (December 17, 2012)

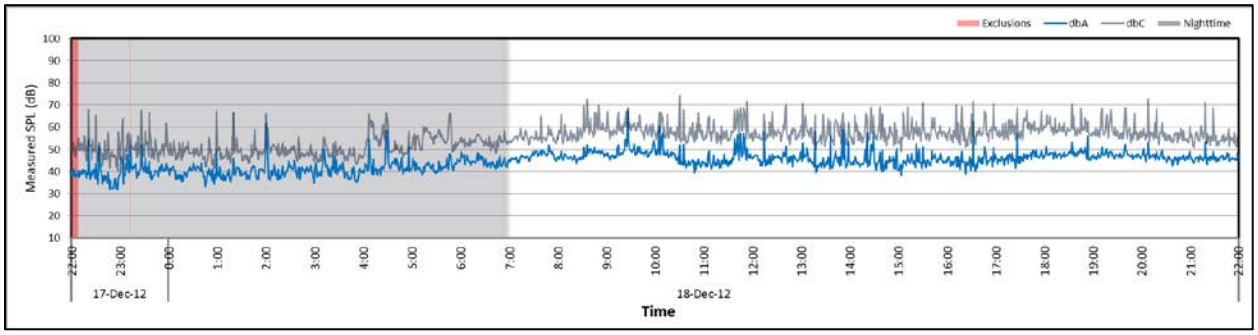


Figure 4-3c Location 3 Measurements - L_{eq} (December 18, 2012)

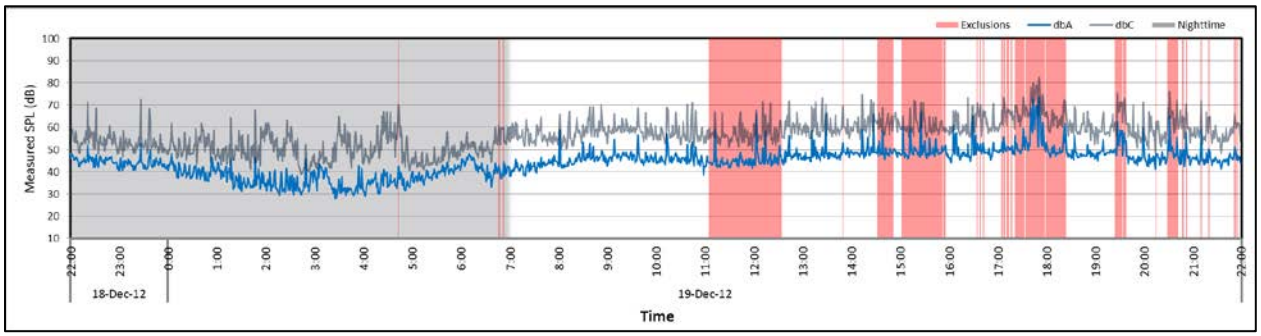


Figure 4-3d Location 3 Measurements - L_{eq} (December 19, 2012)

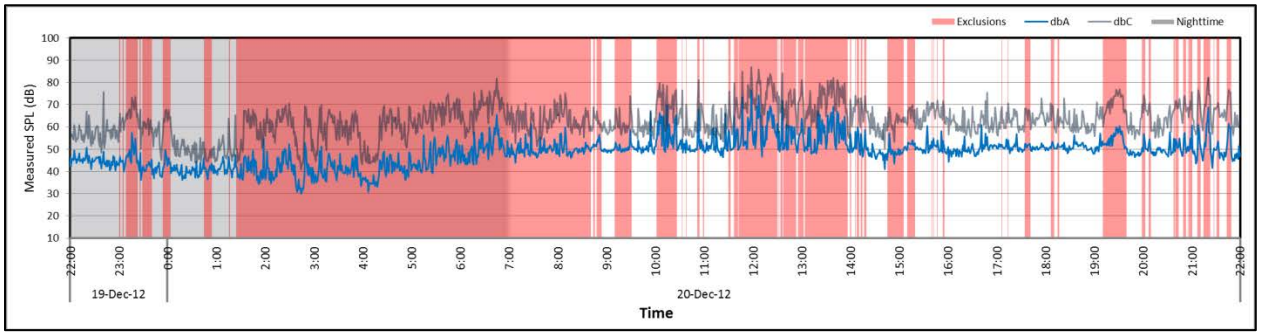


Figure 4-3e Location 3 Measurements - L_{eq} (December 20, 2012)

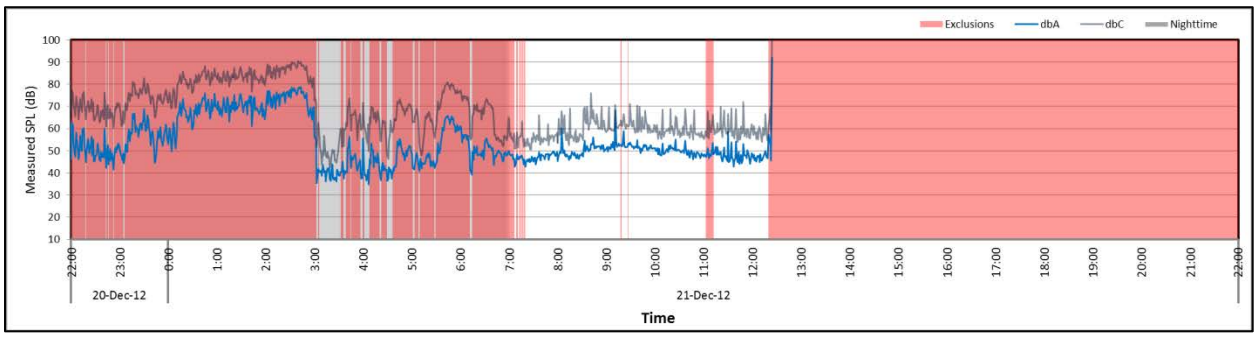


Figure 4-3f Location 3 Measurements - L_{eq} (December 21, 2012)

4.4 MONITORING LOCATION 4

Noise measurements were collected from June 10 to 15, 2014 at the location north of Jacko Lake. The $L_{eq, 1hr}$ values are presented in Table 4-4. There were a total of 60 and 44 valid measurement hours during the daytime and nighttime periods, respectively.

During the daytime period, the lowest and highest $L_{eq, 1hr}$ values were 31.7 dBA and 47.3 dBA, respectively. During the nighttime period, the lowest and highest $L_{eq, 1hr}$ values were 22.4 dBA and 42.7 dBA, respectively.

The measured sound levels ($L_{eq, 1min}$) time history is presented in Figure 4-4a and Figure 4-4b. Non-representative data (anomalous noise events) are shaded in red. These data are isolated from the data analysis of the hourly, daytime, and nighttime equivalent sound level results. Isolated noise events observed at this location were predominantly wildlife (i.e. birds) at close range to the microphone, vehicle traffic along the access road, and field crew activities.

Apart from the isolated events, the acoustic environment at the Jacko Lake location is characterized by wildlife noise, occasional aircraft flyovers, and local activity (boat engines, human conversation) on the lake.

Table 4-4 Monitoring Location 4 Hourly $L_{eq, 1hr}$ Sound Level (June 10 to 15, 2014)

Date	Start Hour	$L_{eq, 1hr}$ [dBA]	Valid Minutes (out of 60) [a]
June 10, 2014	15:00	37.9	48
June 10, 2014	16:00	35.9	60
June 10, 2014	17:00	37.7	52
June 10, 2014	18:00	34.3	53
June 10, 2014	19:00	38.0	57
June 10, 2014	20:00	32.3	56
June 10, 2014	21:00	35.7	44
June 10, 2014	22:00	30.3	58
June 10, 2014	23:00	38.4	55
June 11, 2014	0:00	30.3	58
June 11, 2014	1:00	31.6	50
June 11, 2014	2:00	26.6	60
June 11, 2014	3:00	38.2	58
June 11, 2014	4:00	42.3	39
June 11, 2014	5:00	41.7	45
June 11, 2014	6:00	38.3	52

Table 4-4 Monitoring Location 4 Hourly $L_{eq, 1hr}$ Sound Level (June 10 to 15, 2014)

Date	Start Hour	$L_{eq, 1hr}$ [dBA]	Valid Minutes (out of 60) [a]
June 11, 2014	7:00	36.8	56
June 11, 2014	8:00	38.3	58
June 11, 2014	10:00	37.6	45
June 11, 2014	11:00	39.7	58
June 11, 2014	12:00	36.2	55
June 11, 2014	13:00	38.0	49
June 11, 2014	14:00	33.4	44
June 11, 2014	15:00	34.6	55
June 11, 2014	16:00	36.2	60
June 11, 2014	17:00	31.7	58
June 11, 2014	18:00	36.1	60
June 11, 2014	19:00	35.5	57
June 11, 2014	20:00	32.0	58
June 11, 2014	21:00	35.9	60
June 11, 2014	22:00	29.2	53
June 11, 2014	23:00	31.3	59
June 12, 2014	0:00	25.9	58
June 12, 2014	1:00	28.0	58
June 12, 2014	2:00	30.1	59
June 12, 2014	3:00	35.0	55
June 12, 2014	4:00	41.2	53
June 12, 2014	5:00	41.5	50
June 12, 2014	6:00	41.6	55
June 12, 2014	7:00	39.4	52
June 12, 2014	8:00	39.9	54
June 12, 2014	9:00	36.6	56
June 12, 2014	10:00	32.3	46
June 12, 2014	11:00	35.3	59
June 12, 2014	13:00	39.8	53
June 12, 2014	14:00	38.2	52
June 12, 2014	15:00	36.8	58
June 12, 2014	16:00	40.0	50
June 12, 2014	17:00	42.4	36

Table 4-4 Monitoring Location 4 Hourly $L_{eq, 1hr}$ Sound Level (June 10 to 15, 2014)

Date	Start Hour	$L_{eq, 1hr}$ [dBA]	Valid Minutes (out of 60) [a]
June 12, 2014	18:00	36.3	56
June 12, 2014	19:00	37.7	52
June 12, 2014	20:00	37.5	55
June 12, 2014	21:00	38.6	51
June 12, 2014	22:00	30.1	58
June 12, 2014	23:00	25.9	60
June 13, 2014	0:00	27.4	58
June 13, 2014	1:00	30.6	50
June 13, 2014	2:00	28.9	59
June 13, 2014	3:00	33.7	60
June 13, 2014	4:00	36.9	58
June 13, 2014	5:00	42.7	40
June 13, 2014	6:00	41.0	53
June 13, 2014	7:00	44.2	42
June 13, 2014	10:00	46.1	40
June 13, 2014	11:00	46.1	33
June 13, 2014	12:00	47.3	34
June 13, 2014	13:00	42.5	34
June 13, 2014	14:00	38.9	38
June 13, 2014	20:00	35.5	58
June 13, 2014	21:00	38.1	54
June 13, 2014	22:00	30.2	59
June 13, 2014	23:00	28.9	56
June 14, 2014	0:00	27.1	54
June 14, 2014	1:00	30.9	58
June 14, 2014	2:00	27.6	60
June 14, 2014	3:00	33.0	54
June 14, 2014	4:00	38.0	32
June 14, 2014	5:00	36.2	56
June 14, 2014	6:00	34.8	49
June 14, 2014	7:00	36.6	42
June 14, 2014	8:00	33.7	42
June 14, 2014	9:00	33.7	54

Table 4-4 Monitoring Location 4 Hourly $L_{eq, 1hr}$ Sound Level (June 10 to 15, 2014)

Date	Start Hour	$L_{eq, 1hr}$ [dBA]	Valid Minutes (out of 60) [a]
June 14, 2014	10:00	32.7	36
June 14, 2014	11:00	40.4	52
June 14, 2014	12:00	35.3	33
June 14, 2014	13:00	36.1	52
June 14, 2014	14:00	37.8	36
June 14, 2014	16:00	36.0	40
June 14, 2014	17:00	38.2	43
June 14, 2014	18:00	38.1	58
June 14, 2014	19:00	35.5	42
June 14, 2014	20:00	33.9	56
June 14, 2014	21:00	32.5	52
June 14, 2014	22:00	26.3	59
June 14, 2014	23:00	24.2	58
June 15, 2014	0:00	22.8	58
June 15, 2014	1:00	22.7	60
June 15, 2014	2:00	22.4	58
June 15, 2014	3:00	29.0	60
June 15, 2014	4:00	36.5	52
June 15, 2014	6:00	34.3	31
June 15, 2014	9:00	35.2	34
June 15, 2014	10:00	33.8	58
June 15, 2014	11:00	32.7	54

NOTE:

[a] $L_{eq, 1hr}$ with less than 30 minutes of filtered data is not included in this table. However, the filtered data was included in the calculation of overall L_d and L_n. Nighttime period is indicated with grey shading (22:00 – 7:00)

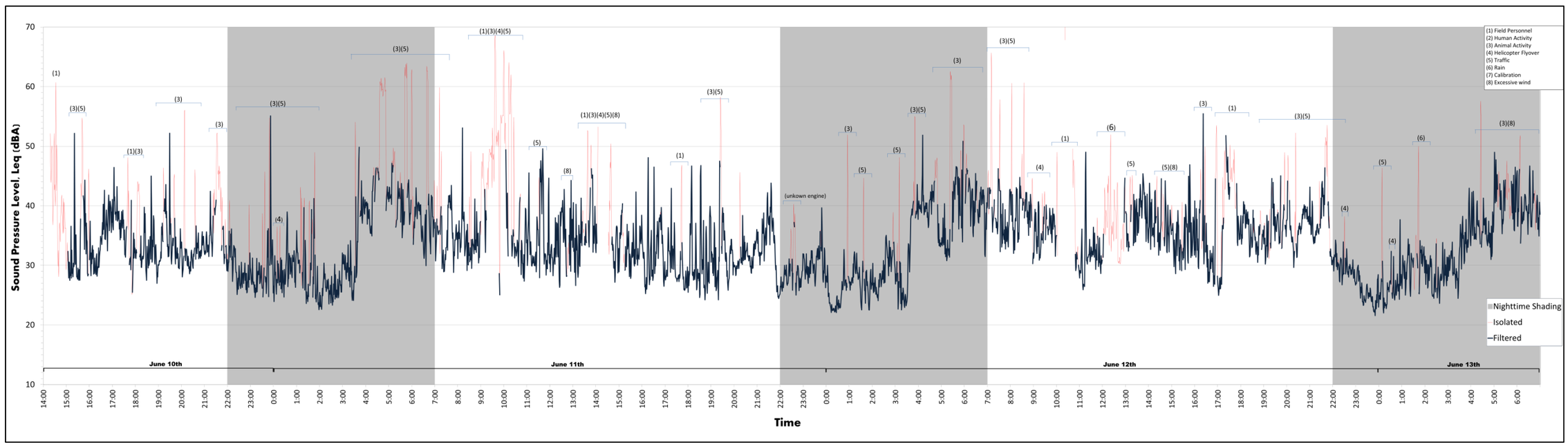


Figure 4-4a Location 4 Measurements - L_{eq} (June 10 to 13, 2014)

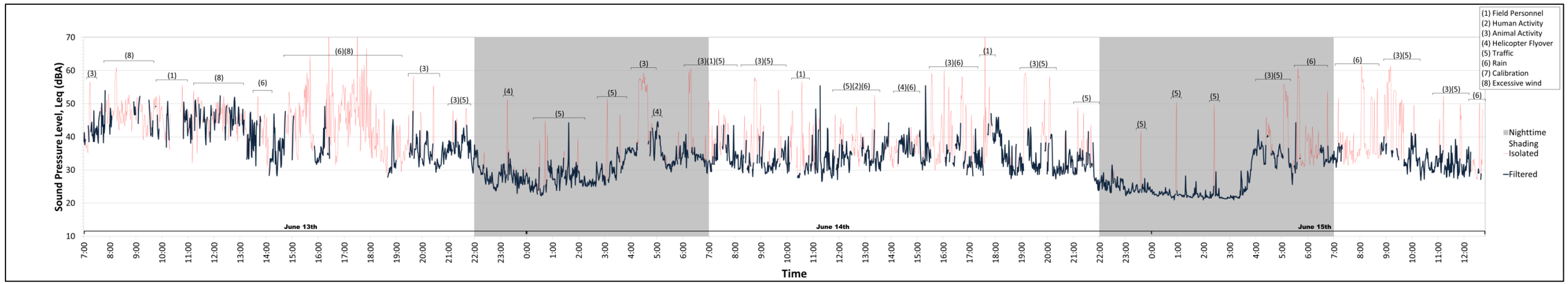


Figure 4-4b Location 4 Measurements - L_{eq} (June 13 to 15, 2014)

4.5 MONITORING LOCATION 5

Noise measurements were collected from June 10 to 15, 2014 at the Straw House location. Filtered $L_{eq, 1hr}$ values are presented in Table 4-5. There were a total of 52 and 40 valid measurement hours during the daytime and nighttime period, respectively.

The shaded cells represent the nighttime period. During the daytime period, the lowest and highest $L_{eq, 1hr}$ values were 27.1 dBA and 45.5 dBA, respectively. During the nighttime period, the lowest and highest $L_{eq, 1hr}$ values were 24.1 dBA and 43.4 dBA, respectively.

The measured sound levels ($L_{eq, 1min}$) time history is presented in Figure 4-5a and Figure 4-5b. Non-representative data (anomalous noise events) are shaded in red. These data are isolated from the data analysis of the hourly, daytime, and nighttime equivalent sound level results. Isolated noise events observed at this location were predominantly wildlife (i.e. birds) at close range to the microphone, Stantec field technicians, and weather related events (i.e. rain, high wind).

Apart from the isolated events, the acoustic environment at the Straw House location is predominantly characterized by wildlife noise, occasional aircraft flyovers, and vehicle traffic.

Table 4-5 Monitoring Location 5 $L_{eq, 1hr}$ Sound Level (June 10 to 15, 2014)

Date	Start Hour	$L_{eq,1hr}$ [dBA]	Valid Minutes (out of 60) [a]
June 10, 2014	16:00	35.8	55
June 10, 2014	17:00	40.0	45
June 10, 2014	18:00	39.9	43
June 10, 2014	19:00	41.7	48
June 10, 2014	20:00	37.9	57
June 10, 2014	21:00	36.0	44
June 10, 2014	22:00	29.4	58
June 10, 2014	23:00	28.9	60
June 11, 2014	0:00	26.7	60
June 11, 2014	1:00	27.2	59
June 11, 2014	2:00	29.9	60
June 11, 2014	3:00	31.4	56
June 11, 2014	6:00	38.7	49
June 11, 2014	7:00	37.2	44
June 11, 2014	8:00	34.0	41

Table 4-5 Monitoring Location 5 $L_{eq, 1hr}$ Sound Level (June 10 to 15, 2014)

Date	Start Hour	$L_{eq,1hr}$ [dBA]	Valid Minutes (out of 60) [a]
June 11, 2014	9:00	34.5	31
June 11, 2014	10:00	35.9	48
June 11, 2014	12:00	35.4	37
June 11, 2014	13:00	32.4	54
June 11, 2014	14:00	39.7	39
June 11, 2014	16:00	36.0	47
June 11, 2014	17:00	35.6	47
June 11, 2014	18:00	37.8	52
June 11, 2014	19:00	27.1	55
June 11, 2014	20:00	33.5	46
June 11, 2014	21:00	32.7	44
June 11, 2014	22:00	25.0	59
June 11, 2014	23:00	25.4	60
June 12, 2014	0:00	28.0	60
June 12, 2014	1:00	25.2	60
June 12, 2014	2:00	24.1	59
June 12, 2014	3:00	37.8	59
June 12, 2014	4:00	38.2	49
June 12, 2014	5:00	36.5	45
June 12, 2014	6:00	32.7	51
June 12, 2014	7:00	40.9	51
June 12, 2014	8:00	35.6	53
June 12, 2014	9:00	30.9	43
June 12, 2014	10:00	32.3	48
June 12, 2014	13:00	43.8	35
June 12, 2014	14:00	39.3	55
June 12, 2014	15:00	35.2	39
June 12, 2014	17:00	44.2	33
June 12, 2014	18:00	40.7	60
June 12, 2014	19:00	37.6	47
June 12, 2014	20:00	38.2	51

Table 4-5 Monitoring Location 5 $L_{eq,\ 1hr}$ Sound Level (June 10 to 15, 2014)

Date	Start Hour	$L_{eq,1hr}$ [dBA]	Valid Minutes (out of 60) [a]
June 12, 2014	21:00	38.0	37
June 12, 2014	22:00	26.8	60
June 12, 2014	23:00	28.4	60
June 13, 2014	0:00	25.2	58
June 13, 2014	1:00	29.1	57
June 13, 2014	2:00	26.4	59
June 13, 2014	3:00	33.9	58
June 13, 2014	4:00	41.2	36
June 13, 2014	5:00	43.4	40
June 13, 2014	7:00	44.1	50
June 13, 2014	10:00	41.0	50
June 13, 2014	12:00	45.5	33
June 13, 2014	13:00	43.3	26
June 13, 2014	19:00	44.1	55
June 13, 2014	20:00	42.7	46
June 13, 2014	21:00	33.8	31
June 13, 2014	22:00	28.8	59
June 13, 2014	23:00	28.3	59
June 14, 2014	0:00	27.0	59
June 14, 2014	1:00	26.5	60
June 14, 2014	2:00	26.8	60
June 14, 2014	3:00	34.4	53
June 14, 2014	4:00	33.6	45
June 14, 2014	5:00	35.9	49
June 14, 2014	6:00	33.4	39
June 14, 2014	7:00	34.8	47
June 14, 2014	8:00	33.3	45
June 14, 2014	9:00	35.9	50
June 14, 2014	10:00	36.7	46
June 14, 2014	11:00	39.8	53
June 14, 2014	12:00	40.9	40

Table 4-5 Monitoring Location 5 $L_{eq,\ 1hr}$ Sound Level (June 10 to 15, 2014)

Date	Start Hour	$L_{eq,1hr}$ [dBA]	Valid Minutes (out of 60) [a]
June 14, 2014	13:00	39.4	49
June 14, 2014	14:00	43.2	45
June 14, 2014	16:00	37.5	44
June 14, 2014	17:00	40.3	49
June 14, 2014	18:00	39.2	46
June 14, 2014	19:00	32.6	54
June 14, 2014	22:00	30.4	60
June 14, 2014	23:00	29.7	60
June 15, 2014	0:00	27.7	60
June 15, 2014	1:00	27.0	60
June 15, 2014	2:00	31.6	60
June 15, 2014	3:00	32.8	58
June 15, 2014	4:00	41.0	44
June 15, 2014	10:00	35.3	41
June 15, 2014	11:00	36.7	46

NOTE:

[a] $L_{eq,\ 1hr}$ with less than 30 minutes of filtered data is not included in this table. However, the filtered data was included in the calculation of L_d and L_n. Nighttime period is indicated with grey shading (22:00 – 7:00)

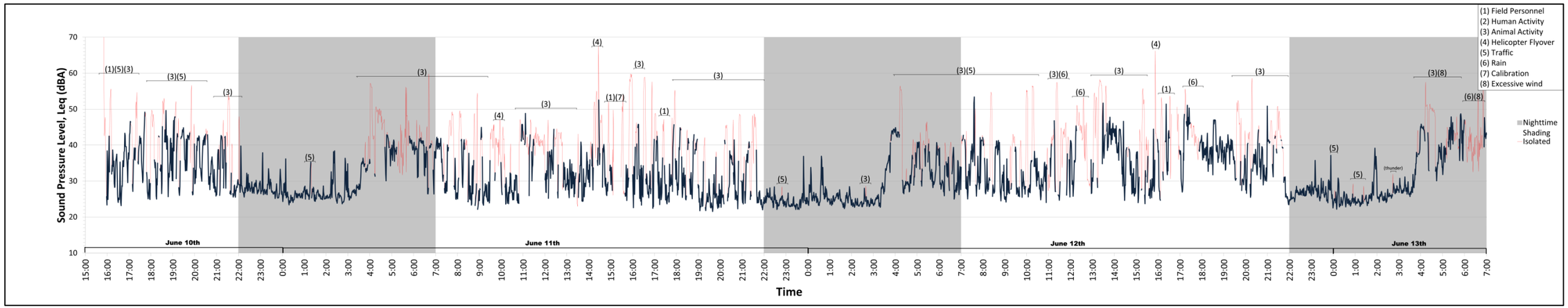


Figure 4-5a Location 5 Measurements - L_{eq} (June 10 to 13, 2014)

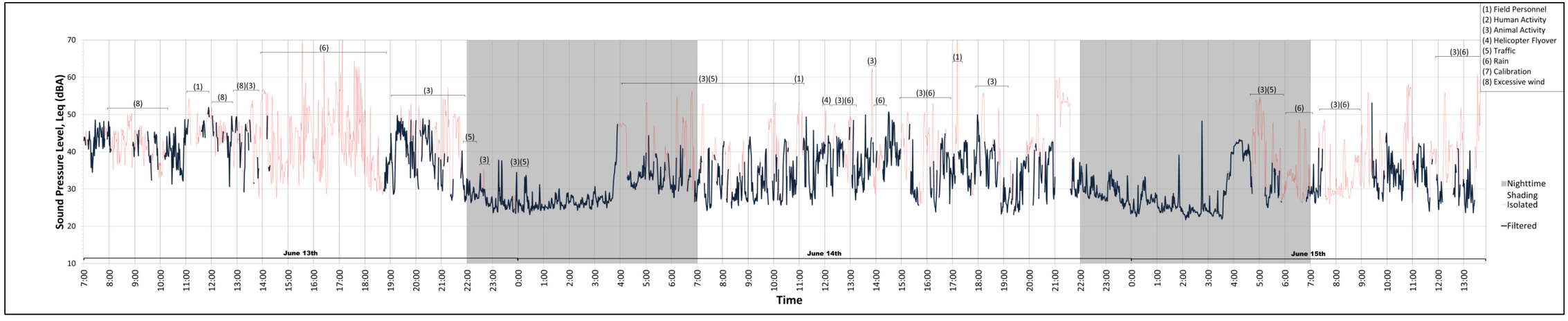


Figure 4-5b Location 5 Measurements - L_{eq} (June 13 to 15, 2014)

4.6 MONITORING LOCATION 6

Noise measurements were collected from June 10 to 15, 2014 at a residential location in Aberdeen. Filtered $L_{eq, 1hr}$ values are presented in Table 4-6. There were a total of 47 and 34 valid measurement hours during the daytime and nighttime period, respectively.

During the daytime period, the lowest and highest $L_{eq, 1hr}$ values were 37.9 dBA and 56.7 dBA, respectively. During the nighttime period, the lowest and highest $L_{eq, 1hr}$ values were 27.7 dBA and 53.0 dBA, respectively.

The measured sound levels ($L_{eq, 1min}$) time history is presented in Figure 4-6a and Figure 4-6b. Non-representative data (anomalous noise events) are shaded in red. These data are isolated from the data analysis of the hourly, daytime, and nighttime equivalent sound level results. Isolated noise events observed at this location were predominantly rain, a dripping spout, Stantec field technicians, animal (i.e. birds) and residential activities (i.e. residence conversation, vehicle, yard work) occurring at close range to the microphone.

Apart from the isolated events, the acoustic environment at the Aberdeen residential location is predominantly characterized by residential activities and road traffic.

Table 4-6 Monitoring Location 6 $L_{eq, 1hr}$ Sound Level (June 10 to 15, 2014)

Date	Start Hour	$L_{eq, 1hr}$ [dBA]	Valid Minutes (out of 60) [a]
June 10, 2014	17:00	44.8	51
June 10, 2014	18:00	42.5	57
June 10, 2014	19:00	42.0	59
June 10, 2014	20:00	38.4	60
June 10, 2014	21:00	37.9	58
June 10, 2014	22:00	35.1	59
June 10, 2014	23:00	33.7	60
June 11, 2014	0:00	31.9	60
June 11, 2014	1:00	30.1	60
June 11, 2014	2:00	27.7	58
June 11, 2014	3:00	29.8	60
June 11, 2014	4:00	33.3	58
June 11, 2014	5:00	34.9	60
June 11, 2014	6:00	39.9	56
June 11, 2014	7:00	43.2	57
June 11, 2014	8:00	43.3	60
June 11, 2014	9:00	40.6	60

Table 4-6 Monitoring Location 6 $L_{eq, 1hr}$ Sound Level (June 10 to 15, 2014)

Date	Start Hour	$L_{eq, 1hr}$ [dBA]	Valid Minutes (out of 60) [a]
June 11, 2014	10:00	39.8	56
June 11, 2014	11:00	39.1	57
June 11, 2014	12:00	39.7	55
June 11, 2014	13:00	39.9	54
June 11, 2014	14:00	41.7	55
June 11, 2014	15:00	43.1	45
June 11, 2014	17:00	55.0	60
June 11, 2014	18:00	53.6	58
June 11, 2014	19:00	51.8	60
June 11, 2014	20:00	50.6	59
June 11, 2014	21:00	49.4	60
June 11, 2014	22:00	46.8	59
June 11, 2014	23:00	48.2	60
June 12, 2014	0:00	40.8	60
June 12, 2014	1:00	39.6	60
June 12, 2014	2:00	33.9	60
June 12, 2014	3:00	33.6	60
June 12, 2014	4:00	40.6	60
June 12, 2014	5:00	47.6	60
June 12, 2014	6:00	51.3	50
June 12, 2014	7:00	54.6	59
June 12, 2014	8:00	54.4	60
June 12, 2014	9:00	51.4	53
June 12, 2014	10:00	51.3	60
June 12, 2014	11:00	51.9	45
June 12, 2014	12:00	55.4	35
June 12, 2014	14:00	56.7	40
June 12, 2014	15:00	56.7	54
June 12, 2014	16:00	-	41
June 12, 2014	17:00	56.1	59
June 12, 2014	18:00	53.6	60
June 12, 2014	19:00	56.7	60
June 12, 2014	20:00	52.5	59
June 12, 2014	21:00	51.4	60
June 12, 2014	22:00	50.8	50

Table 4-6 Monitoring Location 6 $L_{eq, 1hr}$ Sound Level (June 10 to 15, 2014)

Date	Start Hour	$L_{eq, 1hr}$ [dBA]	Valid Minutes (out of 60) [a]
June 12, 2014	23:00	44.5	58
June 13, 2014	0:00	41.2	59
June 13, 2014	1:00	34.7	58
June 13, 2014	2:00	28.1	58
June 13, 2014	3:00	33.5	60
June 13, 2014	4:00	40.7	59
June 13, 2014	5:00	46.1	52
June 13, 2014	8:00	56.5	60
June 13, 2014	9:00	54.3	60
June 13, 2014	10:00	52.9	60
June 13, 2014	11:00	54.1	45
June 13, 2014	12:00	54.0	49
June 13, 2014	21:00	51.1	58
June 13, 2014	22:00	53.0	58
June 13, 2014	23:00	46.6	60
June 14, 2014	0:00	44.6	60
June 14, 2014	1:00	43.7	60
June 14, 2014	2:00	44.1	60
June 14, 2014	9:00	53.7	57
June 14, 2014	10:00	53.2	60
June 14, 2014	11:00	56.1	37
June 14, 2014	12:00	54.4	58
June 14, 2014	13:00	54.2	58
June 14, 2014	14:00	55.1	43
June 14, 2014	15:00	52.1	41
June 14, 2014	23:00	45.3	53
June 15, 2014	0:00	44.6	60
June 15, 2014	1:00	42.2	60
June 15, 2014	13:00	52.3	35

NOTE:

[a] $L_{eq, 1hr}$ with less than 30 minutes of filtered data is not included in this table. However, the filtered data was included in the calculation of L_d and L_n. Nighttime period is indicated with grey shading (22:00 – 7:00)

- No valid data during this time period

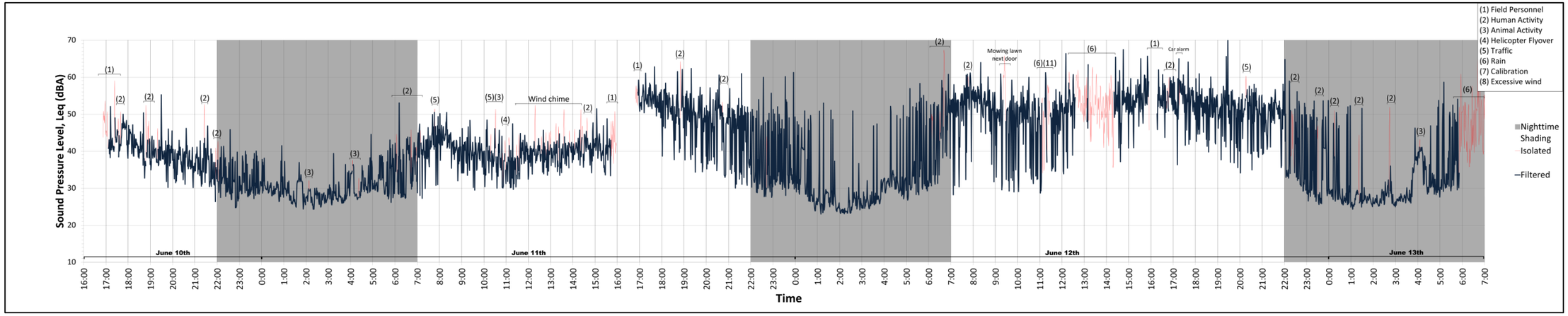


Figure 4-6a Location 6 Measurements - L_{eq} (June 10 to 13, 2014)

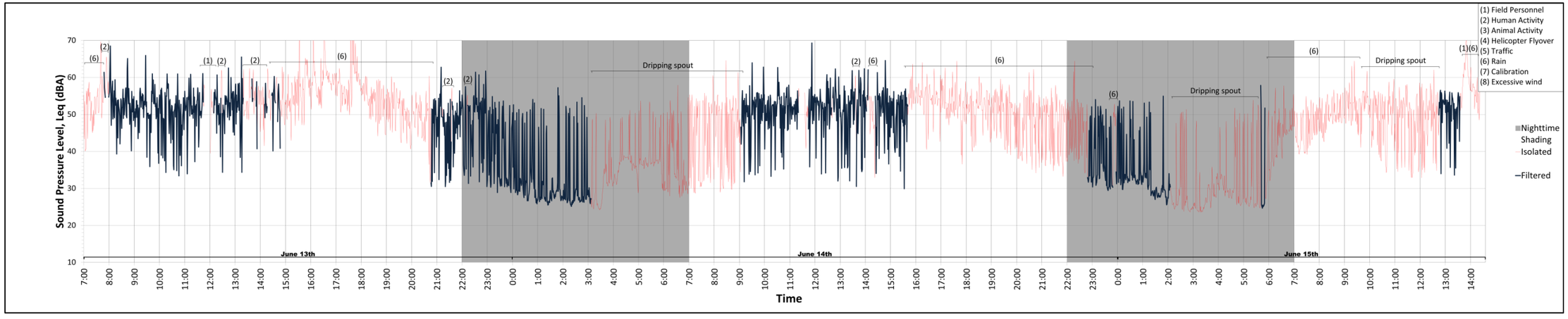


Figure 4-6b Location 6 Measurements - L_{eq} (June 13 to 15, 2014)

4.7 EQUIVALENT SOUND LEVEL SUMMARY REPORT

The daytime (L_d) and nighttime (L_n) equivalent sound level at all monitoring locations during each 24 hour measurement period is summarized in the Table 4-7. In addition, the day-night equivalent sound level (L_{dn}) for each 24 hour period is presented. The total valid hours of measurement is shown for each 24 hour period.

Table 4-7 Daytime, Nighttime, and Day-Night Equivalent Sound Level Summary

Location	Description	Date (M/D/Y)	Daytime, Nightime, and Day-Night Equivalent Sound level			Valid Daytime Hours	Valid Nighttime Hours
			L_d	L_n	L_{dn}		
1	Abbeyglen/Pacific way intersection	12/1/2012	45.7	33.0	45.0	(13 of 15)	(6 of 9)
		12/2/2012	46.6	39.1	47.5	(7 of 15)	(3 of 9)
		12/3/2012	42.6	37.7	46.0	(7 of 15)	(8 of 9)
		12/4/2012	42.9	35.8	44.9	(4 of 15)	(7 of 9)
		12/5/2012	41.2	34.6	42.2	(10 of 15)	(3 of 9)
2	South of the Aberdeen community	12/5/2012	40.3	-	-	(5 of 15)	(0 of 9)
		12/6/2012	38.0	35.8	42.4	(15 of 15)	(8 of 9)
		12/7/2012	42.6	33.6	43.1	(12 of 15)	(9 of 9)
		12/8/2012	39.5	38.4	45.0	(15 of 15)	(9 of 9)
		12/9/2012	35.7	33.7	40.7	(13 of 15)	(9 of 9)
		12/10/2012	38.1	36.6	43.3	(13 of 15)	(8 of 9)
		12/11/2012	35.4	35.5	41.0	(15 of 15)	(6 of 9)
		12/12/2012	-	28.6	-	(0 of 15)	(7 of 9)
3	Pacific Way and Howe Road Intersection	12/16/2012	49.3	-	-	(3 of 15)	(0 of 9)
		12/17/2012	-	-	-	(0 of 15)	(2 of 9)
		12/18/2012	48.3	43.7	51.1	(15 of 15)	(9 of 9)
		12/19/2012	49.0	41.4	50.1	(15 of 15)	(9 of 9)
		12/20/2012	51.0	42.9	51.5	(14 of 15)	(4 of 9)
		12/21/2012	50.6	42.0	51.4	(6 of 15)	(4 of 9)

Table 4-7 Daytime, Nighttime, and Day-Night Equivalent Sound Level Summary

Location	Description	Date (M/D/Y)	Daytime, Nightime, and Day-Night Equivalent Sound level			Valid Daytime Hours	Valid Nighttime Hours
			L_d	L_n	L_{dn}		
4	Jacko Lake	6/10/2014	36.4	37.5	43.8	(6 of 8)	(8 of 9)
		6/11/2014	36.5	37.2	43.5	(13 of 15)	(8 of 9)
		6/12/2014	38.5	36.1	43.0	(12 of 15)	(8 of 9)
		6/13/2014	43.2	32.9	43.1	(8 of 15)	(8 of 9)
		6/14/2014	36.9	30.4	38.6	(11 of 15)	(7 of 9)
		6/15/2014	34.1	-	-	(3 of 6)	-
5	Straw House	6/10/2014	39.0	33.8	41.4	(5 of 6)	(7 of 9)
		6/11/2014	35.8	33.4	40.2	(10 of 15)	(8 of 9)
		6/12/2014	39.4	36.2	43.3	(10 of 15)	(7 of 9)
		6/13/2014	43.4	31.6	42.8	(6 of 15)	(8 of 9)
		6/14/2014	38.5	33.4	41.1	(11 of 15)	(7 of 9)
		6/15/2014	36.3	-	-	(3 of 15)	-
6	Aberdeen Residence	6/10/2014	41.7	34.3	42.9	(5 of 6)	(9 of 9)
		6/11/2014	48.9	45.6	52.7	(13 of 15)	(9 of 9)
		6/12/2014	54.5	44.1	54.4	(12 of 15)	(8 of 9)
		6/13/2014	54.3	47.9	56.0	(7 of 15)	(5 of 9)
		6/14/2014	54.2	44.6	54.3	(6 of 15)	(3 of 9)
		6/15/2014	52.8	-	-	(1 of 8)	-

NOTE:
"-" no measurement data or insufficient data points to estimate a L_d, L_n, or L_{dn} level.

4.8 WEATHER DATA

The weather data during the December 2012 survey was obtained from the Pacific Way meteorological station operated by the City of Kamloops that is situated close to monitoring Location 3. These weather data were used in the data analysis. The data showed that the weather varied considerably during the survey with periods of high winds and precipitation (snow and rain) observed. Sound measurement during periods of precipitation (rain and snow) and high wind (audible wind inducted noise from audio recording) was isolated from data.

Daily meteorological conditions were also obtained from the Environment Canada Kamloops Airport meteorological station to provide general information on conditions in the City of Kamloops during the December 2012 baseline sound monitoring study. During this time period, the Kamloops airport weather data indicates snow coverage on the ground. This condition does not comply with ISO 1996-2 weather condition requirement; however, it does represent ambient condition during the early winter season for the selected locations. The sound measurement during this period with snow covered ground was included in the baseline results.

The weather data during the June 2014 survey was obtained from two portable weather meters setup within 15 m of the sound level meter at monitoring locations 4 and 6. The weather during the June 2014 field study yielded much more representative weather conditions than the December 2012 survey. Towards the end of the field study, intermittent periods of rain and wind exceeding 15 km/hr were filtered out of the hourly, daytime, and nighttime equivalent sound level calculations.

Weather data obtained from the Kamloops Airport and the weather meter is summarized in Appendix C. Measured parameters include wind, temperature, precipitation and relative humidity. The Kamloops Airport weather data is summarized in Table C-1. The comment column in Table C-1 lists the hours of valid noise measurements based on conditions recorded at the Pacific Way meteorological station. Graphical representations of weather data recorded at location 4 (Jacko Lake) are provided in Appendix C, Figures C-1 to C-5. Graphical representations of weather data recorded at location 6 (Aberdeen residential location) are provided in Appendix C, Figures C-6 to C-10.

5.0 DISCUSSION AND CONCLUSIONS

Table 5-1 summarizes the measured baseline sound level results at the six noise monitoring locations. The daytime (L_d), nighttime (L_n) and day-night (L_{dn}) sound levels are presented for the entire measurement period for each location. The results provide a baseline evaluation of the acoustic environment in the area based on measurement. In addition, the recommended baseline sound level from the BC OGC and US EPA are presented in the table for comparison purpose.

Table 5-1 Daytime, Nighttime, and Day-Night Equivalent Sound Level Summary

Monitoring Location	Time Period	Measured L_d (dBA)	BC OGC L_d (dBA)	Measured L_n (dBA)	BC OGC L_n (dBA)	Measured L_{dn} (dBA)	US EPA L_{dn} (dBA)
1	December 1 to 5, 2012	44	51	36	41	45	48 to 52
2	December 5 to 12, 2012	39	51	36	41	43	48 to 52
3	December 16 to 21, 2012	50	61	43	51	51	48 to 52
4	June 10 to 15, 2014	39	45	36	35	43	44
5	June 10 to 15, 2014	39	45	34	35	42	44
6	June 10 to 15, 2014	53	51	45	41	54	53 to 57

5.1 LOCATIONS 1 AND 2

The measured L_d and L_n at locations 1 and 2 during the December 2012 monitoring program are generally below the estimated ambient sound levels BC OGC noise guideline. Similarly, the measured L_{dn} values are below the range of US EPA estimated baseline sound level of 48 to 52 dBA L_{dn} for a quiet suburban residential community. The acoustic environment at both of these locations is similar to baseline sound level expected in a rural environment.

Locations 1 and 2 are near the Aberdeen community development boundary at the south-eastern end of Pacific Way, facing the backyard side of residential development along Abbeyglen Way. The area south of the monitoring locations is undeveloped private land. Most residential activities occur along Abbeyglen Way. At both monitoring locations, noise effect (i.e. traffic) from residential activities along Abbeyglen Way is sheltered from the residential housing structures.

Other potential reasons for the lower measured levels could be seasonal variability. Ambient sound levels determination in the BC OGC noise guideline is for summer conditions. During the winter months, decrease in community outdoor activities and natural sound (i.e. birds, insects, leaves rustling) may result in a lower ambient sound level.

5.2 LOCATION 3

The measured L_d and L_n results at location 3 are higher than results from locations 1 and 2 due to closer proximity to the heavily travelled roadway (i.e. Pacific Way). However, the measured values at location 3 are generally below the BC OGC noise guideline estimated ambient sound levels. The primary reason could be seasonal variability as the sound levels suggested in the BC OGC noise guideline is for summer conditions. During the winter months, decrease in community outdoor activities and natural sound (i.e. birds, insects, leaves rustling) may result in a lower ambient sound level. The measured L_{dn} of 51 dBA is within the sound level range of 53 to 57 dBA suggested in the US EPA noise guideline for a quiet suburban residential community.

5.3 LOCATIONS 4 AND 5

Results from the sound monitoring program in June 2014 are more comparable with the ambient level suggested in the BC OGC and US EPA noise guideline.

Locations 4 and 5 are in a rural environment. The measured L_n at locations 4 and 5 are comparable to the BC OGC noise guideline estimated ambient nighttime sound level of 35 dBA in a rural environment. During the daytime period, the measured L_d at both locations are quieter than the BC OGC noise guideline estimated ambient sound level of 45 dBA during the daytime period in a rural environment. The measured L_{dn} at locations 4 and 5 are comparable to sound levels for rural environments suggested in the US EPA noise guideline.

5.4 LOCATION 6

Location 6 is in a suburban residential community. Measured L_d and L_n at location 6 are comparable to the BC OGC noise guideline estimated ambient sound level of 56 dBA and 46 dBA for a dwelling in a higher population density area. The measured L_{dn} of 54 dBA is within the sound level range of 48 to 52 dBA as suggested in the US EPA noise guideline for a normal suburban residential community.

5.5 CONCLUSION

Variability in seasonal and meteorological conditions will affect the ambient sound level at all the measurement locations. In most rural acoustic environments, the ambient sound level is characterized by natural sounds sources including wind and rain interacting with natural surfaces (e.g., wind noise, vegetation rustling), stream and creek movement, and animal noises (e.g., from birds and insects). These sources are somewhat variable down to the minute because

of changing natural forces. In developed area with more human activities (i.e. suburban area, business and commercial districts), the acoustic environment may vary from one location to another during different time periods.

It is common to have measurement results that are above or below the prescribed or recommended levels from noise guideline and guidance. The measured baseline sound levels are based on approximately one week of measurement data. The measurement result may not be identical to values recommended in noise guideline and guidance; however, it provides an indication of the average acoustic environment for the location. Longer period (monthly or annually) or a permanent monitoring program may provide a large statistical sample; however, the week long program is considered sufficient for an evaluation of the existing acoustic environment in most locations.

The baseline monitoring program included six locations that represent different developed and undeveloped areas. Locations 1 and 2 are near the Aberdeen community development boundary, representative of a rural to suburban area transition. Locations 3 and 6 are within the suburban residential community of Aberdeen. Location 4 and 5 are in a rural environment.

Health Canada recognizes measurement in establishing the baseline sound levels for the communities. On the other hand, the BC OGC noise guideline recommends that baseline sound levels should be calculated on the basis of dwelling density and proximity to transportation sources. In the environmental assessment, the Project noise effect will be assessed by the BC OGC noise guideline and Health Canada noise guidance.

In assessing the Project compliance with the BC OGC noise threshold, the BC OGC prescribed ambient sound level (Table 5-1) will be used. For receptors located along the development boundary, the lower ambient sound level (35 dBA nighttime and 45 dBA daytime) will be used instead of the values recommended for the higher population density. This is considered a conservative approach as a lower baseline sound level will cause a greater change in the acoustic environment when the Project noise effect is assessed. In assessing the Project noise effect with the Health Canada guidance, the measurement results will be used to establish the baseline sound level.

6.0 REFERENCE

Alberta Energy Regulator (AER). 2007. Directive 038: Noise Control. Revised Edition, February 16, 2007. Calgary, Alberta.

ANSI S1.43 1997. Specifications for Integrating-Averaging Sound Level Meters.

ANSI S1.40 2006. American National Standard Specifications and Verification Procedures for Sound Calibrators

British Columbia Oil and Gas Commission (BC OGC). 2009. British Columbia Noise Control Best Practices Guideline. British Columbia.

Heath Canada (HC). 2010. Useful Information for Environmental Assessments.

ISO 1996-2:2007. Acoustics – Description, measurement and assessment of environmental, Part 2: Determination of environmental noise levels.

US EPA. 1974. United States Environmental Protection Agency (EPA). Office of Noise Abatement and Control. Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety.

Appendix A COMMONLY USED NOISE TERMINOLOGY

Airborne Sound: Sound that reaches the point of interest by propagation through air.

Ambient Noise: All noises that exist in an area and are not related to a facility. Ambient noise includes sound from other industrial noise not subject to this directive, transportation sources, animals, and nature. Ambient noise is the same as background sound level.

Ambient Sound Level (ASL): The ASL consists of all noise in the area that is not related to regulated facilities. This noise includes sound from other non-regulated industrial facilities, transportation sources, animals and nature. The ASL does not include any energy-related industrial component and must be measured without it. The ASL can be measured when the sound level in an area is not felt to be represented by the BSLs. The ASL must be measured under representative conditions. As with comprehensive sound levels, representative conditions do not constitute absolute worst-case conditions (i.e., the quietest day in this case) but conditions that portray typical conditions for the area.

Attenuation: The reduction of sound intensity by various means (e.g., air, barrier, porous materials, silencers, enclosures, etc.).

Background Sound Level (i.e., Baseline): It includes noise from all sources other than the sound of interest (i.e. sound other than that being measured, for example, sound from other industrial noise not being measured, transportation sources, animals, and natures sound).

Bands (octave, 1/3 octave): A series of electronic filters separate sound into discrete frequency bands, making it possible to know how sound energy is distributed as a function of frequency. Each octave band has a center frequency that is double the center frequency of the octave band preceding it.

Basic Sound Level (BSL): The A-weighted L_{eq} sound level commonly observed to occur in the designated land-use categories with industrial presence. The BSL is assumed to be 5 dBA above the ASL and is set out in Table 1 of *AER Directive 038: Noise Control*.

Calibration: The procedure used for the adjustment of a sound level meter using a reference source of a known sound pressure level and frequency. Calibration must take place before and after the sound level measurements.

Calibrator (Acoustical): A device which produces a known sound pressure on the microphone of a sound level measurement system, and is used to adjust the system to standard specifications.

Category: A classification of a dwelling unit in relation to transportation routes used to arrive at a BSL.

Class A Adjustment: Consists of the sum of adjustments that account for the adjustment seasonal nature of the noise source, absence of both tonal and impulse/impact components, and the actual ASL in an area. It cannot exceed +10 dBA. The Class A adjustment is added to the BSL, the daytime adjustment, and the Class B adjustment to arrive at a permissible sound level.

Class B Adjustment: An adjustment based on the duration of a noisy activity that recognizes that additional noise can be tolerated if it is known that the duration will be limited. An adjustment of B1, B2, B3, or B4 may be selected as applicable.

Comprehensive Sound Level (CSL): The sound level that is a composite of different airborne sounds from many sources far away from and near the point of measurement. The CSL does include industrial components and must be measured with them, but it should exclude abnormal noise events.

Daytime: Defined as the hours from 07:00 to 22:00.

Daytime Adjustment: An adjustment that allows a 10 dBA increase because daytime sound levels are generally about 10 dBA higher than nighttime values.

dB - Decibel: The logarithmic units associated with sound pressure level, sound power level, or acceleration level. See sound pressure level, for example.

dBA - Decibel, A-Weighted: The logarithmic units associated with a sound pressure level, where the sound pressure signal has been filtered using a frequency weighting that mimics the response of the human ear to quiet sound levels. The resultant sound pressure level is therefore representative of the subjective response of the human ear. A-weighted sound pressure levels are denoted by the suffix 'A' (i.e. dBA), and the term pressure is normally omitted from the description (i.e., sound level or noise level).

dBC - Decibel, C-Weighted: The logarithmic units associated with a sound pressure level, where the sound pressure signal has been filtered using a frequency weighting that mimics the response of the human ear to loud sound levels. C-weighted sound pressure levels are denoted by the suffix 'C' (i.e. dBC). C-weighted levels are often used in low-frequency noise analysis, as the filtering effect is nearly flat at lower frequencies.

Decibel Addition:

In acoustics, due to the logarithmic nature of the decibel scale, the addition of two or more sound pressure levels (denoted as SPL1, SPL2 … SPLn) is done as follows:

$$SPL1 + SPL2 + \ldots SPLn = 10 \log (10^{(SPL1/10)} + 10^{(SPL2/10)} + \ldots + 10^{(SPLn/10)})$$

As an example:

0 dB + 0 dB = 3 dB

50 dB + 50 dB = 53 dB

50 dB + 47 dB = 52 dB

50 dB + 40 dB = 50 dB

Directivity Factor (Q) (also, Directional or Directionality Factor): A factor mathematically related to Directivity Index, used in calculating propagated sound levels to account for the effect of reflecting surfaces near to the source. For example, for a source in free space where the sound is radiating spherically, Q = 1. For a source located on or very near to a surface (such as the ground, a wall, rooftop, etc.), where the sound is radiating hemispherically, Q = 2. This accounts for the additional sound energy reflecting off the surface, and translates into a +3 dB addition.

Dwelling Unit: Any permanently or seasonally occupied residence with the exception of an employee or worker residence, dormitory, or construction camp located within an industrial Project boundary. Trailer parks and campgrounds may qualify as a dwelling unit if it can be demonstrated that they are in regular and consistent use during the applicable season.

Dwelling Unit (most impacted): The nearest dwelling unit may not necessarily be the one most adversely affected because of factors such as topography or man-made features. For example, the nearest dwelling unit to a facility may be located behind an intervening ridge, while a more distant dwelling unit may be in direct line of sight with the facility. Care must be taken in determining the most impacted dwelling unit.

Emergency: An unplanned event requiring immediate action to prevent loss of life or property. Events occurring more than four times a year are not considered unplanned.

Energy Equivalent Sound Level (L_{eq}): An energy-average sound level taken over a specified period of time. It represents the average sound pressure encountered for the period. The time period is often added as a suffix to the label (e.g., $L_{eq}(24)$ for the 24-hour equivalent sound level). L_{eq} is usually A-weighted. An L_{eq} value expressed in dBA is a good, single value descriptor of the annoyance of noise.

Far Field: Describes a region in free space where the sound pressure level from a source obeys the inverse-square law (the sound pressure level decreases 6 dB with each doubling of distance from the source). The far field is that area far enough away from the noise source that the noise emissions can be treated as if they come from a single point or line source and the individual components of the noise source are not apparent as separate sources. This is typically at a distance of at least three to five times the major dimensions of the noise sources.

Filter: A device separating the components of an incoming signal by its frequencies.

Free Sound Field (Free Field): A sound field in which the effects of obstacles or boundaries on sound propagated in that field are negligible.

Frequency: The number of times per second that the sine wave of sound or of a vibrating object repeats itself. Now expressed in hertz (Hz), formerly in cycles per second (cps).

Frequent Aircraft Flyovers: Used in the assessment of categories as part of a site specific analysis for dwellings that lie within a contour area with a noise exposure forecast (NEF) 25 or greater, as designated by Transport Canada. In the absence of any NEF contours for local airport, Transport Canada is to be contacted for current air traffic statistics. In this case, to qualify for the BSL adjustment, a dwelling must be within 5 km of an airport that has a minimum of nine aircraft takeoffs or landings over the nighttime period.

Heavily Travelled Road: Generally includes highways and any other road where the average traffic count is at least 10 vehicles per hour over the nighttime period. It is acknowledged that highways are sometimes lightly travelled during the nighttime period, which is usually the period of greatest concern.

Heavy Truck: Any truck having a gross vehicle weight of 12,000 kg or more and having three or more axles.

Hertz (Hz): Unit of measurement of frequency, numerically equal to cycles per second.

Human Perception of Sound: The human perception of noise impact is an important consideration in qualifying the noise effects caused by projects. The typical threshold for an increase in sound level that is considered to be “barely perceptible” by the human ear in a controlled laboratory setting varies from 1 to 5 dBA, depending on the sound pressure level and frequency of the sound.

Insertion Loss (IL): The arithmetic difference between the sound level from a source before and after the installation of a noise mitigation measure, at the same location. Insertion loss is typically presented as a positive number, i.e., the post-mitigation sound level is lower than the pre-mitigation level. Insertion loss is expressed in dB and is usually specified per 1/1 octave band, per 1/3 octave band, or overall.

Intensity: The sound energy flow through a unit area in a unit time.

Low Frequency Noise (LFN): Noise in the low frequency range, from infrasonic sounds (<20 Hz) up to 100 Hz. Where a clear tone is present below and including 250 HZ and the difference between the overall C-weighted sound level and the overall A-weighted sound level exceeds 20 dB.

Masking: a) The process by which the threshold of audibility for a sound is raised by the presence of another (masking) sound, or b) The amount by which the threshold of audibility of a sound is raised by the presence of another (masking) sound.

Near Field: The region or sound field very near to a source, where sound pressure does not obey the inverse-square law (i.e., 6 dBA loss per doubling of distance for a point source does not apply). Usually this region is located within a few wavelength of the source and is also controlled by the dimension of the source.

Nighttime: Defined as the hours from 22:00 to 07:00.

Noise: Generally associated with the unwanted portion of sound.

Noise Exposure Forecast (NEF): The NEF contours are site specific to each airport and take into account such factors as traffic levels, proximity to runways, flight paths, and aircraft type and size.

Noise Impact Assessment (NIA): An NIA identifies the expected sound level emanating from a facility as measured 15 m from the nearest or most impacted permanently or seasonally occupied dwelling. It also identifies what the permissible sound level is and how it was calculated.

Noise Level: Same as Sound Level, except applied to unwanted sounds.

Permanent Facility: Any existing or proposed facility that will be at a location longer than two months.

Permanently Occupied Dwelling: A fixed residence occupied on a full-time basis.

Permissible Sound Level (PSL): The maximum sound level that a facility should not exceed at a point 15 m from the nearest or most impacted dwelling unit. The PSL is the sum of the BSL, daytime adjustment, Class A adjustment, and Class B adjustment.

Pristine Area: A pure, natural area that might have a residence but no industrial presence, including energy, agricultural, forestry, manufacturing, recreational, or other industries that could make noise generation a consideration.

Representative Conditions: Those conditions typical for an area and/or the nature of a complaint. For ASLs, these are conditions that portray the typical activities for the area, not the quietest time. For CSLs, these do not constitute absolute worst-case conditions or the exact conditions the complainant has highlighted if those conditions are not easily duplicated. Sound levels must be taken only when representative conditions exist; this may necessitate a survey of extensive duration (two or more consecutive nights).

Seasonally Occupied Dwelling: A fixed residence that, while not being occupied on a full-time basis, is occupied on a regular basis. A regular basis does not imply a scheduled occupancy but implies use of six weeks per year or more. The residence must not be mobile and should have some sort of foundation or features of permanence (e.g., electrical power, domestic water supply, septic system) associated with it. Summer cottages or mobile homes are examples of seasonally occupied dwellings, while a holiday trailer simply pulled onto a site is not.

Sound: A dynamic (fluctuating) pressure.

Sound Level (SL): The A-weighted Sound Pressure Level expressed in dBA.

Sound Level Meter: An instrument comprised of a microphone, amplifier, output meter, and frequency-weighting networks which is used for the measurement of noise and sound levels.

Sound Pressure Level (SPL): The logarithmic ratio of the RMS sound pressure to the sound pressure at the threshold of hearing. The sound pressure level is defined by equation (1) where P is the RMS pressure due to a sound and P_0 is the reference pressure. P_0 is usually taken as 2.0×10^{-5} Pascal.

$$SPL\ (dB) = 20 \log(P_{RMS}/P_0)$$

Sound Power Level (PWL): The logarithmic ratio of the instantaneous sound power (energy) of a noise source to that of an international standard reference power. The sound power level is defined by equation (2) where W is the sound power of the source in watts, and W0 is the reference power of 10^{-12} watts.

$$PWL\ (dB) = 10 \log(W/W_0)$$

Inter-relationships between sound pressure level (SPL) and sound power level (PWL) depend on the location and type of source.

Spectrum: The description of a sound wave's resolution into its components of frequency and amplitude.

Tonal Components: Most energy industrial facilities typically exhibit a tonal component. Examples of tonal components are transformer hum, sirens, and piping noise. The test for the presence of tonal components consists of two parts.

The first part must demonstrate that the sound pressure level of any one of the slow-response, A-weighted, 1/3-octave bands between 20 and 16 kHz is 10 dBA or more than the sound pressure level of at least one of the adjacent bands within two 1/3-octave bandwidths. In addition, there must be a minimum of a 5 dBA drop from the band containing the tone within 2 bandwidths on the opposite side. The second part is that the tonal component must be a pronounced peak clearly obvious within the spectrum

Transmission Loss: A measure of the reduction in sound energy resulting from incident sound waves striking a wall, partition or enclosure, and radiating through to the other side. Mathematically, the transmission coefficient t is the ratio of transmitted acoustic power to the incident acoustic power, and in decibels, the Transmission Loss (TL) of the wall is:

$TL = 10 \log (1 / t)$

The TL of a wall varies by frequency. The associated noise reduction (NR) due to the TL of the wall is a function of the TL and the acoustical parameters of the receiving space. For noise radiating from an enclosure into the outdoors, $NR \approx (TL + 6)$.

Windscreen: A specialized piece of porous sponge that fits over the microphone in order to reduce the noise generated by the wind blowing around the microphone. Useful in moderately low wind speeds. Generally, outdoor measurements are not recommended when wind speeds exceed 15 km/hr, as the wind-induced noise on the microphone becomes of the same magnitude as the levels being measured.

Appendix B NOISE MONITORING EQUIPMENT SETUP PHOTOS



Photo B-1 Noise Monitoring Setup at Location 2



Photo B-2 Noise Monitoring setup at Location 4 (Jacko Lake)



Photo B-3 Noise Monitoring setup at Location 5 (Straw House)



Photo B-4 Noise monitoring setup at Location 6 (residential location – NW corner of backyard)



Photo B-5 Noise Monitoring at Location 6 (residential location – NE corner of backyard)



Photo B-6 Weather Meter setup at Location 4 (Jacko Lake)

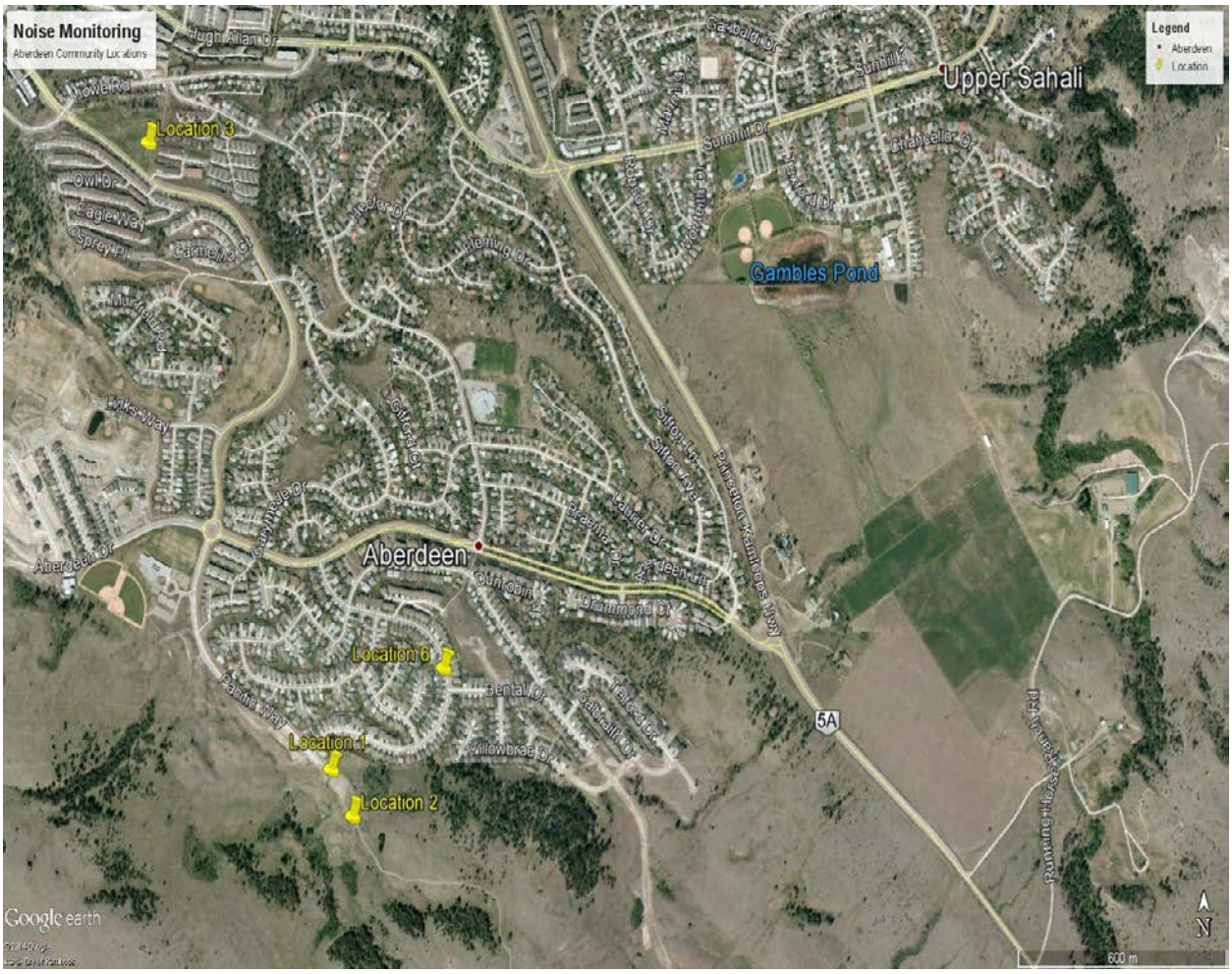


Photo B-7 Locations 1, 2, 3, and 6 on Goggle Earth Map

Appendix C WEATHER INFORMATION

C.1 KAMPLOOPS AIRPORT WEATHER REPORT

Table C-1 Daily Meteorological Data from Kamloops Airport Weather Reporting for December 2012 Field Study

Date	Temperature			Precipitation				Comment
	Max (℃)	Min (℃)	Mean (℃)	Rain (mm)	Snow (cm)	Total (mm)	Cover (cm)	
Nov-30	8.3	2.6	5.5	12.5	0	0	0	0 of 2 hours valid. Reason: wind, started 10 pm.
Dec-01	12.1	5.8	9	0.4	0	0.4	0	19 of 24 hours valid. Reason: wind, rain
Dec-02	9.4	4.4	6.9	2.6	0	2.6	0	10 of 24 hours valid. Reason: wind, rain
Dec-03	9.5	5.3	7.4	0	0	0	0	15 of 24 hours valid. Reason: wind
Dec-04	13.2	5.3	9.3	1.2	0	1.2	0	11 of 24 hours valid. Reason: wind, rain
Dec-05	7.4	1.1	4.3	0	0	0	0	18 of 24 hours valid. Reason: wind, rain
Dec-06	4.8	0	2.4	0.6	Trace	0.6	0	23 of 24 hours valid. Reason: wind, snow
Dec-07	2.5	-2.2	0.2	0	Trace	Trace	0	21 of 24 hours valid. Reason: wind, rain
Dec-08	0.9	-4.4	-1.8	0	0	0	0	24 of 24 hours valid.
Dec-09	-1.7	-6.5	-4.1	0	2	2	1	22 of 24 hours valid. Reason: wind, rain, snow
Dec-10	0.9	-8.6	-3.9	0	3	2.6	2	21 of 24 hours valid. Reason: wind, rain, snow
Dec-11	1.8	-2.4	-0.3	0	0	0	4	21 of 24 hours valid. Reason: wind, rain, snow
Dec-12	3	-0.4	1.3	0	0.2	0.2	0	7 of 7 hours valid.
Dec-13	2.6	-6.1	-1.8	0	1	0.8	3	Baseline sound monitoring not conducted.
Dec-14	2.5	-6	-1.8	0	Trace	Trace	3	Baseline sound monitoring not conducted.
Dec-15	0.9	-5.4	-2.3	0	0.6	0.6	3	Baseline sound monitoring not conducted.

Table C-1 Daily Meteorological Data from Kamloops Airport Weather Reporting for December 2012 Field Study

Date	Temperature			Precipitation				Comment
	Max (℃)	Min (℃)	Mean (℃)	Rain (mm)	Snow (cm)	Total (mm)	Cover (cm)	
Dec-16	0.6	-6.8	-3.1	0	0.2	0.2	3	3 of 5 hours valid. Reason: wind, rain, snow, started 7 pm.
Dec-17	1.4	-1.7	-0.2	0	14.1	9.6	8	2 of 2 hours valid. Reason: wind, rain, snow
Dec-18	-0.5	-12.3	-6.4	0	0	0	18	24 of 24 hours valid.
Dec-19	1.6	-9.9	-4.2	0	0	0	16	24 of 24 hours valid.
Dec-20	4.7	0.9	2.8	0	0.2	0.2	13	18 of 24 hours valid. Reason: wind
Dec-21	2.7	-5	-1.2	0	0.6	0.6	10	10 of 12 hours valid. Reason: wind, monitoring stopped at noon.

C.2 WEATHER METER RESULTS

Weather data from the two Kestrel weather meters is presented in this section. One meter was located at Location 4 and the results are presented in Figures C-1 to C-5. The other meter was located at Location 6 and the results are presented in Figures C-6 to C-10. In all figures, the legend definitions are summarized as follows:

- TP – temperature in Celsius (C˚)
- RH – relative humidity in percentage (%)
- MG – wind direction (N is 0˚ or 360 ˚, E is 90 ˚, S is 180 ˚, W is 270˚)
- WS – wind speed (km/hr)

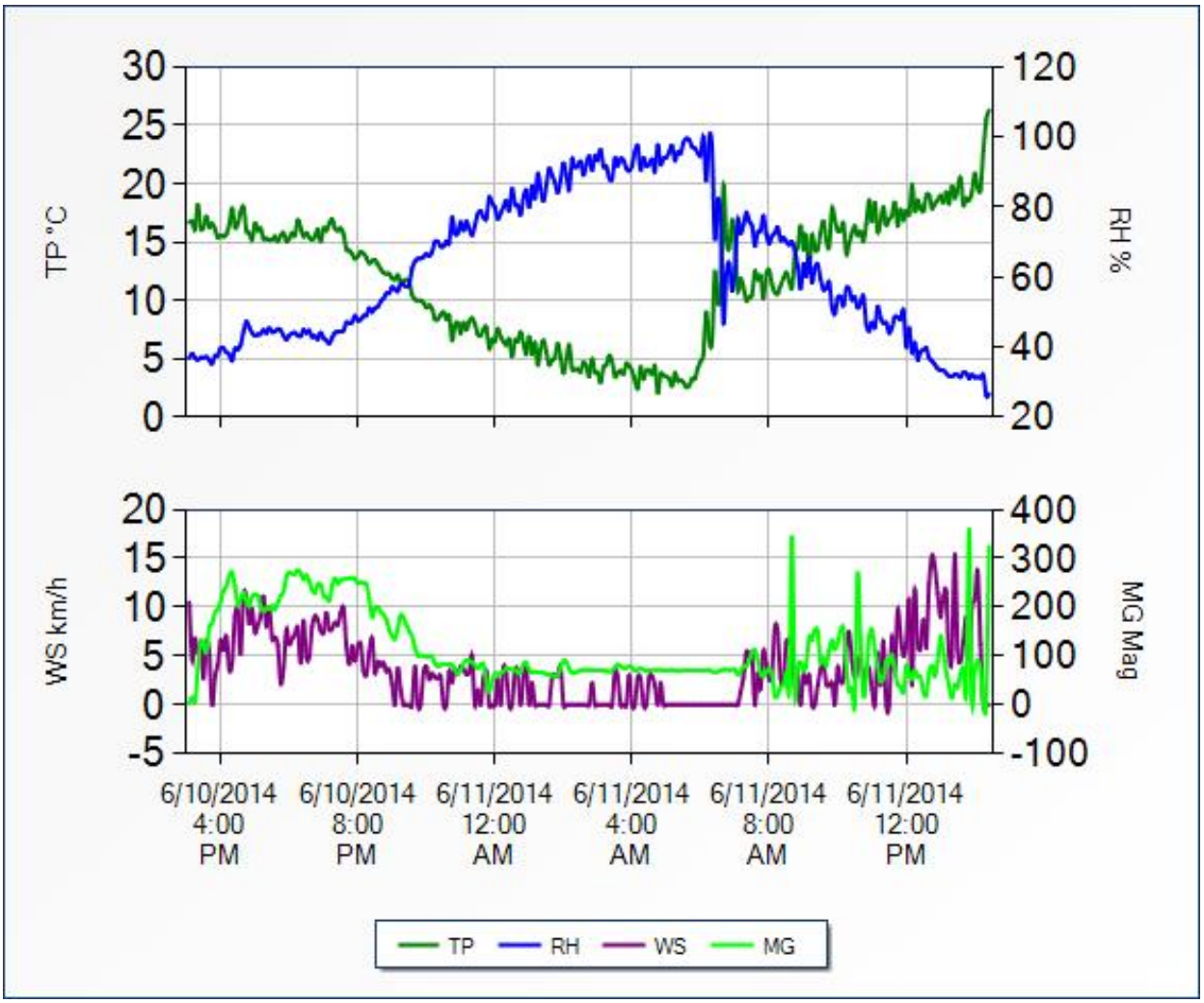


Figure C-1 Location 4 (Jacko Lake) weather, Day 1

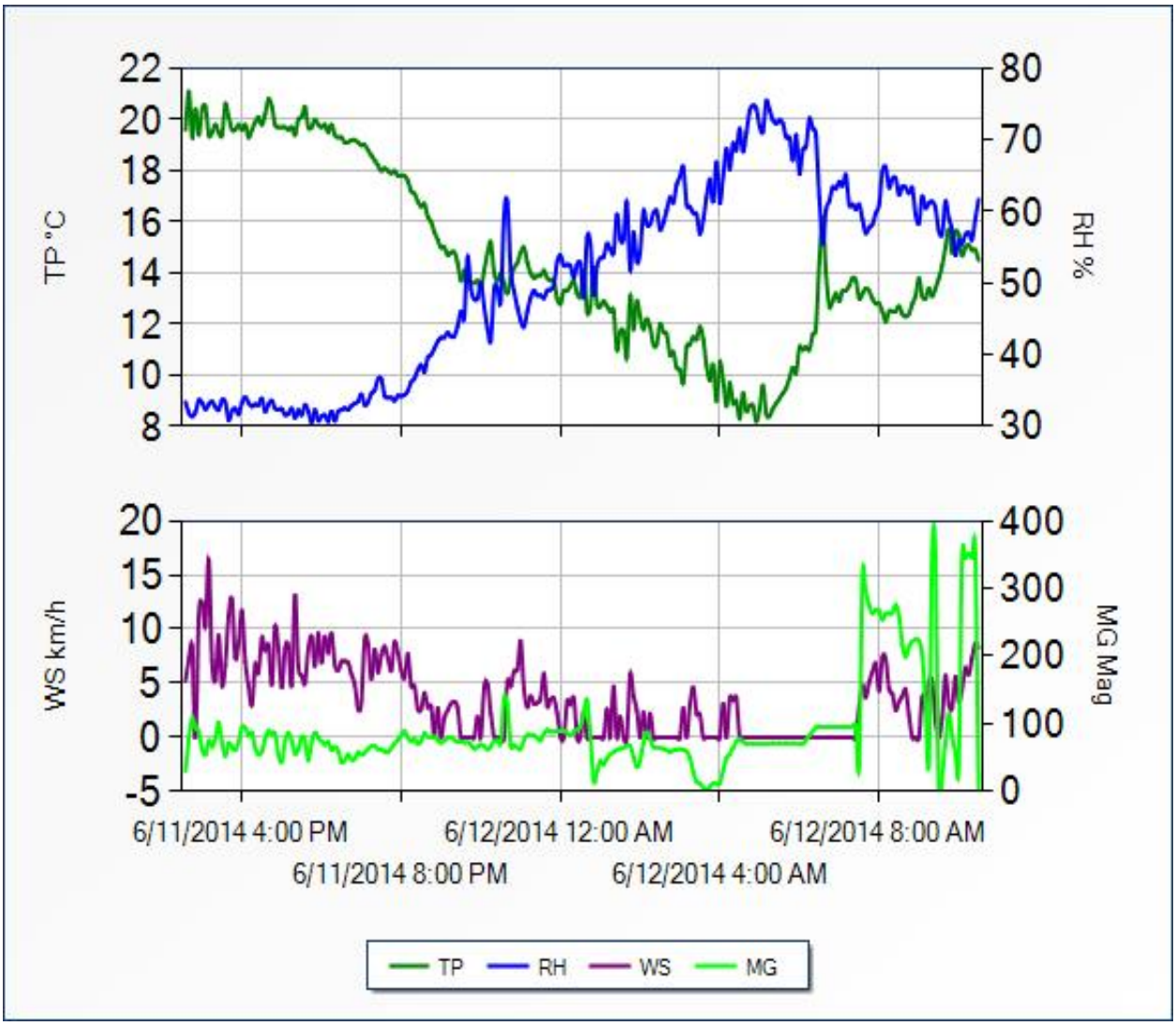


Figure C-2 Location 4 (Jacko Lake) weather, Day2

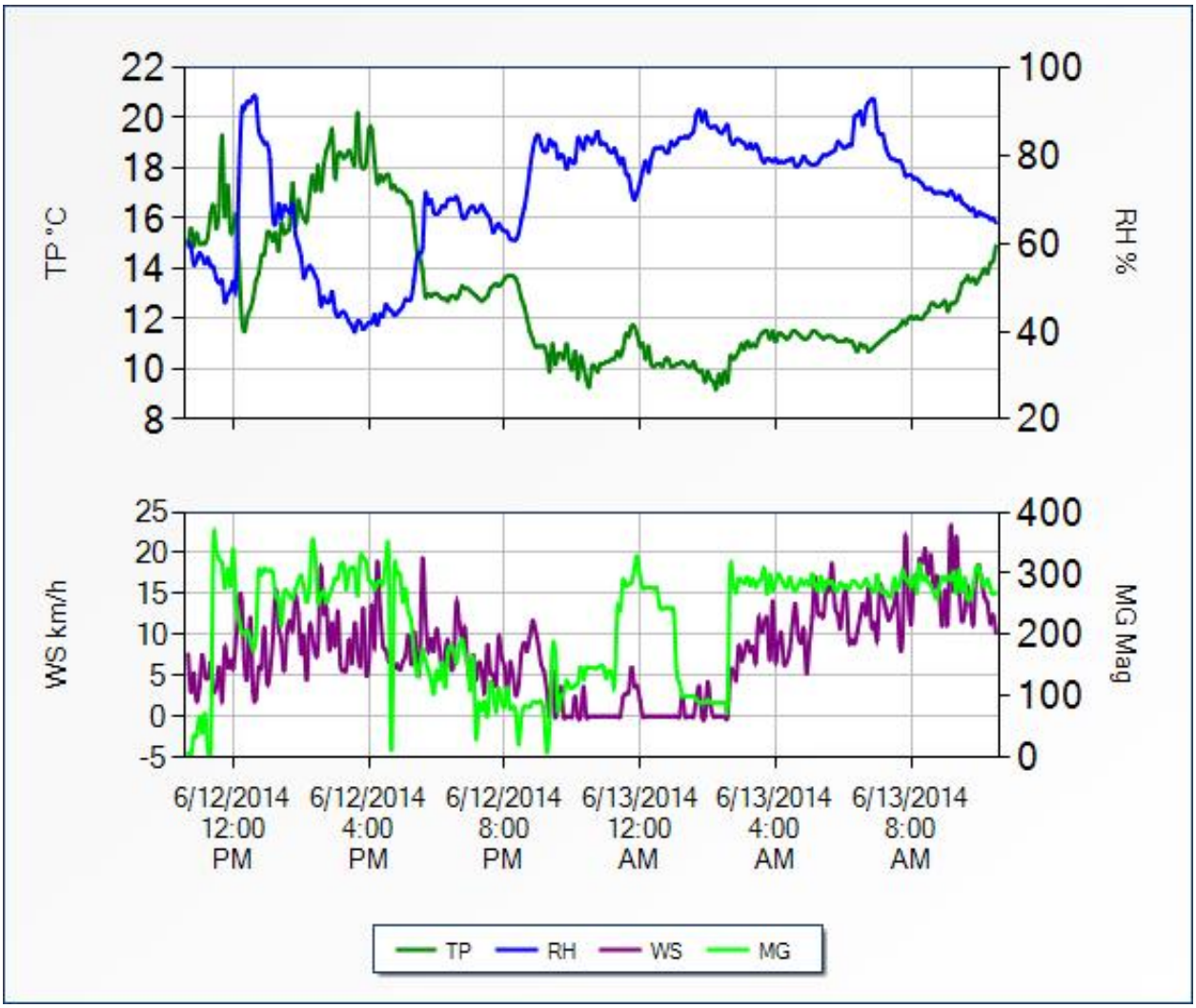


Figure C-3 Location 4 (Jacko Lake) weather, Day 3

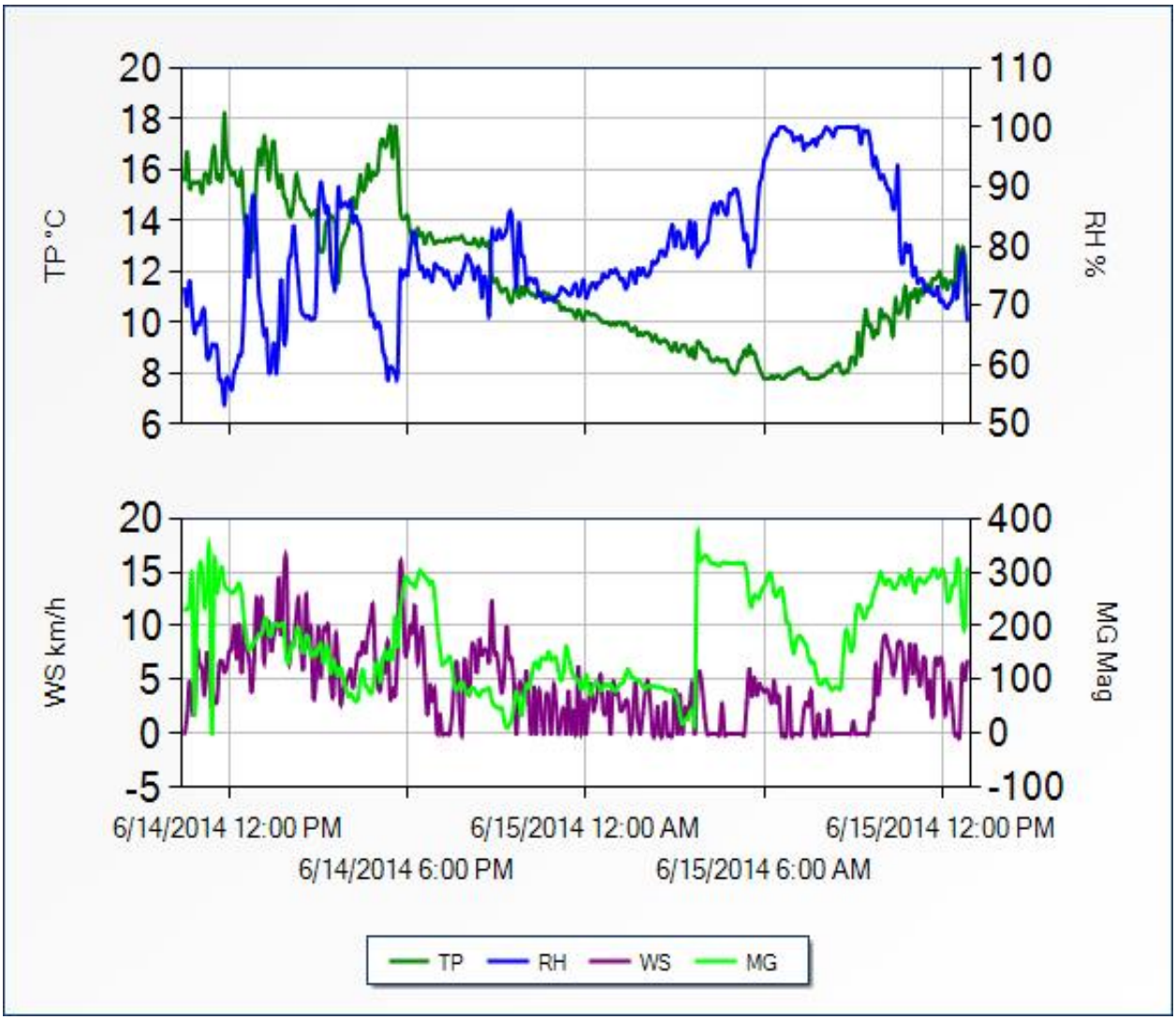


Figure C-4 Location 4 (Jacko Lake) weather, Day 4

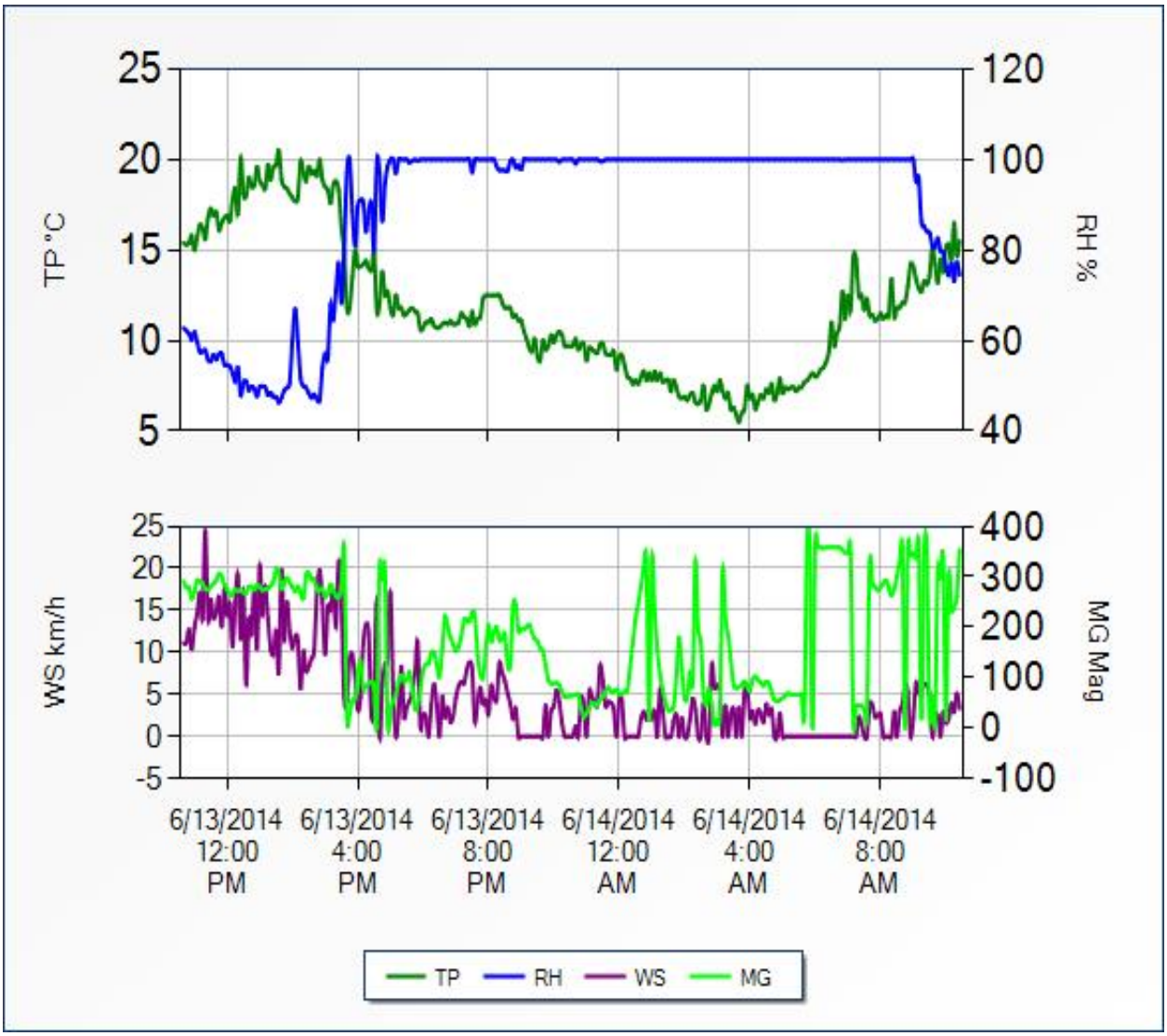


Figure C-5 Location 4 (Jacko Lake) weather, Day 5

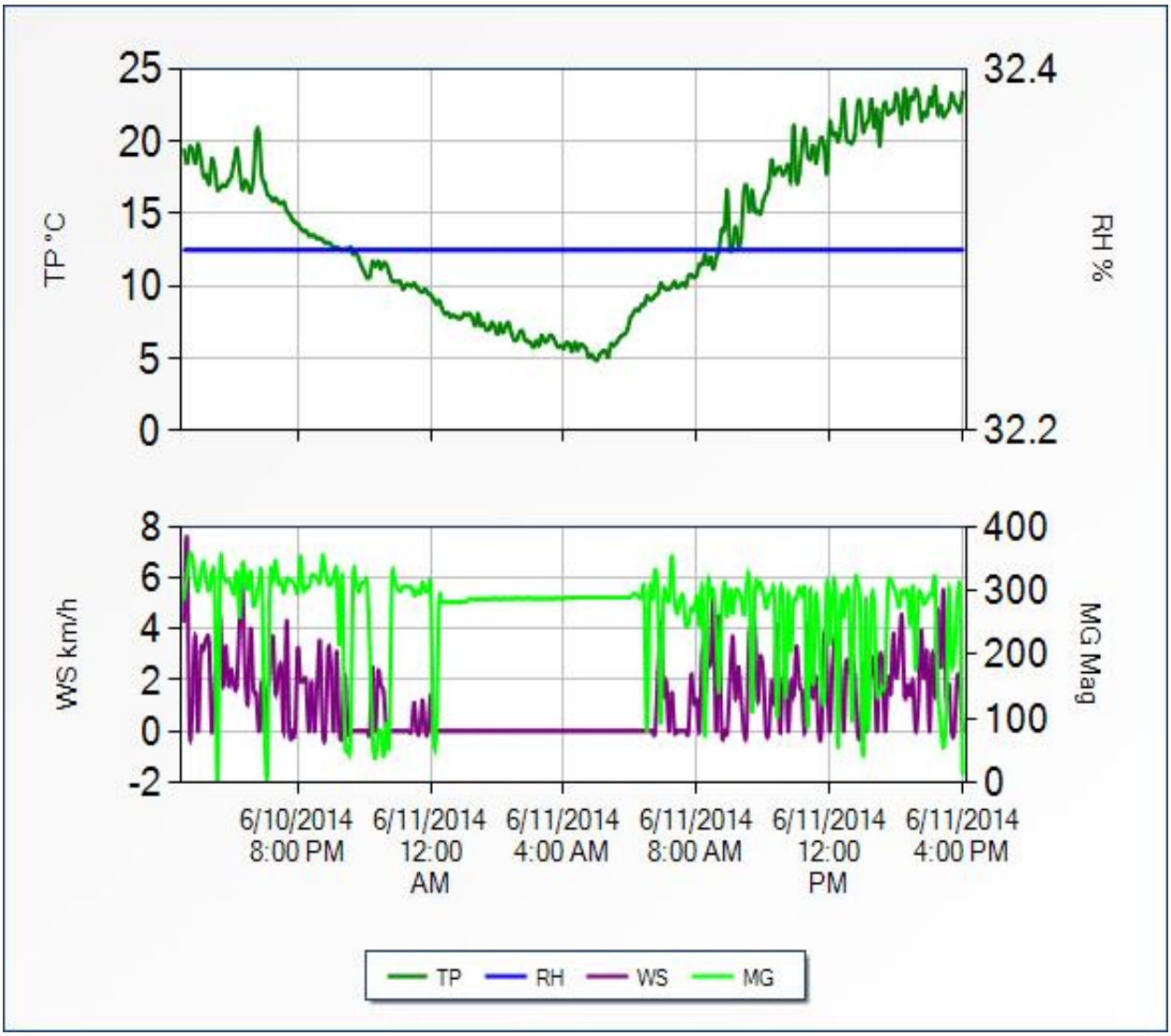


Figure C-6 Location 6 (Residential location) weather, Day 1

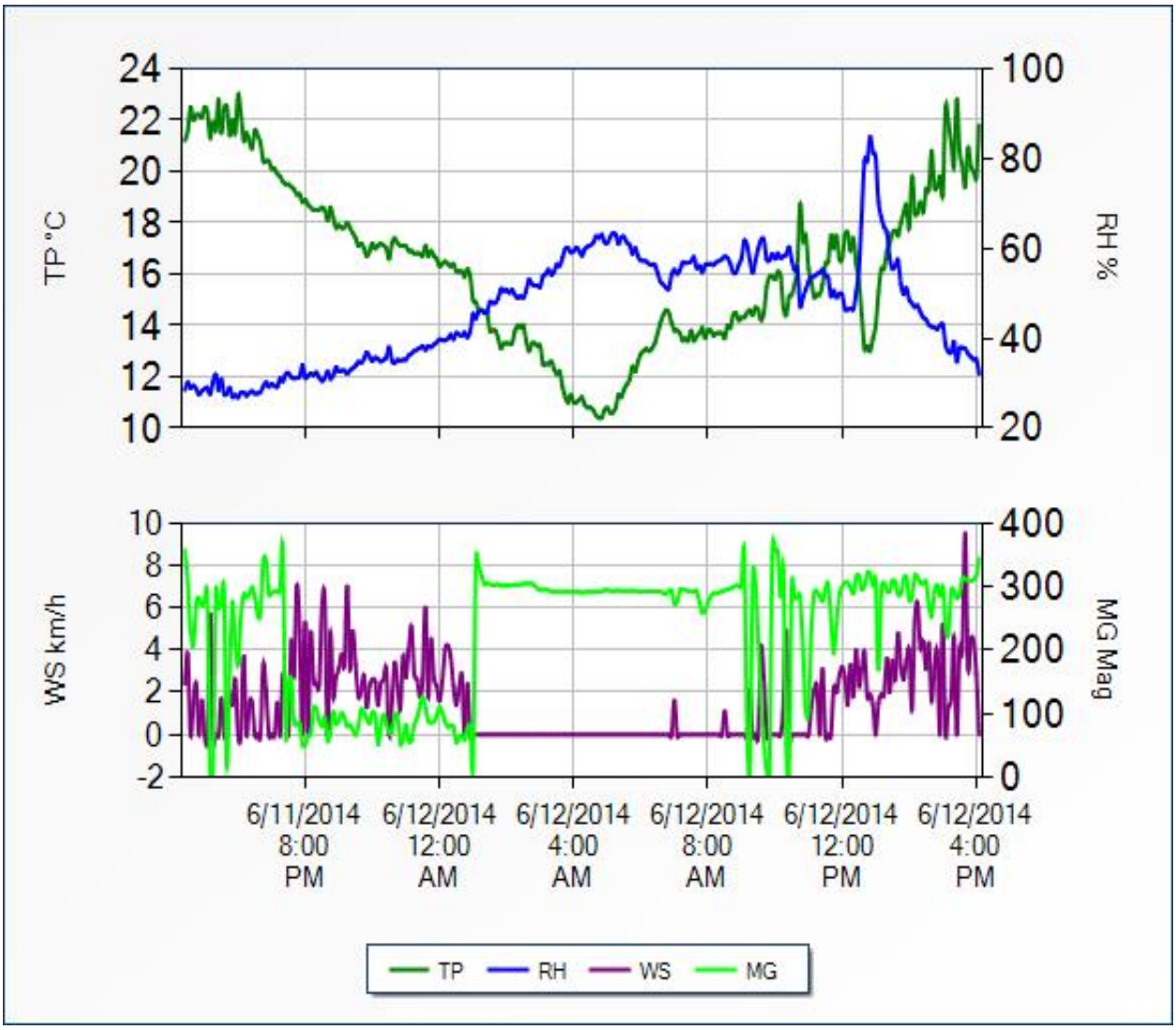


Figure C-7 Location 6 (Residential location) weather, Day 2

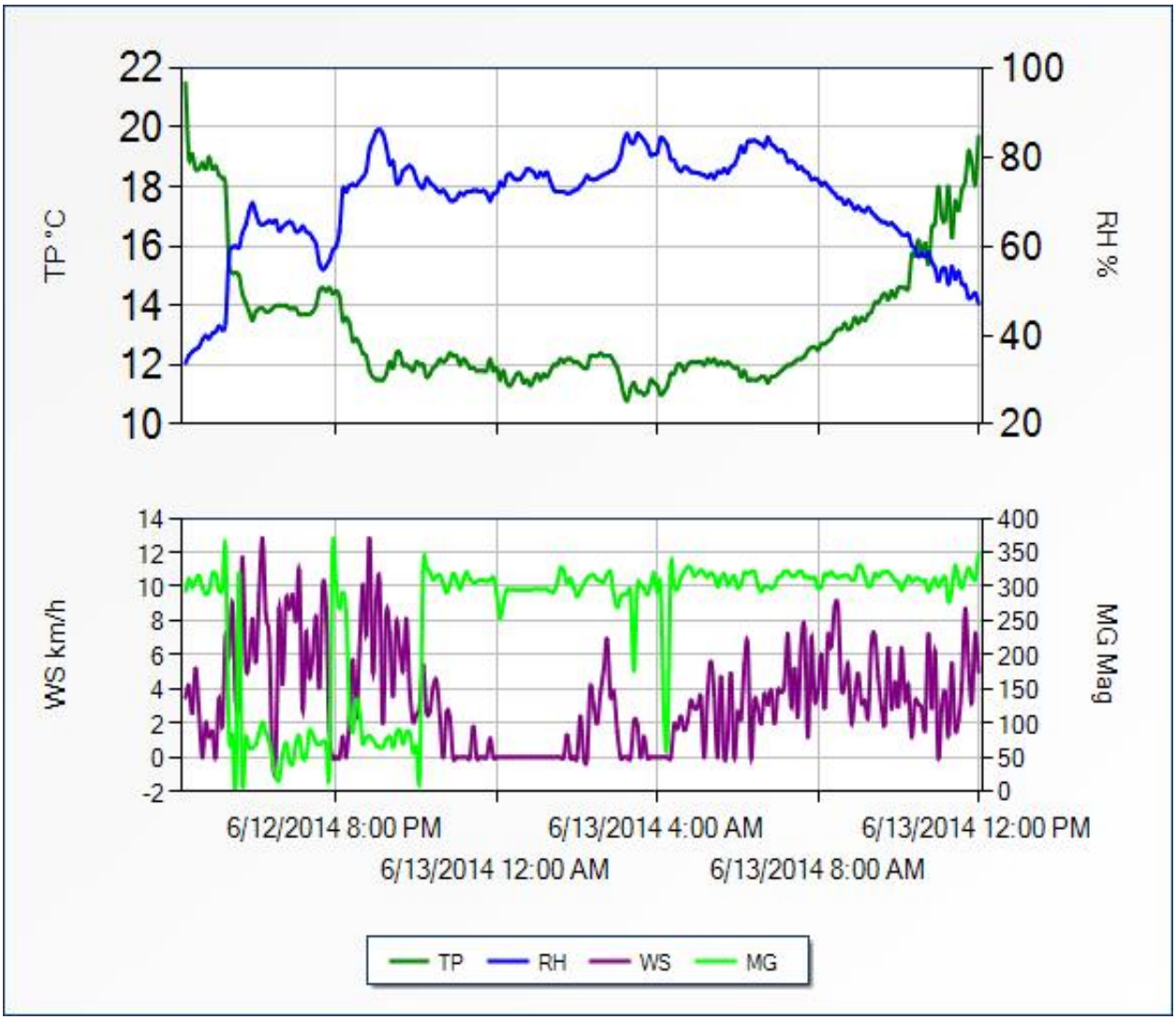


Figure C-8 Location 6 (Residential location) weather, Day 3

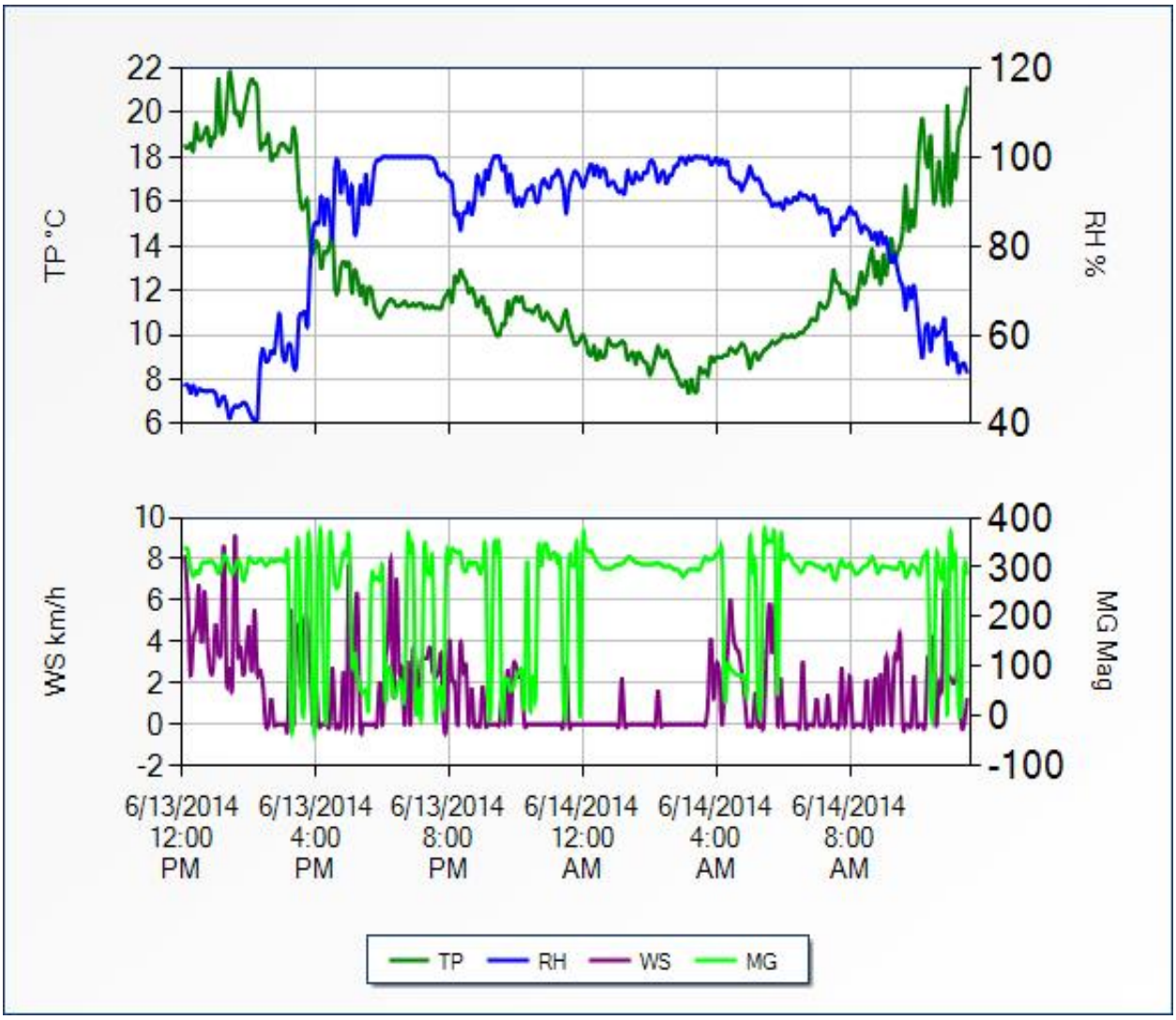


Figure C-9 Location 6 (Residential location) weather, Day 4

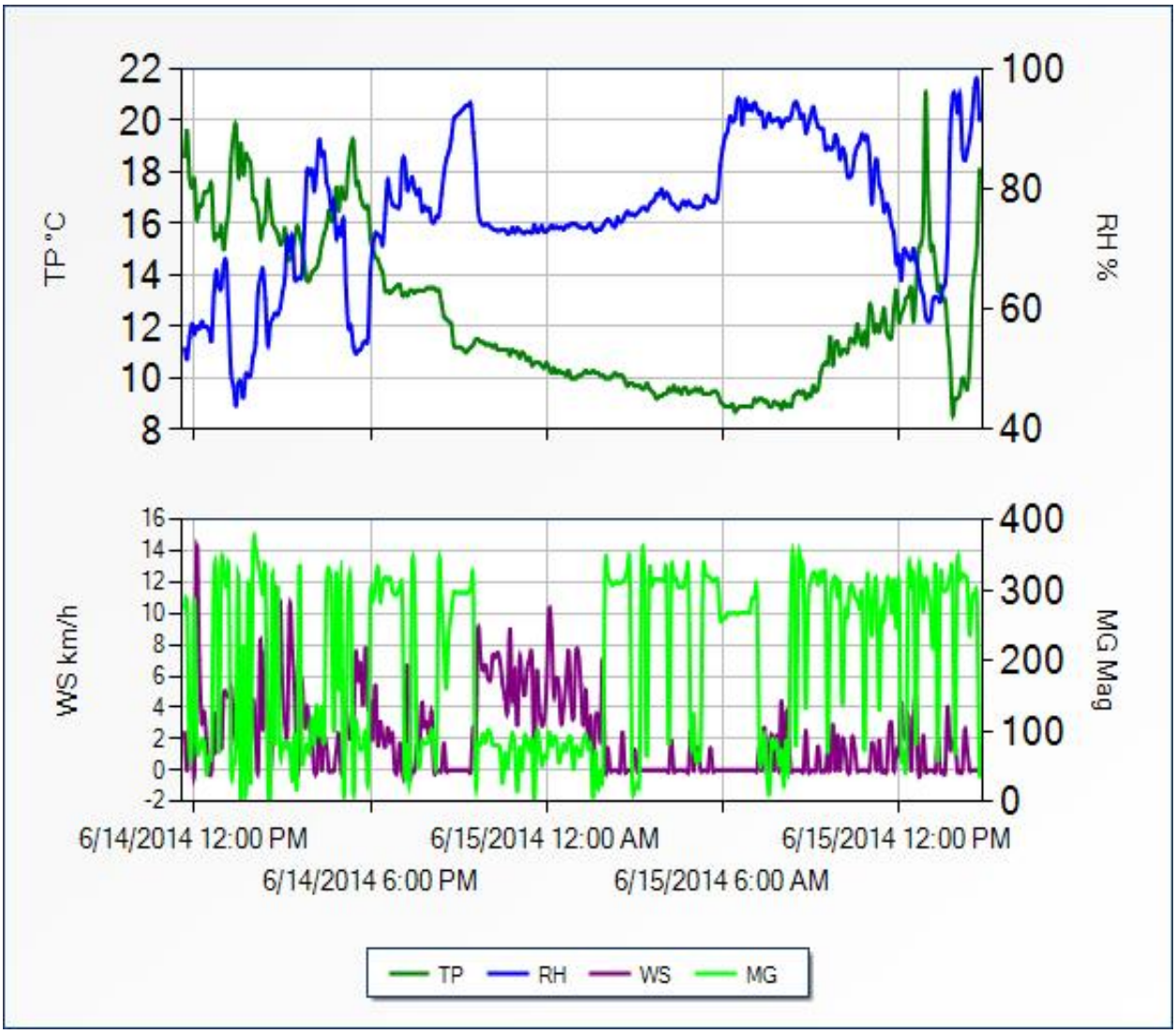


Figure C-10 Location 6 (Residential location) weather, Day 5

Appendix B PERMISSIBLE SOUND LEVEL DETERMINATION

In the BC OGC Noise Control Guideline, a receptor is defined as a dwelling unit which is any permanently or seasonally occupied residence with the exception of an employee or worker residence, dormitory, or construction camp located within an industrial plant boundary. Trailer parks and campgrounds may qualify as dwelling units if it can be demonstrated that they are in regular and consistent use during the applicable season. Noise receptors #37, 44, 52, and 74 are not qualified as a dwelling unit per the BC OGC Noise Control Guideline definition. The receptor locations for a city development boundary (receptors #13 to 18) are potential future receptors. They are included in the assessment in a conservative approach.

The PSL for a dwelling unit is calculated as follows:

> *Permissible Sound Level = Basic Sound Level + Daytime Adjustment + Class A Adjustment + Class B Adjustment*

The following sections describe the PSL determination method.

B.1 BASIC SOUND LEVEL

Basic Sound Levels (BSL) can be determined from a reference table in the BC OGC Noise Control Guideline, with consideration of population density and proximity to transportation corridors (grouped by category). The higher population density and closer proximity to transportation corridors results in higher category BSL values. Most of the selected residential receptors fall in Category 1 for proximity to transportation with the exception of receptors located in busy urban areas near heavily travelled roads. Rural residential receptors closest to the Project are in the population density category of one to eight dwellings per quarter section of land. A quarter section an area of one-fourth of a square mile, or 160 acres or 0.65 km2. It was a common size of a tract under the Dominion Land Survey in Canada,

The following two sections provide more details on the classification method.

B.1.1 Population Density

The population density refers to the number of dwelling units within a quarter land section with the affected dwelling at the center (a 451 m radius). For quarter sections with various land uses or with mixed densities, the density chosen is then averaged for the area under consideration. Receptors 14, 23, 27, 37, 74, 169, and 170 are classified in areas with population density of 9 to 160 dwellings per quarter section. Receptors 28, 44, and 52 are in the population density area higher than 160 dwellings per quarter section. All other receptors are located in areas with population density less than 9 dwellings per quarter section.

B.1.2 Proximity to Transportation

The proximity to transportation category is based on the following criteria:

- Category 1—dwelling units more than 500 m from heavily travelled roads and rail lines and not subject to frequent aircraft flyovers.
- Category 2—dwelling units more than 30 m but less than 500 m from heavily travelled roads and rail lines and not subject to frequent aircraft flyovers.
- Category 3—dwelling units less than 30 m from heavily travelled roads and rail lines and/or subject to frequent aircraft flyovers.

Receptors 3, 23, 28, 37, 44, 52, 74, 169, and 170 are classified as Category 2 due to the receptor distance from heavily travelled roads. All other receptors are classified as Category 1.

B.2 DAYTIME ADJUSTMENT

The daytime adjustment recognizes that daytime ambient sound levels are commonly 10 dBA L_{eq} higher than nighttime levels and that nighttime noise disturbances are generally considered less acceptable. The 10 dB daytime adjustment is applicable at all residential receptors.

B.3 CLASS A ADJUSTMENTS

Class A adjustments are based on the nature of the activity and/or actual ambient sound levels. There are two types of Class A adjustments (i.e. A1 and A2) as described in this section. Technical verification should be supplied to use any of the adjustments to the BSL. More than one Class A adjustment may be claimed for permanent facilities if applicable, to a maximum of 10 dBA L_{eq}. Class A adjustment was not considered for the receptors. Further details are presented in the following subsections.

B.3.1 Class A1 Seasonal Adjustment

Class A1 is the seasonal adjustment. The BSL is for summertime conditions. Therefore, a seasonal adjustment may be approved for wintertime complaints. However, operators should not add this adjustment when determining the PSL for design purposes. Seasonal adjustment should only be used when warranted under the best practices guideline. This adjustment is not applicable to the Project because the facility is expected to operate year around.

B.3.2 Class A2 Ambient Monitoring Adjustment

Class A2 is the ambient monitoring adjustment. The ASL is the average sound environment in a given area without contribution from any energy-related industry. An adjustment for an incremental change to the BSL is applicable only when BSL prescribed in the BC OGC Noise Control Guideline reference table are thought not to be representative of the actual sound

environment and when ASLs have been measured. The only two cases where it may be necessary to determine the ambient sound level are:

- areas considered to be pristine;
- areas with non-energy industrial activity that would impact the background noise levels.

In either case, operators should obtain prior approval from the BC OGC to determine if an ambient sound adjustment is applicable. Operators may choose to conduct background noise surveys determining the total noise levels currently existing in an area. The background noise levels include all current noise sources (such as energy-related industry, non-energy industry, transportation). A Class A2 adjustment is not applicable for the receptors as the BSL prescribed in the OGC Noise Control Guideline is considered to be representative.

B.4 CLASS B ADJUSTMENT

These values are intended to permit adjustments to the BSLs based on responses to temporary noise generating activity. In order to use this adjustment, operators should inform residents of the duration and character of the temporary noise. Any activity lasting longer than 60 days is not considered temporary. No Class B adjustment is applicable because the continuous operation of the mine is longer than 60 days.

Appendix C NOISE EMISSION SOURCES

Table C-1 Building Interior Noise Emissions Total Sound Power Level [1]

Building Description [2, 3]	Sound Power Level (dB) in Octave Bands (Hz)									Overall	
	31.5	63	125	250	500	1000	2000	4000	8000	dBA	dB
Coarse Ore Stockpile	113	113	115	115	113	110	108	106	102	116	122
Central Warehouse	116	119	123	114	109	109	107	102	91	115	126
HPGR & Secondary Crusher Building	123	123	125	124	123	120	117	114	111	126	131
Mill Building – Section 1-7	110	112	113	111	109	109	105	101	95	113	119
Mill Building - Section 7-23	113	114	115	116	118	118	117	112	105	123	125
Mill Building - Section 23-24	121	122	123	120	118	118	117	110	102	123	129
Water Intake Pump Station	93	93	95	97	99	100	98	94	87	104	106
Fresh Water Booster Pump Station 1	101	102	103	105	105	107	105	101	95	111	113
Fresh Water Booster Pump Station 2	100	102	103	104	104	107	104	101	94	111	113
Fresh Water Booster Pump Station 3	101	102	103	105	105	107	105	101	95	111	113

NOTES:
[1] Corresponds to Table 4-4 in TDR.
[2] Sound power level does not include the building wall and roof transmission. However, the attenuation effect of building walls and roof is included in the noise model and presented in Table 2.
[3] Breakdown of noise sources inside each building are summarized in Table 4.

Table C-2 Building Exterior Noise Sources[1]

Building Description	Sound Power Level (dB) in Octave Bands (Hz)									Overall	
	31.5	63	125	250	500	1000	2000	4000	8000	dBA	dB
Coarse Ore Stockpile											
Coarse Ore Conveyor	116	116	118	116	116	113	111	109	102	119	124
Coarse Ore Reclaim Area Dust Collector	103	103	103	102	100	99	94	86	78	103	110
Coarse Ore Reclaim Tunnel Ventilation Fan	103	103	103	102	100	99	94	86	78	103	110
Coarse Ore Stockpile Wall [2]	108	102	102	99	84	73	62	58	47	92	110
HPGR And Secondary Crushing Building											
HPGR & Secondary Crushing Electrical Rooms Supply Fan / Filter 1 & Filter 2	81	81	81	80	78	77	72	64	56	81	88
HPGR & Secondary Crushing Building Rollup Door	88	91	90	85	79	75	71	66	65	82	95
HPGR & Secondary Crushing Building Rollup Door	91	94	93	88	82	77	73	69	67	85	98
HPGR & Secondary Crushing Building Rollup Door	90	93	92	87	82	77	73	69	67	84	98
HPGR & Secondary Crushing Building Roof [2]	116	110	110	105	93	81	69	64	53	99	118
HPGR & Secondary Crushing Building Wall [2]	121	114	114	110	97	85	74	68	58	104	123
HPGR Area Dust Collector	105	105	105	104	102	101	96	88	80	105	112
HPGR Feed Bin Vent	92	92	92	91	89	88	83	75	67	92	99
HPGR Feed Conveyor	97	97	91	91	82	82	81	86	86	91	101
HPGR Screen Feed Bin Vent	92	92	92	91	89	88	83	75	67	92	99
HPGR Screen Feed Conveyor	94	94	88	88	79	79	78	83	83	89	99
HPGR Screen Feed Conveyor	95	95	89	89	80	80	79	84	84	90	99
HPGR Screen Oversize Transfer Conveyor	94	94	88	88	79	79	78	83	83	89	99
HPGR Stockpile Wall	107	101	101	98	84	72	62	58	46	92	109

Table C-2 Building Exterior Noise Sources[1]

Building Description	Sound Power Level (dB) in Octave Bands (Hz)									Overall	
	31.5	63	125	250	500	1000	2000	4000	8000	dBA	dB
Crushing Building HVAC	84	87	88	88	87	85	81	77	71	90	95
Crushing Building Upblast Roof Exhaust Fan	97	97	97	96	94	93	88	80	72	97	104
Mill Building											
Mill Building 1 - 7 Bays Roof [2]	103	99	97	93	79	69	58	50	38	87	106
Mill Building 1 - 7 Bays Wall [2]	105	101	99	95	81	71	60	52	40	88	107
Mill Building 23-34 Roof [2]	113	108	107	100	86	78	69	58	44	95	115
Mill Building 7-23 Roof [2]	105	100	99	97	87	78	69	61	47	91	108
Mill Building 23-34 Wall [2]	118	113	112	105	91	82	74	63	48	100	120
Mill Building 7-23 Wall [2]	109	103	102	101	90	81	72	64	50	94	111
Mill Building E Operating Floor Electrical Room Air Conditioning Unit	94	94	94	93	91	90	85	77	69	94	101
Mill Building E Operating Floor Electrical Room Air Cooled Condensing Unit	86	89	90	90	89	87	83	79	73	92	97
Mill Building E Operating Floor Electrical Room Supply Fan / Filter Unit	86	86	86	85	83	82	77	69	61	86	93
Process Plant Building Control Room Air Cooled Condensing Unit	84	87	88	88	87	85	81	77	71	90	95
Process Plant Building Control Room Grinding & Classification Air Conditioning Unit – Fan Coil	91	91	91	90	88	87	82	74	66	91	98
Process Plant Building Control Room Grinding & Classification Supply Fan / Filter Unit	86	86	86	85	83	82	77	69	61	86	93
Process Plant Building Flotation and Regrind Exhaust/Heat Recovery Fan – Compressor / Blower Room	95	95	95	94	92	91	86	78	70	95	102

Table C-2 Building Exterior Noise Sources[1]

Building Description	Sound Power Level (dB) in Octave Bands (Hz)									Overall	
	31.5	63	125	250	500	1000	2000	4000	8000	dBA	dB
Process Plant Building Flotation & Regrind Roof Upblast Exhaust Fan	101	101	101	100	98	97	92	84	76	101	108
Process Plant Building Grinding & Classification Air Cooled Condensing Unit – Offices	84	87	88	88	87	85	81	77	71	90	95
Process Plant Building Grinding & Classification Supply Air Fan – No Heat	100	100	100	99	97	96	91	83	75	100	107
Process Plant Building Grinding & Classification Roof Upblast Exhaust Fan	101	101	101	100	98	97	92	84	76	101	108
Process Plant Building HVAC	84	87	88	88	87	85	81	77	71	90	95
Central Warehouse											
Central Warehouse Axial Exhaust Fan – Lube Oil Storage	87	87	87	86	84	83	78	70	62	87	94
Central Warehouse Roof Exhaust Fan – Wash Bay, FAB and Machine Shop	92	92	92	91	89	88	83	75	67	92	99
Central Warehouse Roof Exhaust Fan – Repair Bay	98	98	98	97	95	94	89	81	73	98	105
Warehouse Truck Shop / Mine Dry Roof [2]	111	108	110	98	81	72	62	54	36	96	115
Warehouse Truck Shop / Mine Dry Wall [2]	112	109	111	99	82	73	63	55	37	96	116
Administration Building											
Administration Building Air Conditioning Unit – Office North and South Zone	90	90	90	89	87	86	81	73	65	90	97
Administration Building Air Conditioning Unit – Server and UPS Room	87	87	87	86	84	83	78	70	62	87	94
Administration Building Exhaust Fan - ENV Lab	90	90	90	89	87	86	81	73	65	90	97

Table C-2 Building Exterior Noise Sources[1]

Building Description	Sound Power Level (dB) in Octave Bands (Hz)									Overall	
	31.5	63	125	250	500	1000	2000	4000	8000	dBA	dB
Administration Building Remote Air Cool Condensing Unit – Core	88	91	92	92	91	89	85	81	75	94	99
Administration Building Remote Air Cooled Condensing Unit – Offices North Zone	81	84	85	85	84	82	78	74	68	87	92
Administration Building Remote Air Cooled Condensing Unit – Offices North and South Zone	84	87	88	88	87	85	81	77	71	90	95
Assay Laboratory											
Assay Laboratory Exhaust Fan – Dust Collector Lab	95	95	95	94	92	91	86	78	70	95	102
Assay Laboratory Exhaust Fan – Perchloric Scrubber	89	89	89	88	86	85	80	72	64	89	96
Ball Mill Electrical Room											
Ball Mill Electrical Room Air Handling Unit	98	98	98	97	95	94	89	81	73	98	105
BHPGR & Secondary Crushing Electrical Rooms											
BHPGR & Secondary Crushing Electrical Rooms Air Cooled Condensing Unit 2	86	89	90	90	89	87	83	79	73	92	97
Main Substation E-House											
Main Substation E-House Air Conditioning Units	84	87	88	88	87	85	81	77	71	90	95
Primary Crusher E-House											
Primary Crusher E-House Air Conditioning Unit1 & Unit 2	85	88	89	89	88	86	82	78	72	91	96

Table C-2 Building Exterior Noise Sources[1]

Building Description	Sound Power Level (dB) in Octave Bands (Hz)									Overall	
	31.5	63	125	250	500	1000	2000	4000	8000	dBA	dB
Tailings Facilities E-House											
Tailings Facilities E-House Air Conditioning Unit 1 & Unit 2	85	88	89	89	88	86	82	78	72	91	96

NOTES:
[1] Corresponds to Table 4-5 in TDR.
[2] Sound transmission loss of building roof or walls included.

Table C-3 Outdoor Noise Sources[1]

Source Description	Sound Power Level (dB) in Octave Bands (Hz)									Overall	
	31.5	63	125	250	500	1000	2000	4000	8000	dBA	dB
Main Conveyor	106	106	100	100	91	91	90	95	95	100	110
Rock Breaker	106	106	101	102	98	97	95	93	89	103	111
Open Pit Primary Crusher	113	112	115	113	114	111	106	102	100	116	121
Primary Crusher Air Compressor System	87	88	88	89	90	92	94	91	86	99	100
Primary Crusher Discharge Apron Feeder	66	69	104	111	99	95	96	100	99	107	113
Primary Crusher Maintenance Crane	50	50	53	55	58	58	57	52	44	63	65
Transformers: 1-1, 1-2, 2-1, 2-2	91	97	99	94	94	88	83	78	71	94	103
Concentrate Area Dust Collector	108	108	108	107	105	104	99	91	83	108	115
Cone Crusher and HPGR Screen and Area Dust Collector	106	106	106	105	103	102	97	89	81	106	113
Cone Crusher Area Dust Collector	97	97	97	96	94	93	88	80	72	97	104
Cone Crusher Feed Bin Vent	92	92	92	91	89	88	83	75	67	92	99
Cone Crusher Screen Feed Conveyor 1	89	89	83	83	74	74	73	78	78	84	94
Cone Crusher Screen Feed Conveyor 2	95	95	89	89	80	80	79	84	84	90	99

NOTE:
[1] Corresponds to Table 4-6 in TDR.

Table C-4 Building Interior Noise Sources

Building and Internal Sound Source	Sound Power Level (dB) in Octave Bands (Hz)[1]									Overall	
	31.5	63	125	250	500	1000	2000	4000	8000	dBA	dB
Coarse Stockpile											
Coarse Ore Reclaim Apron Feeder 5	62	65	100	107	95	91	92	96	95	103	109
Coarse Ore Reclaim Apron Feeder 6	62	65	100	107	95	91	92	96	95	103	109
Coarse Ore Reclaim Apron Feeder 7	62	65	100	107	95	91	92	96	95	103	109
Coarse Ore Reclaim Tunnel Ventilation Fan	103	103	103	102	100	99	94	86	42	102	109
Cone Crusher Screen Feed Conveyor	112	112	114	112	112	109	107	105	98	115	120
Coarse Ore Reclaim Tunnel Ventilation Fan	103	103	103	102	100	99	94	86	78	102	109
HPGR and Secondary Crushing Building											
Cone Crusher and HPGR Screen Area Dust Collector	106	106	106	105	103	102	97	89	81	106	113
Cone Crusher Area Dust Collector	106	106	106	105	103	102	97	89	81	105	112
HPGR Area Dust Collector	105	105	105	104	102	101	96	88	80	105	112
Cone Crusher Feed Bin Vent	92	92	92	91	89	88	83	75	43	92	99
HPGR FEED BIN VENT	92	92	92	91	89	88	83	75	43	92	99
HPGR Screen Feed Bin Vent	92	92	92	91	89	88	83	75	43	92	99
Cone Crusher 1	111	110	113	111	112	109	104	100	98	114	119
Cone Crusher 2	111	110	113	111	112	109	104	100	98	114	119
HPGR 1	116	115	118	116	117	114	109	105	103	119	125
HPGR 2	116	115	118	116	117	114	109	105	103	119	125
Cone Crusher Screen 1	109	109	107	104	104	99	99	96	89	106	114
Cone Crusher Screen 2	109	109	107	104	104	99	99	96	89	106	114
HPGR Screen 5	111	111	109	106	106	101	101	98	91	108	116
HPGR Screen 6	111	111	109	106	106	101	101	98	91	108	116

Table C-4 Building Interior Noise Sources

Building and Internal Sound Source	Sound Power Level (dB) in Octave Bands (Hz)[1]									Overall	
	31.5	63	125	250	500	1000	2000	4000	8000	dBA	dB
Cone Crusher Belt Feeder 11	65	68	103	110	98	94	95	99	98	106	112
Cone Crusher Belt Feeder 12	65	68	103	110	98	94	95	99	98	106	112
HPGR Belt Feeder 21	67	70	105	112	100	96	97	101	100	108	114
HPGR Belt Feeder 22	67	70	105	112	100	96	97	101	100	108	114
HPGR Screen Belt Feeder 25	62	65	100	107	95	91	92	96	95	103	109
HPGR Screen Belt Feeder 26	62	65	100	107	95	91	92	96	95	103	109
Cone Crusher Screen Oversize Transfer Conveyor	95	95	97	95	95	92	90	88	81	98	103
Cone Crusher Feed Conveyor	109	109	111	109	109	106	104	102	95	112	117
Cone Crusher 1 Discharge Conveyor	95	95	97	95	95	92	90	88	81	98	103
Cone Crusher 2 Discharge Conveyor	95	95	97	95	95	92	90	88	81	98	103
Cone Crusher Transfer Conveyor	99	99	101	99	99	96	94	92	85	102	107
HPGR Screen Oversize Conveyor	100	100	102	100	100	97	95	93	86	103	108
HPGR Feed Conveyor	113	113	115	113	113	110	108	106	99	116	121
HPGR Feed Tripper Conveyor	101	101	103	101	101	98	96	94	87	104	109
HPGR 1 Discharge Conveyor	95	95	97	95	95	92	90	88	81	98	103
HPGR 2 Discharge Conveyor	95	95	97	95	95	92	90	88	81	98	103
HPGR Screen Feed Conveyor	112	112	114	112	112	109	107	105	98	115	120
HPGR Screen Tripper Conveyor	101	101	103	101	101	98	96	94	87	104	109
Cone/HPGR Area Crane	73	73	76	78	81	81	80	75	67	86	87
Cone Crusher 1 Lubrication Cooler	100	107	104	97	92	89	85	81	76	95	109
Cone Crusher 2 Lubrication Cooler	100	107	104	97	92	89	85	81	76	95	109
HPGR 1 Lubrication Cooler	100	107	104	97	92	89	85	81	76	95	109

Table C-4 Building Interior Noise Sources

Building and Internal Sound Source	Sound Power Level (dB) in Octave Bands (Hz)[1]									Overall	
	31.5	63	125	250	500	1000	2000	4000	8000	dBA	dB
HPGR 2 Lubrication Cooler	100	107	104	97	92	89	85	81	76	95	109
Mill Building Section 1-7											
Concentrate Filter Press	106	110	110	108	104	102	95	93	92	107	115
Concentrate Filter Feed Tank Agitator	86	86	89	91	94	94	93	88	80	99	100
Concentrate Thickener Underflow Pump 1	82	83	85	87	89	90	88	83	76	94	96
Concentrate Thickener Overflow Pump 1	89	90	91	93	95	96	95	90	83	101	102
Concentrate Filter Feed Pump 1	96	97	99	101	103	104	102	97	90	108	110
Filtrate Pump 1	80	81	82	84	85	87	85	80	74	91	93
Concentrate Stockpile Feed Conveyor	99	99	101	99	99	96	94	92	85	102	107
Concentrate Area Dust Collector	108	108	108	107	105	104	99	91	83	107	114
Mill Building Section 7-23											
Rougher Flotation Line 1 Cell 1 Agitator	96	96	99	101	104	104	103	98	90	109	110
Rougher Flotation Line 1 Cell 2 Agitator	96	96	99	101	104	104	103	98	90	109	110
Rougher Flotation Line 1 Cell 3 Agitator	96	96	99	101	104	104	103	98	90	109	110
Rougher Flotation Line 1 Cell 4 Agitator	96	96	99	101	104	104	103	98	90	109	110
Rougher Flotation Line 1 Cell 5 Agitator	96	96	99	101	104	104	103	98	90	109	110
Rougher Flotation Line 1 Cell 6 Agitator	96	96	99	101	104	104	103	98	90	109	110
Rougher Flotation Line 2 Cell 7 Agitator	96	96	99	101	104	104	103	98	90	109	110
Rougher Flotation Line 2 Cell 8 Agitator	96	96	99	101	104	104	103	98	90	109	110
Rougher Flotation Line 2 Cell 9 Agitator	96	96	99	101	104	104	103	98	90	109	110
Rougher Flotation Line 2 Cell 10 Agitator	96	96	99	101	104	104	103	98	90	109	110
Rougher Flotation Line 2 Cell 11 Agitator	96	96	99	101	104	104	103	98	90	109	110

Table C-4 Building Interior Noise Sources

Building and Internal Sound Source	Sound Power Level (dB) in Octave Bands (Hz)[1]									Overall	
	31.5	63	125	250	500	1000	2000	4000	8000	dBA	dB
Rougher Flotation Line 2 Cell 12 Agitator	96	96	99	101	104	104	103	98	90	109	110
Conditioning Tank 15 Agitator	93	93	96	98	101	101	100	95	87	106	107
Conditioning Tank 16 Agitator	93	93	96	98	101	101	100	95	87	106	107
1st Cleaner Flotation Cell 21 Agitator	89	89	92	94	97	97	96	91	83	102	103
1st Cleaner Flotation Cell 22 Agitator	89	89	92	94	97	97	96	91	83	102	103
1st Cleaner Flotation Cell 23 Agitator	89	89	92	94	97	97	96	91	83	102	103
1st Cleaner Flotation Cell 24 Agitator	89	89	92	94	97	97	96	91	83	102	103
2nd Cleaner Flotation Cell 31 Agitator	76	76	79	81	84	84	83	78	70	89	90
2nd Cleaner Flotation Cell 32 Agitator	76	76	79	81	84	84	83	78	70	89	90
2nd Cleaner Flotation Cell 33 Agitator	76	76	79	81	84	84	83	78	70	89	90
2nd Cleaner Flotation Cell 34 Agitator	76	76	79	81	84	84	83	78	70	89	90
2nd Cleaner Flotation Cell 35 Agitator	76	76	79	81	84	84	83	78	70	89	90
2nd Cleaner Flotation Cell 36 Agitator	76	76	79	81	84	84	83	78	70	89	90
Cleaner Scavenger Flotation Cell 41 Agitator	83	83	86	88	91	91	90	85	77	96	97
Cleaner Scavenger Flotation Cell 42 Agitator	83	83	86	88	91	91	90	85	77	96	97
Cleaner Scavenger Flotation Cell 43 Agitator	83	83	86	88	91	91	90	85	77	96	97
Cleaner Scavenger Flotation Cell 44 Agitator	83	83	86	88	91	91	90	85	77	96	97
Cleaner Scavenger Flotation Cell 45 Agitator	83	83	86	88	91	91	90	85	77	96	97
Primary Regrind Cyclone Feed Pump 1	97	98	100	102	104	105	103	98	91	109	111
Primary Regrind Feed Pump 1	90	91	93	95	97	98	96	91	84	102	104
Primary Regrind Discharge Pump 1	90	91	93	95	96	98	96	91	84	102	103
Primary Regrind Media Pump	81	81	83	85	86	88	85	81	75	92	93

Table C-4 Building Interior Noise Sources

Building and Internal Sound Source	Sound Power Level (dB) in Octave Bands (Hz)[1]									Overall	
	31.5	63	125	250	500	1000	2000	4000	8000	dBA	dB
1st Cleaner Feed Pump 1	95	96	98	100	101	103	101	96	89	107	109
2nd Cleaner Tailings Pump 1	82	83	84	86	87	89	87	83	76	93	95
2nd Cleaner Feed Pump 1	82	83	84	86	87	89	87	83	76	93	95
Cleaner Scavenger Concentrate Transfer Pump 1	84	84	86	88	90	91	90	85	78	96	97
Cleaner Scavenger Tailings Pump 1	95	95	97	99	101	102	100	96	89	106	108
Secondary Regrind Cyclone Feed Pump 1	90	90	92	94	96	97	95	91	84	101	103
Secondary Regrind Feed Pump 1	88	88	90	92	94	95	93	89	82	99	101
Secondary Regrind Media Pump	80	81	82	84	85	87	85	80	74	91	93
Gravity Concentrate Feed Pump 1	92	93	94	96	98	99	97	93	86	103	105
Flotation Area Overhead Crane	71	71	74	76	79	79	78	73	65	84	85
Regrind Area Crane	71	71	74	76	79	79	78	73	65	84	85
Tailings Pump 1	98	99	101	102	102	104	102	98	92	108	110
Tailings Booster Pump 1	98	99	101	102	102	104	102	98	92	108	110
Primary Regrind Mill	107	108	107	106	104	105	105	96	86	110	115
Secondary Regrind Mill	103	104	103	101	100	101	100	91	81	105	110
Concentrate Thickener Feed Pump 1	85	86	88	90	91	93	91	86	79	97	98
Coarse Ore Stockpile Air Compressor 1	90	91	91	92	93	95	97	94	89	102	103
Process Plant Compressor 1	90	91	91	92	93	95	97	94	89	102	103
Filter Press Compressor 1	90	91	91	92	93	95	97	94	89	102	103
Process Plant Instrument Air Compressor 1	90	91	91	92	93	95	97	94	89	102	103
Lime Discharge Screw Feeder	62	65	100	107	95	91	92	96	95	103	109
Lime Slaking Mill	92	92	92	90	88	89	89	80	70	94	99

Table C-4 Building Interior Noise Sources

Building and Internal Sound Source	Sound Power Level (dB) in Octave Bands (Hz)[1]									Overall	
	31.5	63	125	250	500	1000	2000	4000	8000	dBA	dB
Floatation Aeration Blower 1	102	102	102	101	99	98	93	85	77	102	109
Floatation Aeration Blower 2	102	102	102	101	99	98	93	85	77	102	109
Lime Blower	98	98	98	97	95	94	89	81	73	98	105
Lime Silo Dust Collector	94	94	94	93	91	90	85	77	69	94	101
Lime Area Dust Collector	94	94	94	93	91	90	85	77	69	94	101
Lime Holding Tank Agitator	71	71	74	76	79	79	78	73	65	84	85
Tailings Reclaim Pump 1	96	98	99	100	100	102	100	97	90	106	109
Reclaim Booster Station Pump 1	96	98	99	100	100	102	100	97	90	106	109
Process Water Distribution Pump 1	93	94	96	98	99	101	98	94	87	105	106
Low Pressure Gland Service Water Distribution Pump 1	81	81	83	85	86	88	85	81	75	92	93
High Pressure Gland Service Water Distribution Pump 1	84	85	86	88	90	91	89	85	78	95	97
Fresh Water Distribution Pump 1	93	94	96	98	99	101	98	94	87	105	106
MIBC Transfer Pump	79	80	81	83	84	86	84	79	73	90	92
Mill Building Section 23-34											
Cyclone 1 Feed Pump 1	98	100	101	102	102	104	102	99	92	108	110
Cyclone 2 Feed Pump 3	98	100	101	102	102	104	102	99	92	108	110
Ball Mill 1	116	116	116	114	112	113	113	104	94	118	123
Ball Mill 2	116	116	116	114	112	113	113	104	94	118	123
Grinding Area Crane	91	91	89	84	85	92	84	76	67	93	97
Ball Mill Loading Pocket Conveyor	95	95	97	95	95	92	90	88	81	98	103
Ball Mill Transfer Conveyor	95	95	97	95	95	92	90	88	81	98	103

Table C-4 Building Interior Noise Sources

Building and Internal Sound Source	Sound Power Level (dB) in Octave Bands (Hz)[1]									Overall	
	31.5	63	125	250	500	1000	2000	4000	8000	dBA	dB
Caterpillar 777F Track idling	113	116	120	111	106	106	104	99	88	112	123
Ball Mill Autocharge	62	65	100	107	95	91	92	96	95	103	109
Transfer House	116	116	116	114	112	111	109	103	96	116	123
Central Warehouse											
Central Warehouse Truck Wash Booster Pump	79	80	81	83	84	86	84	79	73	90	92
Caterpillar 777F Track idling	113	116	120	111	106	106	104	99	88	112	123
Caterpillar 777F Track idling	113	116	120	111	106	106	104	99	88	112	123
Water Intake Pump Station											
Water Intake Booster Inline Pump No.1	93	93	95	97	99	100	98	94	87	104	106
Fresh Water Booster Station 1											
Fresh Water Booster Station 1 Pump 1	96	97	99	100	100	102	100	96	90	106	108
Fresh Water Booster Station 1 Pump 2	96	97	99	100	100	102	100	96	90	106	108
Fresh Water Booster Station 1 Pump 3	96	97	99	100	100	102	100	96	90	106	108
Fresh Water Booster Station 2											
Fresh Water Booster Station 2 Pump 1	96	97	99	100	100	102	100	96	90	106	108
Fresh Water Booster Station 2 Pump 2	96	97	99	100	100	102	100	96	90	106	108
Fresh Water Booster Station 2 Pump 3	96	97	99	100	100	102	100	96	90	106	108
Fresh Water Booster Station 3											
Fresh Water Booster Station 3 Pump 1	96	97	99	100	100	102	100	96	90	106	108
Fresh Water Booster Station 3 Pump 2	96	97	99	100	100	102	100	96	90	106	108
Fresh Water Booster Station 3 Pump 3	96	97	99	100	100	102	100	96	90	106	108

NOTE:
1. Sound power levels represent raw power per unit of equipment.

Table C-5 Fleet Equipment Overall Sound Power Summary

Equipment	Sound Power Level (dB) in Octave Bands (Hz)[1]									Overall	
	31.5	63	125	250	500	1000	2000	4000	8000	dBA	dBC
Fleet Primary Equipment											
Haul Trucks (290T)	113	122	128	119	117	115	111	106	103	120	130
76 yard Shovel _P&H 4100 XPB	113	112	112	112	119	117	115	112	108	122	124
Loaders - L1850	119	119	117	110	113	112	109	102	90	116	123
Drills -140/311 mm	107	110	119	115	113	112	110	105	101	117	122
152mm Preshear Drills	107	110	119	115	113	112	110	105	101	117	122
Track Dozers - Cat D10	103	106	116	110	106	105	103	98	90	110	118
Rubber Tire Dozers (WD 600)	110	104	119	113	109	109	106	100	91	113	121
Graders - Cat 16M	104	109	114	112	110	110	104	100	95	114	119
Water Trucks (20k gallon HD785)	106	108	115	110	108	107	104	99	90	112	118
Fleet Support Equipment											
Excavator - 4.5m3 bucket CAT374Dl	110	115	108	107	107	103	101	98	93	109	117
Cable Reeler – FEL mounted	102	107	112	109	102	102	99	91	85	107	115
Truck mounted cable reel c/w hydraulic arm Ground Force	102	107	112	109	102	102	99	91	85	107	115
Mobile Cable Repair Station	93	96	99	96	90	94	94	83	74	99	103
Shovel Lube truck	93	96	99	96	90	94	94	83	74	99	103
Pickup Trucks	93	96	99	96	90	94	94	83	74	99	103
Fire truck	110	115	108	107	107	103	101	98	93	109	117
Ambulance	93	96	99	96	90	94	94	83	74	99	103
100 ton Tow truck and low bed trailer	113	122	128	119	117	114	111	105	103	120	129
Loader for the load-out	104	104	96	94	94	93	90	89	80	98	107
Extend a-boom loader	104	104	96	94	94	93	90	89	80	98	107
Crane for the Tailings	109	109	105	94	90	87	85	79	74	95	111
Dump Truck	113	113	102	106	101	101	102	95	91	107	116

Table C-5 Fleet Equipment Overall Sound Power Summary

Equipment	Sound Power Level (dB) in Octave Bands									Overall	
Backhoe Extend Hoe CAT IT420E	100	100	91	95	95	91	90	84	78	97	104
Forklift, CAT DP30	108	108	106	92	93	90	89	88	79	97	111
Forklift, CAT DP60	96	96	101	98	100	95	92	84	79	101	106
Forklift Dynalift Reachform	97	97	101	98	100	95	92	84	79	101	106
Hyster 80 Forklift	97	97	101	98	100	95	92	84	79	101	106
CAT MC30 Forklift	108	108	106	92	93	90	89	88	79	97	111
Crane, Mobile RT528C, 28 TON	103	103	101	98	100	96	93	84	79	101	107
Wacker Yard Light Model LTC4C	94	101	99	96	87	87	86	84	77	94	104
Mechanic's Service truck	93	96	99	96	90	94	94	83	74	99	103
CAT Skid Steer 246B	101	101	92	96	96	92	91	85	79	98	104
Boom Truck 95 Ford	106	109	106	104	102	100	97	92	84	105	113
Boom Truck Ford w/ Man Basket	106	109	106	104	102	100	97	92	84	105	113
Crane, F80 Boom Truck	106	109	106	104	102	100	97	92	84	105	113
Ford L-8000 Boom Truck	106	109	106	104	102	100	97	92	84	105	113
Crane, JLG	109	109	105	94	90	87	85	79	74	95	111
2008 Genie 45' Man Lift	109	109	105	94	90	87	85	79	74	95	111
Knuckle Boom, F800, N-50	109	109	105	94	90	87	85	79	74	95	111
Miller Big Blue Air Pac Welder	103	103	100	95	96	98	94	90	88	101	107
Welder 400AMP DSL TRLR MTD	103	103	100	95	96	98	94	90	88	101	107
Welder600 AMP	103	103	100	95	96	98	94	90	88	101	107
Kenworth Lube truck	95	98	101	98	92	96	96	85	76	100	105
Carry Deck Crane 15 ton	109	109	105	94	90	87	85	79	74	95	111
Loader For Ball Mill Media & Misc Work CAT 966	110	110	110	99	101	97	95	94	86	103	114
Explosives transport	116	116	110	105	107	108	107	101	95	113	119

NOTE:
1. Sound power levels represent raw power per unit of equipment.

Table C-6 Fleet Equipment Adjusted Sound Power Summary per Phase

Equipment	Sound Power Level (dB) in Octave Bands (Hz)[1]									Overall	
	31.5	63	125	250	500	1000	2000	4000	8000	dBA	dBC
Fleet Primary Equipment – Year -1											
Haul Trucks (290T)	109	118	124	115	113	110	107	101	99	116	125
76 yard Shovel _P&H 4100 XPB	110	108	109	109	116	113	112	109	105	119	120
Loaders - L1850	113	113	111	104	107	106	103	96	84	111	118
Drills -140/311 mm	90	93	102	97	95	94	93	88	83	99	105
152mm Preshear Drills	-	-	-	-	-	-	-	-	-	-	-
Track Dozers - Cat D10	103	106	116	110	106	105	103	98	90	110	118
Rubber Tire Dozers (WD 600)	104	98	113	107	103	103	100	95	86	108	115
Graders - Cat 16M	103	108	113	111	109	109	103	99	94	113	118
Water Trucks (20k gallon HD785)	102	104	111	106	104	103	100	95	86	108	114
Fleet Primary Equipment – Year 2											
Haul Trucks (290T)	109	118	124	115	113	110	107	101	99	115.9	125
76 yard Shovel _P&H 4100 XPB	115	113	114	113	121	118	117	114	110	123.5	125
Loaders - L1850	113	113	111	104	107	106	103	96	84	110.5	118
Drills -140/311 mm	105	108	117	113	111	110	108	103	99	115.1	120
152mm Preshear Drills	105	108	117	112	110	109	108	103	98	114.5	120
Track Dozers - Cat D10	105	108	117	112	107	107	104	100	92	111.9	119
Rubber Tire Dozers (WD 600)	109	103	118	112	108	108	105	99	91	112.5	120
Graders - Cat 16M	104	109	114	112	111	110	105	101	96	113.8	119
Water Trucks (20k gallon HD785)	104	106	113	108	106	105	102	97	88	109.4	116

Table C-6 Fleet Equipment Adjusted Sound Power Summary per Phase

Equipment	Sound Power Level (dB) in Octave Bands (Hz)[1]									Overall	
	31.5	63	125	250	500	1000	2000	4000	8000	dBA	dBC
Fleet Primary Equipment – Year 4/8											
Haul Trucks (290T)	109	118	124	115	113	110	107	101	99	109	118
76 yard Shovel _P&H 4100 XPB	115	113	114	113	121	118	117	114	110	115	113
Loaders - L1850	113	113	111	104	107	106	103	96	84	113	113
Drills -140/311 mm	106	109	118	114	112	111	109	104	100	106	109
152mm Preshear Drills	105	108	117	112	110	109	108	103	98	105	108
Track Dozers - Cat D10	105	108	117	112	107	107	104	100	92	105	108
Rubber Tire Dozers (WD 600)	109	103	118	112	108	108	105	99	91	109	103
Graders - Cat 16M	104	109	114	112	111	110	105	101	96	104	109
Water Trucks (20k gallon HD785)	105	107	114	109	107	106	103	98	89	105	107
Fleet Support Equipment – Year -1, Year 2, Year 4/8[2]											
Excavator - 4.5m3 bucket CAT374Dl	109	114	107	106	106	102	100	97	92	108	116
Cable Reeler – FEL mounted	98	103	108	105	98	98	95	87	81	103	111
Truck mounted cable reel c/w hydraulic arm Ground Force	98	103	108	105	98	98	95	87	81	103	111
Mobile Cable Repair Station	89	92	95	92	86	90	90	79	70	94	99
Shovel Lube truck	84	87	90	87	81	85	85	74	65	90	95
Pickup Trucks	100	103	106	103	97	101	101	90	81	105	110
Fire truck	92	97	90	89	89	85	83	80	75	91	100
Ambulance	75	78	81	78	72	76	76	65	56	81	86
100 ton Tow truck and low bed trailer	104	113	119	110	108	106	102	96	94	111	121
Loader for the load-out	99	99	91	89	89	88	85	84	75	92	101
Extend a-boom loader	96	96	88	86	86	85	82	81	72	89	98

Table C-6 Fleet Equipment Adjusted Sound Power Summary per Phase

Equipment	Sound Power Level (dB) in Octave Bands (Hz)[1]									Overall	
	31.5	63	125	250	500	1000	2000	4000	8000	dBA	dBC
Crane for the Tailings	103	103	99	88	84	81	79	73	68	89	106
Dump Truck	109	109	98	102	97	97	98	91	87	103	111
Backhoe Extend Hoe CAT IT420E	91	91	82	86	86	82	81	75	69	88	95
Forklift, CAT DP30	103	103	101	87	88	85	84	83	74	92	106
Forklift CAT DP60	92	92	96	93	95	91	88	79	74	96	101
Forklift Dynalift Reachfork	93	93	96	93	95	91	88	79	74	96	101
Hyster 80 Forklift	92	92	96	93	95	91	88	79	74	96	101
CAT MC30 Forklift	108	108	106	92	93	90	89	88	79	97	111
Crane, Mobile RT528C, 28 Ton	97	97	95	92	94	90	87	78	73	95	102
Wacker Yard Light Model LTC4C	97	104	102	99	90	90	89	87	80	97	107
Mechanic's Service truck	92	95	98	95	89	93	93	82	73	97	102
CAT Skid Steer 246B	97	97	88	92	92	88	87	81	75	94	100
Boom Truck 95 Ford	102	105	102	100	98	96	93	88	80	101	108
Boom Truck Ford w/ Man Basket	102	105	102	100	98	96	93	88	80	101	108
Crane, F80 Boom Truck	100	103	100	98	96	94	91	86	78	99	107
Ford L-8000 Boom Truck	102	105	102	100	98	96	93	88	80	101	108
Crane, JLG	103	103	99	88	84	81	79	73	68	89	106
2008 Genie 45' Man Lift	105	105	101	90	86	83	81	75	70	90	107
KNUCKLE BOOM, F800, N-50	105	105	101	90	86	83	81	75	70	90	107
Miller Big Blue Air Pac Welder	97	97	94	89	90	92	88	84	82	96	101
Welder 400AMP DSL TRLR MTD	94	94	91	86	87	89	85	81	79	93	98
Welder 600 AMP	100	100	97	92	93	95	91	87	85	99	104

Table C-6 Fleet Equipment Adjusted Sound Power Summary per Phase

Equipment	Sound Power Level (dB) in Octave Bands (Hz)[1]									Overall	
	31.5	63	125	250	500	1000	2000	4000	8000	dBA	dBC
Kenworth Lube truck	90	93	96	93	87	91	91	80	71	96	101
Carry Deck Crane 15 ton	103	103	99	88	84	81	79	73	68	89	106
Loader For Ball Mill Media & Misc Work CAT 966	101	101	101	90	92	88	86	85	77	95	105
Explosives transport	98	98	92	87	89	90	89	83	77	95	101

NOTES:

1 Sound power levels are inclusive of adjustments for quantity, working hours and load factor (utilization). Refer to Table C-7.

2 Sound power levels of support equipment for Year-1, Year2 and Year4/8 are equal. Refer to Table C-8.

Table C-7 Fleet Primary Equipment Quantity, Working Hours and Load Factor By Phase

Equipment	Year -1				Year 2				Year 4/8			
	Quantity	Working Hours		Load Factor	Quantity	Working Hours		Load Factor	Quantity	Working Hours		Load Factor
		Day	Night			Day	Night			Day	Night	
Haul Trucks (290T)	5	11.9	7.1	0.37	17	11.9	7.1	0.37	28	11.9	7.1	0.37
76 yard Shovel _P&H 4100 XPB	1	11.9	7.1	0.59	3	11.9	7.1	0.59	3	11.9	7.1	0.59
Loaders - L1850	1	11.3	6.8	0.37	1	11.3	6.8	0.37	1	11.3	6.8	0.37
Drills -140/311 mm	1	0.6	0.4	0.43	3	8.1	4.9	0.43	3	9.4	5.6	0.43
152mm Preshear Drills	0	10.6	6.4	0.43	2	10.6	6.4	0.43	2	10.6	6.4	0.43
Track Dozers - Cat D10	4	9.4	5.6	0.40	6	9.4	5.6	0.40	6	9.4	5.6	0.40
Rubber Tire Dozers (WD 600)	1	9.4	5.6	0.43	3	9.4	5.6	0.43	3	9.4	5.6	0.43
Graders - Cat 16M	3	9.4	5.6	0.43	4	9.4	5.6	0.43	4	9.4	5.6	0.43
Water Trucks (20k gallon HD785)	3	10.6	6.4	0.21	4	10.6	6.4	0.21	5	10.6	6.4	0.21

Table C-8 Fleet Support Equipment Quantity, Working Hours and Load Factor By Phase

Equipment	Year -1, Year 2, Year 4/8			
	Quantity	Working Hours		Load Factor
		Day	Night	
Excavator - 4.5m3 bucket CAT374DI	2	9.4	5.6	0.59
Cable Reeler – FEL mounted	1	9.4	5.6	0.59
Truck mounted cable reel c/w hydraulic arm Ground Force	1	9.4	5.6	0.59
Mobile Cable Repair Station	1	9.4	5.6	0.59
Shovel Lube truck	1	9.4	5.6	0.21
Pickup Trucks	35	9.4	5.6	0.21
Fire truck	1	1.3	0.8	0.21
Ambulance	1	1.3	0.8	0.21
100 ton Tow truck and low bed trailer	1	9.4	5.6	0.21
Loader for the load-out	2	9.4	5.6	0.21
Extend a-boom loader	1	9.4	5.6	0.21
Crane for the Tailings	1	9.4	5.6	0.43
Dump Truck	1	9.4	5.6	0.59
Backhoe Extend Hoe CAT IT420E	1	9.4	5.6	0.21
Forklift, CAT DP30	1	9.4	5.6	0.59
Forklift CAT DP60	1	9.4	5.6	0.59
Forklift Dynalift Reachfork	1	9.4	5.6	0.59
Hyster 80 Forklift	1	9.4	5.6	0.59
CAT MC30 Forklift	3	9.4	5.6	0.59
Crane, Mobile RT528C, 28 Ton	1	9.4	5.6	0.43
Wacker Yard Light Model LTC4C	8	9.4	5.6	0.43

Table C-8 Fleet Support Equipment Quantity, Working Hours and Load Factor By Phase

Equipment	Year -1, Year 2, Year 4/8			
	Quantity	Working Hours		Load Factor
		Day	Night	
Mechanic's Service truck	2	9.4	5.6	0.59
CAT Skid Steer 246B	3	9.4	5.6	0.21
Boom Truck 95 Ford	1	9.4	5.6	0.59
Boom Truck Ford w/ Man Basket	1	9.4	5.6	0.59
Crane, F80 Boom Truck	1	9.4	5.6	0.43
Ford L-8000 Boom Truck	1	9.4	5.6	0.59
Crane, JLG	1	9.4	5.6	0.43
2008 Genie 45' Man Lift	1	9.4	5.6	0.59
KNUCKLE BOOM, F800, N-50	1	9.4	5.6	0.59
Miller Big Blue Air Pac Welder	2	9.4	5.6	0.21
Welder 400AMP DSL TRLR MTD	1	9.4	5.6	0.21
Welder 600 AMP	4	9.4	5.6	0.21
Kenworth Lube truck	1	9.4	5.6	0.59
Carry Deck Crane 15 ton	1	9.4	5.6	0.43
Loader For Ball Mill Media & Misc Work CAT 966	1	9.4	5.6	0.21
Explosives transport	1	0.4	0.2	0.59

Appendix D AJAX MINE BLAST REVIEW – CONCLUSIONS AND RECOMMENDATION

AJAX MINE BLAST REVIEW, CONCLUSIONS AND RECOMMENDATIONS

Prepared for

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AJAX MINE BLAST REVIEW, CONCLUSIONS AND RECOMMENDATIONS

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BLASTING ANALYSIS INTERNATIONAL, INC.

SUMMARY OF CONCLUSIONS, RECOMMENDATIONS AND OPINIONS

Blasting Analysis International (BAI) was commissioned by KGHM International (KGHM) in May, 2014 to:

- Conduct a thorough blast review, using the new rock properties, mine plans and technical changes.

- Develop blast designs to eliminate structural damage and minimize annoyance effects from blast induced ground vibrations and airblast, which could emanate into the nearby communities, residential homes, businesses, towers and other free standing structures.

- Develop blast designs to protect aquatic life in Jacko Lake during the spawning period, by complying with the maximum allowable ground vibration level of 13 mm/s, and the maximum allowable airblast level of 100 kPa, as stipulated by the DFO (Department of Fisheries and Ocean Canada).

- Predict the ground vibration and airblast amplitudes at 30 other areas of concern within the nearby communities.

- Predict the ROM (Run of Mine) fragmentation distributions in the ore and mine rock, with the recommended blast designs to satisfy the plant requirements.

- Provide detailed blast designs and field procedures for presplitting the final highwalls.

- Provide advice on the necessary field controls to eliminate explosive performance problems, noxious fumes and nitrate residues to prevent groundwater contamination.

- Recommend procedures for blast notifications, warning signage, blast clearance, communications, five minute count down just prior to blasting, and post blast inspections.

- Advice on the safety radii offset for equipment and people.

- Recommend safe procedures for electrical storms, pertaining to safe distances, evacuation procedures and monitoring lightning activity.

Primary conclusions, recommendations and opinions are listed as follows:

1. A total of 30 structures and areas surrounding the mine were identified, which would be subject to blast induced ground vibrations and airblast. These included residential homes, industrial structures, communication towers, road cuts, storage tanks, official and unofficial recreational areas, and other open areas. From the recommended blast designs, the average predicted ground vibration level expected at these locations is 1.09 mm/s, and the average airblast level is 109 dBL. To be very conservative with the predictions, distances to the 30 locations were always taken from the final pit boundary, and a maximum weight of explosives/delay of 1,020 kg was used for all production blasts using the 311 mm holes. Refer to Section 4.0 for all of the specific predictions at each of the 30 locations.

2. The USBM (United States Bureau of Mines) safe blast damage criteria were used as guidelines to eliminate structural damage to all structures in the surrounding communities to the mine. The USBM studies completed in 1981 are still the most comprehensive, and they are used in over 90% of the countries in the world. The USBM recommended a maximum ground vibration level of 19 mm/s to 51 mm/s (depending on the predominant frequencies), and a maximum airblast level of 133 dBL to eliminate cosmetic hairline cracks in drywall. In most residential and commercial structures, drywall is usually the most sensitive structural component member to blast induced ground vibrations. Refer to Section 2.0 for more details on the specific damage thresholds for all other materials.

   There are no regulations in British Columbia, which outline maximum allowable ground vibrations or airblast levels. Other than in Ontario, the author is not aware of any ground vibration/airblast regulations in the other provinces. But the Ontario regulations are a very close derivative of the USBM recommendations.

3. Because the predicted ground vibrations (i.e. 1 – 2 mm/s) are an order of magnitude lower than the minimum vibration level that will cause cracks in drywall at 19 mm/s, it is highly unlikely that blasting can cause any structural damage to any of the free standing structures in all of the surrounding communities. A 1 – 2 mm/s vibration is equivalent to a grown up walking briskly across an uncarpeted floor. The recommended factor of safety for blast designs described in this report ranges from 9 to740 to eliminate the risk of any cosmetic or structural damage to mine infrastructure and the surrounding community. The factor of safety for homes in Kamloops, which are closest to the blast zones, is approximately 17. The factor of safety is dependent on the maximum weight of explosives/delay, distance from the blast, and the damage threshold for drywall. To put the factor of safety into some perspective, public bridges for pedestrian and vehicle traffic are typically designed with a factor of safety between 1.5 and 2.0.

4. The average predicted airblast level of 109 dBL in the 30 areas of concern surrounding the mine, is well under the USBM safe recommended level of 133 dBL. Thus, it is also highly unlikely that any blast induced airblast can cause any cosmetic or structural damage. Damage from airblast usually starts with cracked window glass panes. At 150 dBL, some single pane glass windows will begin to crack.

5. Ground vibrations and airblast resulting from the blasting will have minimal, if any detrimental effects, on the surrounding wildlife, domesticated animals or at the TLC Pet Boarding facility. Animals typically become stressed when they are startled by an unfamiliar sound, which must be accompanied by visual and odor effects. These three things will trigger the animal into survival mode to either flee or defend itself. Unless the disturbance is accompanied with a visual and odor effect, animals will very quickly adapt to the ground vibrations and airblast disturbances as non-threatening. Refer to Section 4.3 for more details.

   In reference to the TLC Pet Boarding Facility, which is located approximately 4,231 m from the pit boundary, the predicted ground vibration level is 0.46 mm/s, and the predicted airblast level is 109 dBL. Both of these levels are so low, that the blasting would have no detrimental effects on the pets.

6. A legitimate concern, which often comes up with homeowners, is that of repeated blasting. Even when ground vibration levels are very low, could repeated blasting over the 20 – 23 year mine life cause fatigue and ultimately structural damage? Based on the USBM data, predicted ground vibration levels of under 2 mm/s, and an average of four blasts/week, fatigue in the residential homes would not set in for at least 622 years.

7. The maximum allowable ground vibration and airblast levels to protect fish in Jacko Lake during the spawning period are 13 mm/s and 100kPa, respectively. These maximum levels are stipulated by the DFO (Department of Fisheries and Oceans Canada), and they dictate the maximum weight of explosives/delay, which can be used in the blasts approaching Jacko Lake. In order to comply with this, the maximum weight of explosives/delay must be incrementally reduced from 1,020 kg in Zone 1 to 68 kg beyond Zone 3, by using explosive decks, smaller diameter 152 mm holes, or both. Refer to Section 3.0 for details on the blast designs, blast zones, hole loads, and cautionary notes when using explosive decking and stem charges.

8. A ground vibration/airblast monitoring program with six seismographs and one weather station is recommended. This is required for compliance, maintaining transparency within the nearby communities, developing predictive linear regression equations for future use, and to help resolve any disputes as to what actually took place on the blasts. Good record keeping for this will be essential. Refer to Section 5.0 for details on the proposed monitoring program, important blast, seismic and airblast information to record, and an example linear regression analysis.

9. A total of 35 predictive fragmentation runs were done using a combination of drill patterns, top stemmings, stem charges, full column loads, and explosive decks with 311 mm and 152 mm holes. The processing plant requires a specific ROM fragmentation distribution in the ore with the 100% passing size as 1100 mm. Preference in the ROM mine rock fragmentation is the same 100% passing at 1100 mm, but with a coarser intermediate fragmentation distribution. The predicted ore blast fragmentation distributions came very close to the plant requirements. But some of the predicted mine rock fragmentation distribution requirements did not, primarily because of the imposed vibration/airblast limits at Jacko Lake. Thus, some compromises with the mine rock fragmentation requirements were necessary. The final selected ore and mine rock blast designs are listed Table 1. Refer to Section 6.1 and Appendix A for the detailed fragmentation distribution results. In any case, all of the blast designs for the 33 predictive fragmentation runs comply with the vibration and airblast restrictions at Jacko Lake.

Table 1 – Selected Blast Designs for Use in the Ore and Mine Rock

Run No.	Blast Zone	Material	Hole Diam. (mm)	Bench Height (m)	Hole Depth (m)	Drill Pattern B x S (m x m)	Top Stem. (m)	Subgrade (m)	Stem Charge Mass (Kg)	No. of Expl. Decks Per Hole	No. of Primers Plus Dets. Per Hole	Max. Weight Expl. Per Delay (Kg)	Total Expl. Per Hole (Kg)	Powder Factor (Kg/t)	100% Passing Size (mm)
R4a	Up to Z1	Ore	311	15	16.5	8.5 x 8.5	6	1.5	64	1	3 + 3	1020	1020	0.331	1980
R6	Z1 - Z2	Ore	311	15	16.5	8.0 x 8.0	6	1.5	64	2	3 + 3	328	720	0.264	1200
R13	Z2 - Z3	Ore	152	15	16.5	4.0 x 4.0	2.8	1.5	None	2	2 + 2	127.5	255	0.375	850
R15a	Beyond Z3	Ore	152	15	16.5	4.2 x 4.2	2.8	1.5	None	3	3 + 3	68	204	0.271	1130
R9a	Up to Z1	Waste	311	15	16.5	8.0 x 8.0	6	1.5	None	1	2 + 2	956	956	0.321	2230
R12e	Z1 - Z2	Waste	311	15	16.5	10 x 10	6	1.5	64	2	3 + 3	328	720	0.155	2020
R14c	Z2 - Z3	Waste	152	15	16.5	5.2 x 5.2	2.8	1.5	None	2	2 + 2	127.5	255	0.203	1620
R16c	Beyond Z3	Waste	152	15	16.5	4.8 x 4.8	2.8	1.5	None	3	3 + 3	68	204	0.190	1570

10. Implementing good field controls will be critical when blasting begins, due to the vibration and airblast restrictions at Jacko Lake, and people's sensitivity to the blasting and environment. A number of specific recommendations and procedures are outlined in Sections 8.1 to 8.11 regarding proper loading in wet holes, and in eliminating explosive contamination, noxious fumes, and nitrate residues.

11. Due to the open areas around the mine where people and livestock could traverse freely, and potentially towards a blast area, the blast clearance procedures will need to be done very carefully. Refer to Section 10.0 for more details and recommendations on blast notifications, warning signage, clearing the blast area, safety radii for equipment and people, communicating with blast guards, warning sirens, post blast inspection procedures, and in dealing with misfires.

12. Electrical storms can be a concern when explosives are on site, and very strict protocols must be established before any blasting takes place. The best policy is to track the weather, days in advance, for planning purposes. But electrical storms can crop up unexpectedly, even with the best of weather forecasts. Thus, it is recommended that a permanent land based lightning detection and tracking system is installed around the pit, and portable lightning detection systems are provided to each blast crew for backups. Special attention must be given to lightning storm notifications, evacuation procedures, safe distances for evacuation, and safe distances parked explosive trucks should be separated away from each other. Refer to Section 11.0 for the detailed recommendations.

1.0 INTRODUCTION AND BACKGROUND INFORMATION

Blasting Analysis International, Inc. (BAI) was commissioned by KGHM International to assist the Ajax Mine with their blasting objectives. The overall scope of work consisted of three phases, which focused on protecting aquatic life in Jacko Lake, assisting with the detailed blast designs to minimize blasting impacts in the surrounding communities, providing the processing plant with a targeted fragmentation distribution, and in assisting with future public meetings.

More specifically, this report addresses the following subjects and community concerns:

1. Blast induced ground vibration and airblast controls.
2. Protection of aquatic life in Jacko Lake.
3. Field controls for noxious fumes, dust and flyrock.
4. Detailed blast deigns for use in the ore and mine rock.
5. Fragmentation predictions for the ore and mine rock blasts.
6. Presplitting and highwall controls.
7. Operational Safety.

This report is based and qualified on:

1. New rock properties and the desired fragmentation distribution for the processing plant.

2. Performance characteristics of Anfo and Emulsion/Anfo blends (70%/30%).

3. An on-site visit to the Ajax mine during May 20 – 23, 2014 for meetings conducted with various department personnel, observe where all the critical areas of concern were regarding blasting, and to obtain the most recent updated technical information.

4. Digital images taken by BAI while on site.

5. Technical, historical and long term mining plan information supplied by KGHM.

6. Review of the Orica Explosives report dated December 16, 2011, which was prepared for Abacus.

7. Review of a summary report entitled “Potential Effects of Blasting on Fish and Related Guidelines”, prepared by Stefanie Eagen from Knight Piésold Consulting.

8. BAI’s worldwide experience base involved in similar blasting projects, applications and community concerns.

Figure 1.01 illustrates a plan view of the final pit boundary, in relation to the City of Kamloops, Jacko Lake and nearby residential homes.

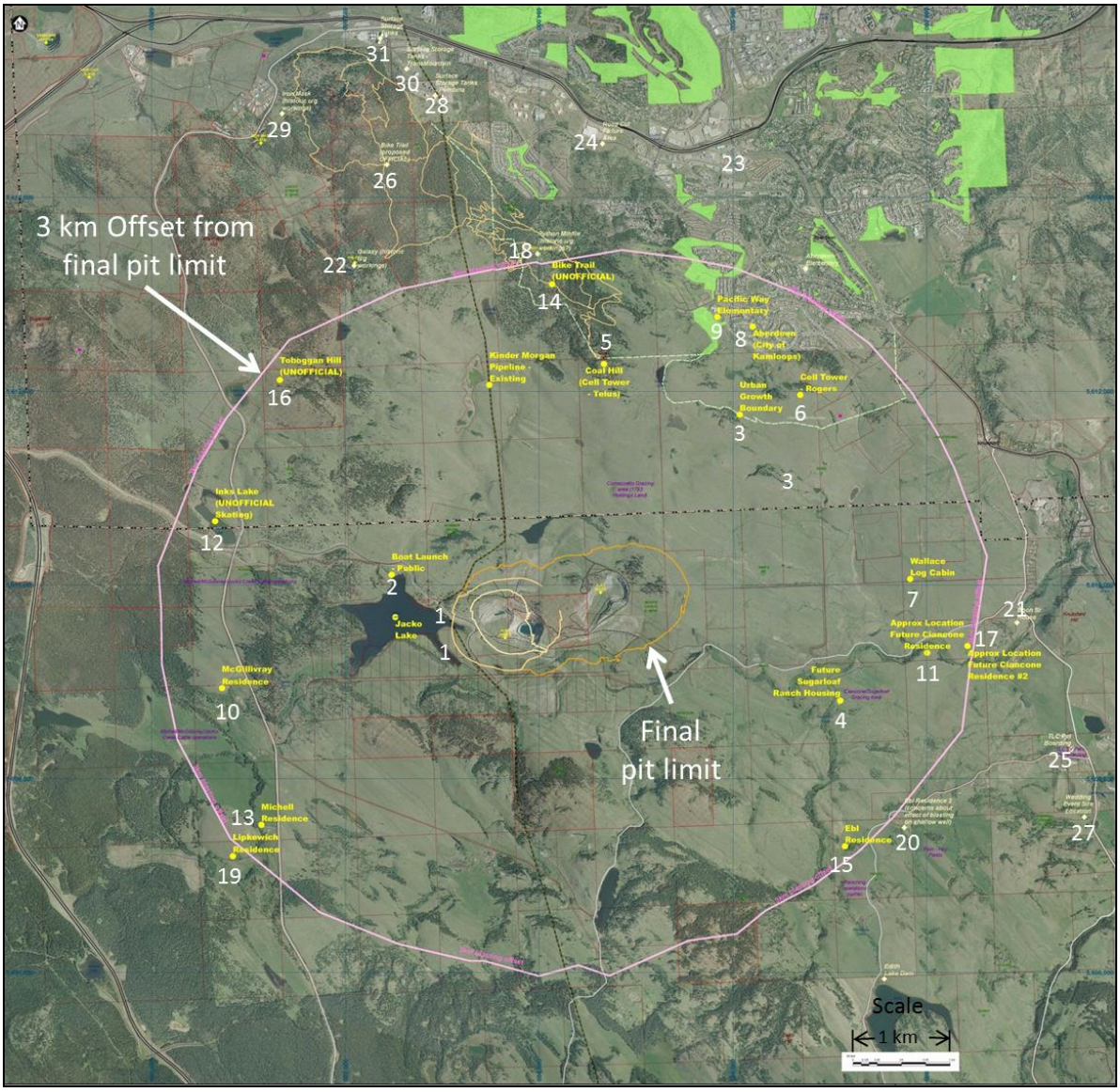


Figure 1.01 – Plan view of the final pit limit boundary in relation to the City of Kamloops, Jacko Lake and nearby residential homes.

1.1 Assumptions and Technical Information Used for Jacko Lake, Blast Designs and Fragmentation Predictions

The following technical information and assumptions were used regarding protection of aquatic life in Jacko Lake, developing appropriate blast designs and predicting the ROM fragmentation distributions in the ore and mine rock:

1. Main hole diameter for production blasting – 311 mm (12 ¼-in).
2. Main hole diameter for presplitting – 152 mm (6-in).
3. Explosive types = Anfo at a density of 0.82 g/cc, with a RBS (Relative Bulk Strength) 100.
4. Emulsion/Anfo blend (70% Emulsion and 30% Anfo) at a density of 1.20 t/m^3, with a RBS = 130.
5. Emulsion part in the 70%/30% blend will most likely be gas sensitized.
6. Approximately 90% of the blast holes are expected to be wet.
7. Horizontal holes will be used in pit to alleviate hydrostatic heads of water for highwall stability, and to control water in active working areas.
8. Explosives will be augured from top of hole in all dry holes.
9. Explosives will be pumped starting at the bottom of the holes in all wet holes.
10. Electronic detonators will be used in all critical areas of vibration/airblast/flyrock concerns, regardless of whether the material blasted is mine rock or ore.
11. Nonel detonators can be used as an option in the mine rock blasts, providing that they are at least 482 m away from the Northern and Southern Jacko Lake fingers, which are closest to the final pit boundary.
12. Booster size = 450 g.
13. Main mineral mined – Copper.
14. Standard bench height = 15 m.
15. Subgrade = 1.5 m in ore and mine rock.
16. Top stemming in the 311 mm production holes = 6 to 7 m.
17. Top stemming in the 152 mm production holes = 2.5 – 4.5 m.
18. Shovel bucket size = 76 yd^3.
19. Holes will be loaded full column, and then will gradually progress to two and three explosive decks as the blasts get closer to Jacko Lake.
20. Only one explosive column or deck per delay will be fired on the blasts. The term delay refers to the detonation of several explosive charges in a specified sequence over certain intervals of time usually measured in milliseconds. Delayed blasting improves the quality of blasting and reduces vibration and airblast magnitude.
21. Delays between holes and/or explosive decks will be at least 8 ms or greater.

22. Row delays will be incremented between approximately 100 to 300 ms from the front towards the back of the blast.
23. Presplitting in the final highwalls will be done in advance of the active blast blocks.
24. Safety radius for people and equipment will be 500 m and 250 m, respectively. This applies only to when the blasts are completely loaded, and ready to be fired with the blast guards and spotters are in place. The only exception to this will be if there is an electrical storm while explosives are on the blast site.
25. Ground vibrations and airblast overpressure will not exceed 13 mm/s and 100kPa, respectively, as recommended the DFO (Department of Fisheries and Oceans Canada) to protect aquatic life in Jacko Lake.
26. The new rock properties for the ore and mine rock are listed as follows:

Rock Properties	Ore	Mine rock
Specific Gravity (g/cc)	2.84	3.10
UCS Compressive Strength (MPa)	91	86
Young's Modulus (GPa)	75	94
Poisson's Ratio	0.24	0.25

Note that these are new rock properties, and they are different than those used in the Orica report and BAI'S 2013 report.

27. The desired ROM fragmentation distribution for the ore is listed as follows:

Desired Fragmentation Size				Cumulative Percent Passing
43.3 in	1.10 m	110 cm	1100 mm	100%
19.7 in	0.50 m	50 cm	500 mm	90%
12.2 in	0.31 m	31 cm	310 mm	80%
7.9 in	0.20 m	20 cm	200 mm	65%
2.0 in	0.05 m	5 cm	50 mm	18%

28. The targeted 100% passing ROM fragmentation for the ore is 1100 mm. The preferred 100% passing ROM fragmentation for the mine rock is also 1100 mm, but with a coarser overall fragmentation distribution and less fines.

2.0 GROUND VIBRATION AND AIRBLAST CONTROLS

2.1 Blast Vibration Damage Thresholds for Various Materials and Conditions

Table 2.11 lists general blast vibration damage thresholds for various building materials and conditions, which are commonly accepted worldwide. These were developed over many decades by researchers, regulatory agencies, consultants and educators. The listed thresholds are the absolute minimum vibration levels needed to cause permanent damage. Below the threshold levels, no permanent structural damage is possible. Exceeding the threshold levels does not necessarily guarantee damage, but it does increase the probability of the potential damage exponentially.

Table 2.11 – Damage Thresholds for Different Materials and Conditions.

Type of Permanent Damage	Minimum Vibration Levels to Cause Damage (mm/s)
Plaster – hairline cracks.	13
Drywall (Sheetrock) – hairline cracks.	19 - 51
Mortar fill cracks and separations.	52 - 76
Ground settlement, depending on depth, type of soil and dry/wet conditions.	51 - 500
Brick cracks.	77 - 102
Cracks in fully cured concrete.	103 - 203
Cracks and or joint separations in buried pressurized water, gas and fuel lines, etc.	125 - 635
Separation of ceiling/wall corner junctions, door/window frame offsets, floors off level, etc.	204 - 508
Structural distortions (window/door frames, corner junction separations, and sagging floors, etc.)	250 - 1000
Major structural distortions for building frames, beam supports, floors, ceilings, walls, misaligned shafts, etc.	1016 - 1524

2.2 USBM Damage Criteria to Protect Residential Homes

Figure 2.21 illustrates the USBM (United States Bureau of Mines) damage criteria graph. Over 90% of the countries in the world use these damage criteria, or a very close derivative of it as a regulation or guideline including a few provinces in Canada. The USBM graph is a plot of measured ground vibration amplitude versus frequency. This graph was developed for 1-2 story

dwellings to establish the damage thresholds for plaster and drywall, which are typically the weakest structural component members in homes. The onset of permanent damage in the plaster or drywall is usually noted as barely visible, hairline, surface cracks.

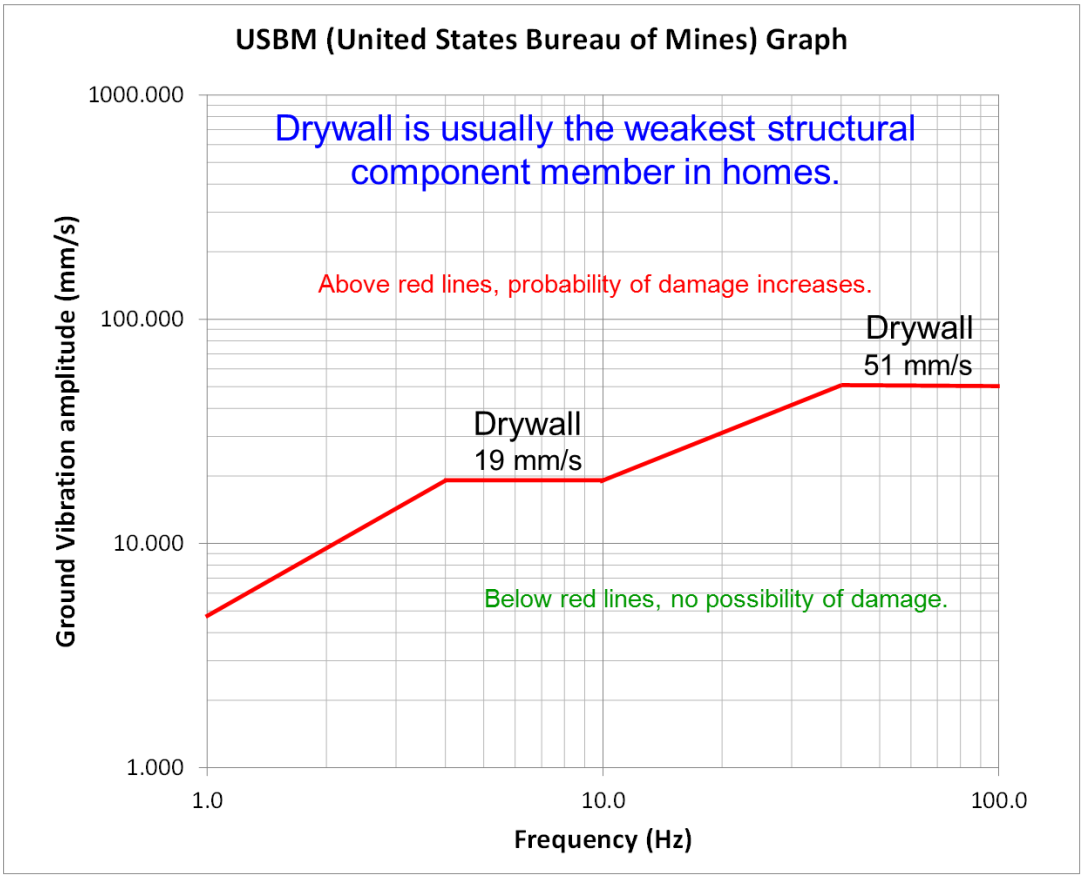


Figure 2.21 – USBM graph of ground vibration amplitude versus frequency

As long as a vibration level is not above the red lines within a specific frequency range, no structural damage is possible from blasting. The USBM damage criteria is very stringent, but also a very conservative threshold of damage. It does not mean that damage is guaranteed to occur by just going over the damage threshold limits. It simply means that the probability of damage goes up. The higher the threshold limit value is exceeded, for a particular building material, the higher is the probability of damage. If the vibration measurement falls below the red lines for specific frequency ranges, no structural damage is possible. Note that the higher the predominate frequency is for the PPV (Peak Particle Velocity or vibration level), the higher is the damage threshold. This means that for most materials, higher PPV'S (i.e. vibration levels) can be tolerated at the higher frequencies.

2.3 Factors Affecting Ground Vibration Levels

Table 2.31 lists the controllable and uncontrollable variables which could influence the ground vibration amplitudes. Note that if electronic detonators are used, and the explosives are purchased from a reputable supplier, the "detonator precision and VOD (Velocity of Detonation) scatter" variables would be shifted into the insignificant column. *Thus, the two most influential factors in the control of ground vibration amplitudes at the Ajax mine would be the maximum amount of explosives fired per delay, and the delay timing.*

Table 2.31 – Factors Affecting Ground Vibration Levels

Ground Vibrations	Significant	Moderately Significant	Insignificant
CONTROLLABLE BLAST DESIGN PARAMETERS			
Amount of explosives per delay or detonation	X		
Delay time between decks, holes and rows	X		
Detonator precision (Accuracy, crowding, overlaps)	X		
VOD scatter from hole to hole	X		
Confinement (Burden, spacing, subgrade, buffers, relief)		X	
Top stemming (amount and type)			X
Charge length and diameter		X	
Charge decoupling		X	
Angle of borehole			X
Direction of initiation		X	
Total charge weight per blast			X
Total shot duration		X	
Charge depth			X
Bare versus covered detonating cord			X
Open presplit holes			X
Electric versus non-electric initiation			X
UNCONTROLLED PARAMETERS	Significant	Moderately Significant	Insignificant
General surface terrain		X	
Overburden type and depth		X	
Ground structure and orientation		X	
Atmospheric conditions (Inversions and temp. variations)			X
Wind speed and direction			X

Modified after Wiss, Jenny & Elstner, 1980 *Blasting Analysis International, Inc.*

BAI recommends keeping the vibration level below 19 mm/s to eliminate structural damage to drywall in homes, offices and industrial structures. To minimize vibration annoyance complaints from homeowners in the surrounding areas, the maximum vibration target should not exceed 5 – 7 mm/s.

2.4 Ground Vibration Predictions for All Structures and Areas beyond the Final Pit Boundary

BAI did not use the Orica test data for predicting the ground vibrations and airblast in the nearby communities, because the borehole diameter, maximum weight of explosives/delay, subgrade, top stemming, and the rock properties have changed since Orica's two test blasts. But overall, the Orica and BAI vibration/airblast predictions are within the same order of magnitude.

In the absence of reliable or statistically significant seismic data, a commonly used and accepted equation (from 175th Anniversary Edition of DuPont Blasters Handbook) to initially predict vibration levels, is listed as follows:

$$\mathbf{PPV = 1143(D/W^{1/2})^{-1.60}} \quad \textbf{…..Eqn. 1}$$

Where:

PPV = Peak particle velocity (mm/s).

D = Distance from the blast to nearest inhabited residential dwelling (m).

W = Maximum weight of explosives fired per delay (Kg)

Assumptions used to predict the ground vibrations were:

1. The explosive used is heavy Anfo at a density of 1.20 t/m^3.

2. The largest hole diameter used is 311 mm (12 ¼ in), with a maximum weight of explosives/delay = 1,020 kg.

3. The bench height is 15 m, subgrade is 1.5 m and the top stemming is 6 m.

4. All distances to a point of concern in the nearby communities were always taken from the final pit boundary, even though the early blasts will be much farther away.

5. The weakest structural component member in residential homes is drywall, which can withstand vibration levels from 19 – 52 mm/s, depending on the associated predominant frequencies.

6. Only one hole/delay will be fired on the blasts.

7. The minimum delay between holes in all blasts blast will not be less than 8 ms, and the row delays will be incremented from the front of the blast towards the back with 100 – 300 ms.

2.5 Factors Affecting Airblast Levels

Table 2.51 lists the controllable and uncontrollable variables which could influence the airblast amplitudes. Note that there are many more variables which could influence the airblast levels, including atmospheric conditions, which are illustrated in Figure 2.51.

Table 2.51 – Factors Affecting Airblast Levels

Airblast Overpressure	Significant	Moderately Significant	Insignificant
CONTROLLABLE BLAST DESIGN PARAMETERS			
Amount of explosives per delay or detonation	X		
Delay time between decks, holes and rows	X		
Detonator precision (Accuracy, crowding, overlaps)	X		
VOD scatter from hole to hole	X		
Confinement (Burden, spacing, subgrade, buffers, relief)	X		
Top stemming (amount and type)	X		
Charge length and diameter			X
Charge decoupling		X	
Angle of borehole			X
Direction of initiation	X		
Total charge weight per blast			X
Total shot duration		X	
Charge depth	X		
Bare versus covered detonating cord	X		
Open presplit holes	X		
Electric versus non-electric initiation			X
UNCONTROLLED PARAMETERS	Significant	Moderately Significant	Insignificant
General surface terrain		X	
Overburden type and depth			X
Ground structure and orientation			X
Atmospheric conditions (Inversions and temp. variations)	X		
Wind speed and direction	X		

Modified after Wiss, Jenny & Elstner, 1980

Blasting Analysis International, Inc.

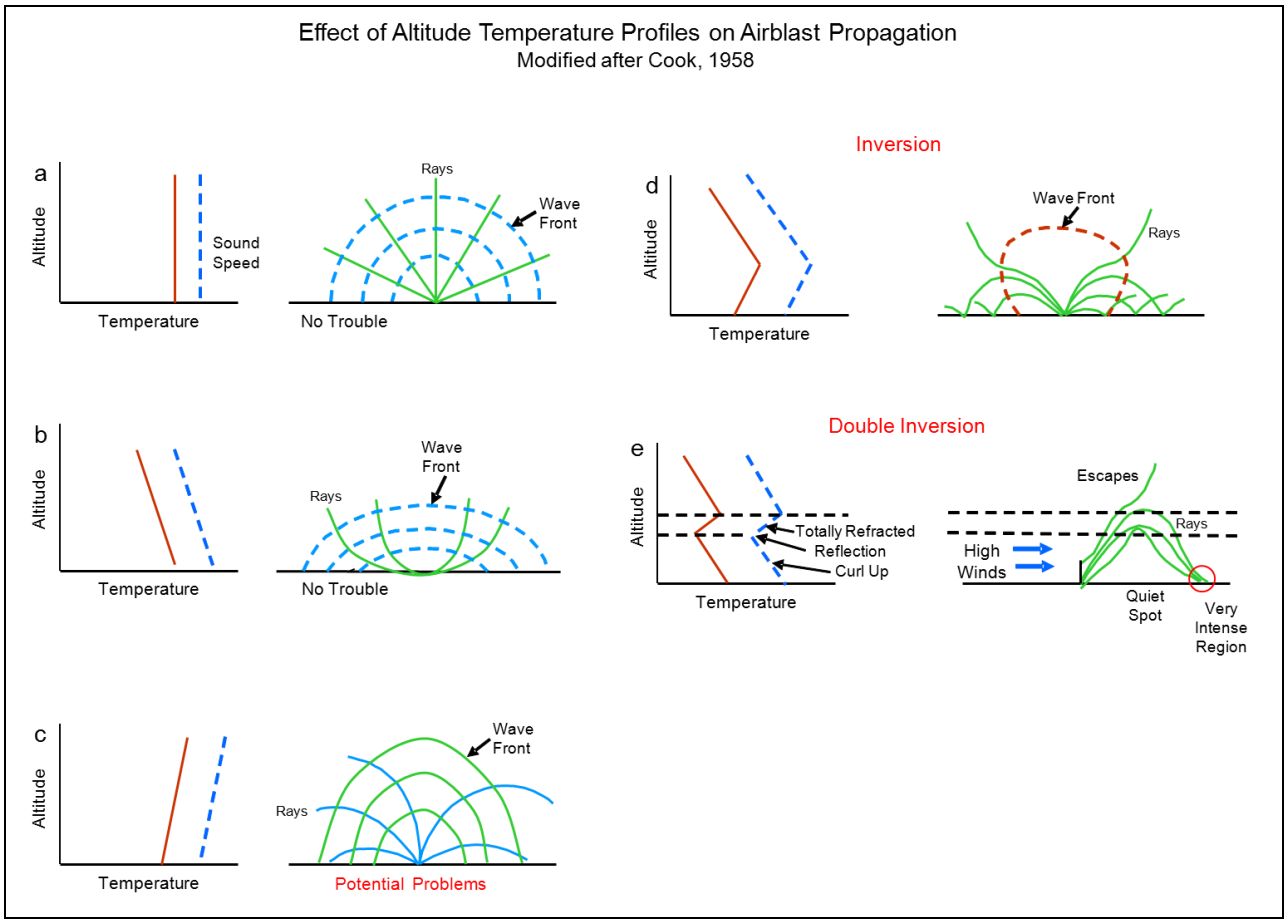


Figure 2.52 – Effects of weather conditions on airblast levels and transmission. Modified after Cook, 1958

In reference to the DuPont Blasters Handbook (1977), favorable atmospheric conditions for blasting are generally when there are clear to partly cloudy skies with fleecy clouds, light winds, and a steadily increasing surface air temperature from daybreak to shot time. The blast time should be delayed until midmorning to allow any early morning temperature inversions to be eliminated.

Unfavorable atmospheric conditions for blasting are generally:

- Foggy, hazy or smoky days with little or no wind. This condition is typical of a temperature inversion and high pollution index.
- During strong directional winds accompanying the passage of a cold front.
- During periods of the day when the surface temperature is falling.
- Too early in the morning or after sunset on clear days with very light winds.
- Cloudy days with a low ceiling, especially when there is little or no wind.

2.6 Definition of Airblast and Some Airblast Effects

Blast induced airblast is the pressure over and above normal atmospheric pressure, which is measured in decibels (dBL) on a logarithmic scale. The "L" in dBL, means that the airblast is measured with a microphone having a flat response between 2 and 200 Hz. Table 2.61 lists a few examples of airblast effects.

Table 2.61 – Airblast Effects on People, Windows and Structures

TYPICAL OVERPRESSURE, AIRBLAST AND NOISE LEVELS	
***Sound Pressure (dB)**	**Source, Activity, Response and/or Damage**
110 - 115	Blast effects are barely perceptible, with very few or no complaints.
115 - 120	Could be felt or sensed, but are mostly tolerated depending on the ambient levels inside the home and/or community.
120 - 125	Blasts are felt or sensed more frequently, and they could be annoying to some people, but no damages occur.
125 – 130	Sounds very loud from rattling effects inside home, but no damage.
133	USBM recommended safe blast damage limit for homes.
150	Some loose, single pane glass in windows begins to break.
160 - 170	Majority of window pane glass breaks.
180+	Major structural damage equivalent to a very strong earthquake.

**Sound pressure is measured on a logarithmic scale, so for every 6 dBL increase, the sound pressure will double. Similarly, doubling the distance will decrease the sound pressure by 6 dBL.*

2.7 Airblast Predictions for All Structures and Areas beyond the Final Pit Limit

A good starting point to predict the airblast levels at any point of concern is with Equation No. 2, which was developed by the USBM. *Note that this equation uses Imperial units, but the final answer is later converted to dBL (decibels).*

$$\textbf{Airblast} = C\,(D/W^{0.333})^{-1.10} \quad \text{…….Eqn. 2}$$

Where

Airblast = Overpressure (psi)

C = Confinement constant.

D = Distance from blast to point of concern (ft.).

W = Weight of explosives per delay (lbs).

The confinement constant, C, refers to how well the blast is confined in terms of the blowout potential from the top stemming and/or along the bench face. C = 1.0 for normal explosive confinement, C = 0.10 for very heavy explosive confinement, and C = 10 for very little explosive confinement. In all of the airblast predictions, a normal explosive confinement of C = 1.0 was used.

Converting psi from Equation 2 to dBL would be calculated with Equation 3 as follows:

$$\textbf{dBL = 20 LOG (Airblast in psi/2.9 x } 10^{-9}\textbf{) …….Eqn. 3}$$

BAI recommends keeping the maximum airblast level at 133 dBL, which is the safe USBM recommended level to eliminate any structural damage to all homes beyond the final pit limit. To minimize the airblast annoyance complaints, the maximum airblast level should be kept below 120 dBL.

2.8 Vibration and Airblast Limits on Buried Steel and PVC Pressurized Pipelines

Many studies have been conducted by various researchers and organizations on the effects of blasting near steel and/or PVC pressurized pipelines. The explosive weight per delay varied from as low as 3 lbs (1.7 Kg) to as high as 9 tonnes (9000 Kg), at distances of 6 ft (1.8 m) to well over 1000 ft (305 m). Materials consisted of soils, rocks and coal mine overburdens. Pipeline diameters varied from 6 inches (152 mm) to 30 inches (762 mm). In all cases, the levels required to cause permanent damage, deformation, depressurization and/or breaks were at least an order of magnitude greater than the ground vibration levels generated from typical commercial blasting operations, (i.e. quarries, construction, coal mines and open pits.)

In the USBM study (Siskind et all 1992), it was concluded that buried pipelines are relatively resistant to blast vibrations. In fact, it was reported that no failures or damage of any kind occurred from blasting as close as 50 ft (15 m), which produced ground vibration levels of over 24 in/sec (600 mm/s). Based on the USBM studies, a very safe and conservative vibration level of 5 in/sec (127 mm/s) was established for buried pressurized pipelines.

BAI'S understanding is that the Kinder Morgan buried pipeline, which runs along the West side of the pit near Jacko Lake, may be relocated, and thus would alleviate this concern. But, even if the pipeline was not relocated, the maximum allowable vibration of 13 mm/s at Jacko Lake to protect the aquatic life, will always predominate over the pipeline.

2.9 Effects of Repeated Blasting Over the Mine Life of 20 – 23 Years

A legitimate concern which often comes up with homeowners is that of repeated blasting. Even when ground vibration levels are kept very low, could repeated blasting over the years cause fatigue and ultimately damage? The USBM also investigated this and published a report with their main conclusions as follows:

> *"Cosmetic or hairline cracks 0.01 to 0.10 mm wide occurred during construction of the house and also during periods when no blasts were detonated. The formation of cosmetic cracks increased from 0.3 to 1.0 crack per week when ground motions exceeded 25.4 mm/s. Human activity and changes in temperature and humidity caused strains in walls that were equivalent to those produced by ground motions up to 30.5 mm/s. When the entire structure was mechanically shaken, the first crack appeared after 56,000 cycles, the equivalent of 28 yrs of shaking by blast-generated ground motions of 12.7 mm/s twice a day."*

The average predicted ground vibration amplitude at homes surrounding the mine is expected to be well under 2 mm/s. If we assume the frequency of blasting at the mine is an average of four times per week, fatigue in the residential homes from the blasting would not set in for at least 622 years.

2.10 Blasting Effects at Inks Lake for Ice Skating

Inks Lake, which is situated approximately 2,625 m Northwest of the mine, is currently used as an unofficial skating area and for other recreational use. The main concern here is, "Could blasting cause cracks or weaken the ice regarding the public for safety reasons?" The predicted vibration level at Inks Lake is 0.99 mm/s. and the predicted airblast is 109 dBL. Both the vibration and airblast levels are so low, that blasting would have no effect on damaging the ice.

Because ice has a lower density than water (i.e. 0.92 g/cc or 0.92 tonnes/m^3) and floats on top of the water, it has some flexibility and a moderate resistance to vibrations. Snowmobiles and heavy vehicles moving over the ice would actually produce higher vibration levels than the blasting.

Ice forms with an average volume expansion of approximately 9 – 10%, but it has variable material responses to dynamic loads. The more reliable safety criterion for the integrity of the ice is its thickness. The U.S.A. Army manuals recommend minimum ice thicknesses for the following activities listed in Table 2.101.

Table 2.101 – U.S.A. Army Recommendations for Minimum Ice Thicknesses and Safe Moving Loads

Minimum Ice Thickness (mm)	Minimum Ice Thickness (inches)	Description of Safe Moving Load
44	1.75	One person on skis
50	2	One person on foot or skates
76	3	One snowmobile
76	3	One group of people walking single file
178	7	One single passenger automobile
203	8	One 2 ½ Ton truck, where one ton = 2000 lbs = 0.907 tonnes
228 - 254	9 -10	One 3 ½ Ton truck
254	10	One 7 – 8 Ton truck
381	15	One 10 Ton vehicle
508	20	One 25 Ton vehicle
635	25	One 45 Ton vehicle
762	30	One 70 Ton vehicle
914	36	One 110 Ton vehicle

3.0 VIBRATION/AIRBLAST LIMITS ON AQUATIC LIFE IN JACKO LAKE

3.1 DFO Recommendations on Maximum Allowable Vibration and Airblast Amplitudes on Fish in Jacko Lake

Guidelines provided by Fisheries and Oceans Canada (DFO) to prevent the destruction of fish or potentially harmful effects on fish habitat that could result from the use of explosives include (Wright and Hopky 1998):

1. No explosive is to be detonated in or near fish habitat that produces an instantaneous pressure change (overpressure) greater than 100 kiloPascals (kPa) in the swimbladder of a fish.

2. If a confined explosive is to be detonated close to the substrate-water interface, the weight of explosive charge per delay will have to be adjusted in order to meet the 100 kPa guideline.

3. No explosive is to be detonated that produces a peak particle velocity (PPV) greater than 13 mm/second in a spawning bed during the period of egg incubation.

The following generalized equations can be used to estimate the setback distance, (i.e. distance from blast to Jacko Lake's closest shoreline).

The setback distance to meet the 13 mm/sec PPV guideline is:

$$\mathbf{R = 15.09\ W^{0.5}} \quad \textbf{…….Eqn 4.}$$

Where: R = Distance to the detonation point in (m).
W = Maximum charge weight per delay (Kg).

The setback distance to meet the 100 kPa airblast guideline for overpressure is:

$$\mathbf{R = K\ W^{0.5}} \quad \textbf{…….Eqn 5.}$$

Where: R = Distance to the detonation point (m).
W = Maximum charge weight per delay (kg).
K = Constant for a given substrate type (5.03 for rock).

Note that Equations 3 and 4 estimate only the setback distances to satisfy the maximum allowable vibration amplitude of 13 mm/s, and the maximum allowable airblast level of 100 kPa. It is implied that the delay must be at least 8 ms or higher. It is important to note that for any given maximum explosive mass/delay, the setback distance for vibration control will always be considerably higher than the setback distance for the control of airblast. Thus, if the vibration damage criterion is met, the airblast damage criterion will also always be automatically met by default.

Equation 5 allows one to estimate the vibration level at Jacko Lake, given any distance and maximum weight of explosives/delay:

$$\mathbf{PPV = 1000\ (R/W^{0.5})^{-1.60}} \quad \textbf{.....Eqn 6.}$$

Where: PPV = Estimated vibration level (mm/s)
R = Distance to the detonation point (m).
W = Maximum charge weight per delay (kg).

3.2 Blast Design Details to Comply with the DFO Vibration Recommendations for Jacko Lake

The mitigating avenues to minimize the blasting impacts on fish in Jacko Lake would primarily be driven by the maximum amount of explosives fired per delay. Thus, as the blasts get closer to Jacko Lake, the maximum amount of explosives/delay will need to be reduced by:

1. Reducing the borehole diameter.
2. Using explosive decks.
3. Using lower density explosives.
4. Firing only one hole and/or explosive deck per delay.

Of the above mentioned mitigation measures, the combined use of Item No's 1, 2 and 4 will allow the blast designs to be appropriately designed to satisfy the DFO recommendations, while still satisfying the plant fragmentation requirements.

Equation 4 was used to estimate the setback distances from Jacko Lake with different blast designs, hole diameters and explosive decking. These utilized the 311 mm main production holes, and the 152 mm holes which are planned for presplitting the final highwalls.

Figure 3.21 illustrates a plan view of the pit, the three mining phases 1 to 3, the final pit perimeter, where the pit is in relation to Jacko Lake, and the three blast zones 1 to 3. As the blasts progress from zone 1 (Z1) to beyond zone 3 (Z3), the maximum amount of explosives will need to be reduced substantially.

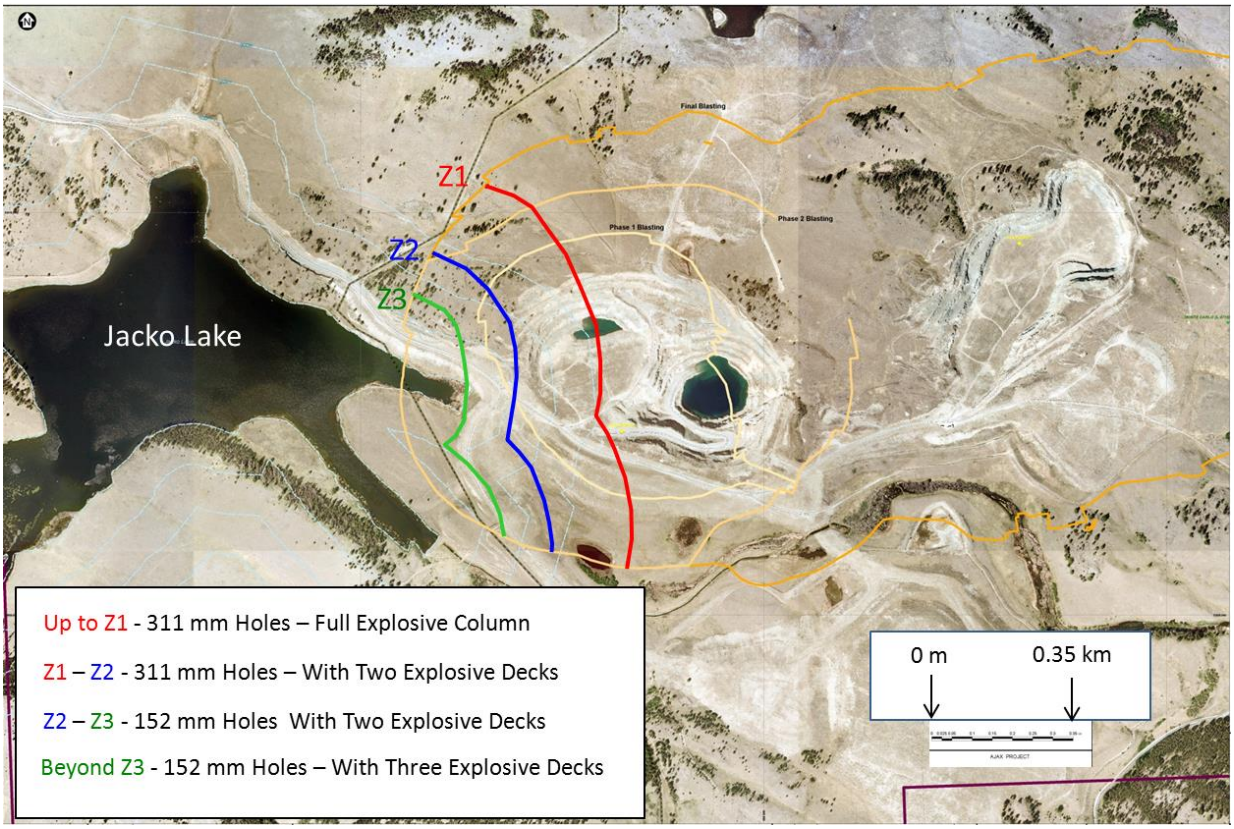


Figure 3.21 – Plan view of pit, Jacko Lake, mining phases and blast zones.

For example, a full column of explosives with 311 mm holes can be used in the ore and mine rock blasts up to zone 1, which is approximately 482 m from the nearest sections of Jacko Lake.

Between zones 1 and 2, the 311 mm holes can still be used, but the explosive column will need to be reduced to two explosive decks, with a stem deck separation of 3.3 m.

Between zones 2 and 3, the 152 mm holes will need to be used with two explosive decks, and a stem deck separation of 2.3 m.

Beyond zone 3, the 152 mm holes will need to be used with three explosive decks, and also with stem deck separations of 2.3 m. Refer to Figure 3.22 for the detailed hole loads and timing sequences within the holes for both the ore and mine rock blasts.

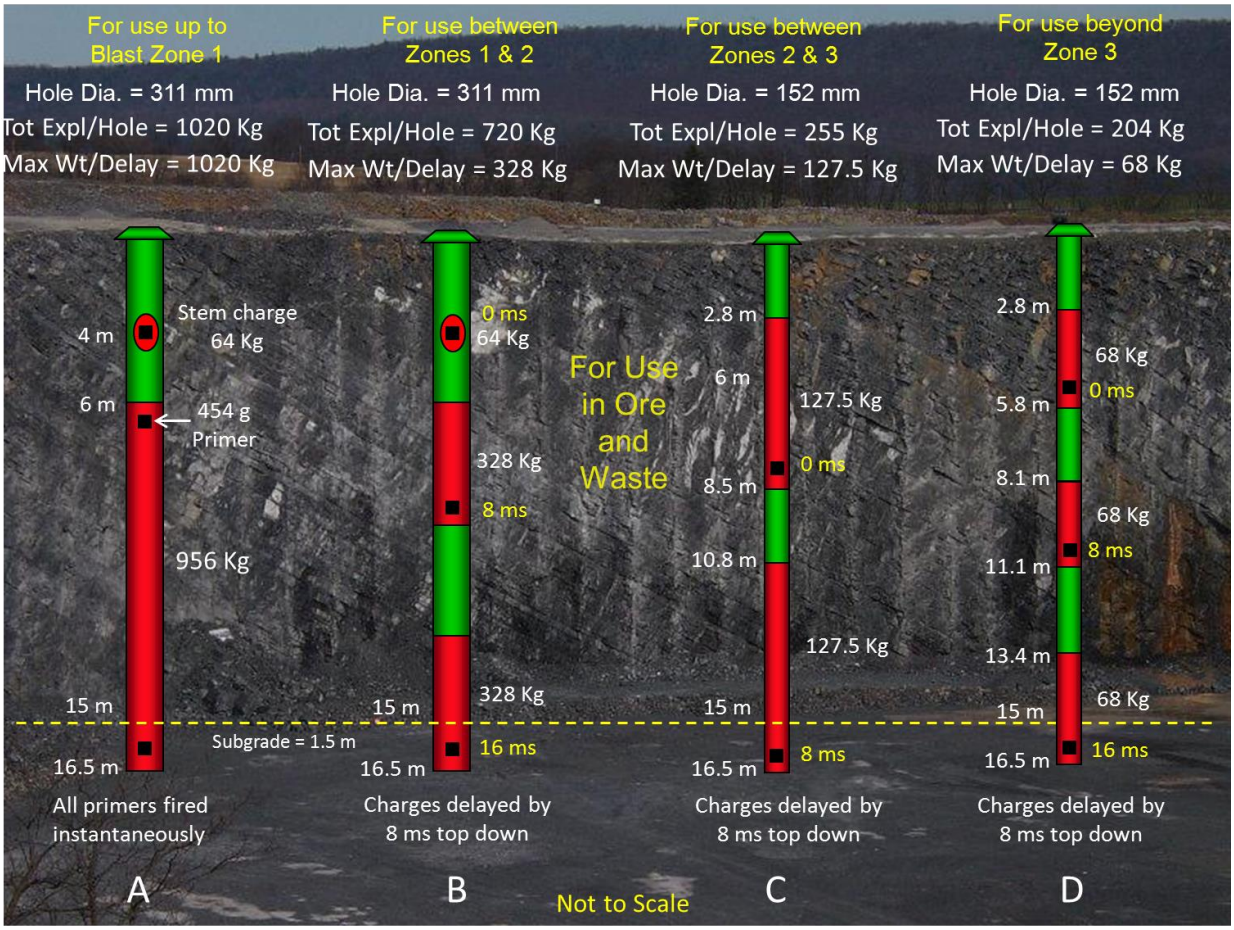


Figure 3.22 – Recommended hole loads and timing sequence for the different blast zones in ore.

The maximum explosives mass/delay for the different blast zones are:

1. Up to blast zone Z1 = 1020 Kg with a full column load, plus a stem charge in 311 mm holes.

2. Between blast zones Z1 and Z2 = 328 Kg with two explosive decks, plus a stem charge in 311 mm holes.

3. Between blast zones Z2 and Z3 = 127.5 Kg with two explosive decks in 152 mm holes.

4. Beyond blast zone Z3 = 68 Kg with three explosive decks in 152 mm holes.

Note that the maximum amount of explosives/delay decreases substantially from 1020 Kg to 68 Kg as the blasts approach Jacko Lake.

Providing that only one hole and/or explosive deck is fired per delay, all of the hole loads will comply with the DFO vibration/airblast damage criteria to protect the aquatic life in Jacko Lake.

Note that the in-hole delay sequence for all holes using explosive decking has been changed to fire top down. This will result in less ground vibrations by relieving the confinement conditions when firing the explosive decks top down, and it will standardize the in-hole delays in all blast zones to make it less complicated for the blast crews.

As mining and blasting gets deeper into the pit from the surface elevation, all of the blast designs will still comply with the DFO recommendations in protecting the aquatic life in Jacko Lake, but they will become less restrictive, as illustrated in Figure 3.23. For example, the blast designs stipulated for Zone 1 can be used up to Zone 2, but only when the pit is at least four benches down from surface. Likewise, the blasts for Zone 1 can be used up to Zone 3, but only when the pit is at least six benches down from surface. At the final pit boundary, the Zone 1 blast designs can only be used when the pit is at least eight benches down from surface. The objective in the Zone 1 blasts is to always maintain a minimum total distance of 482 m from Jacko Lake. The minimum total distance is the horizontal distance along the surface plus the pit slope distance. The same approach applies to the Zone 2 and 3 blasts, as the blasts approach Jacko Lake and the pit gets deeper.

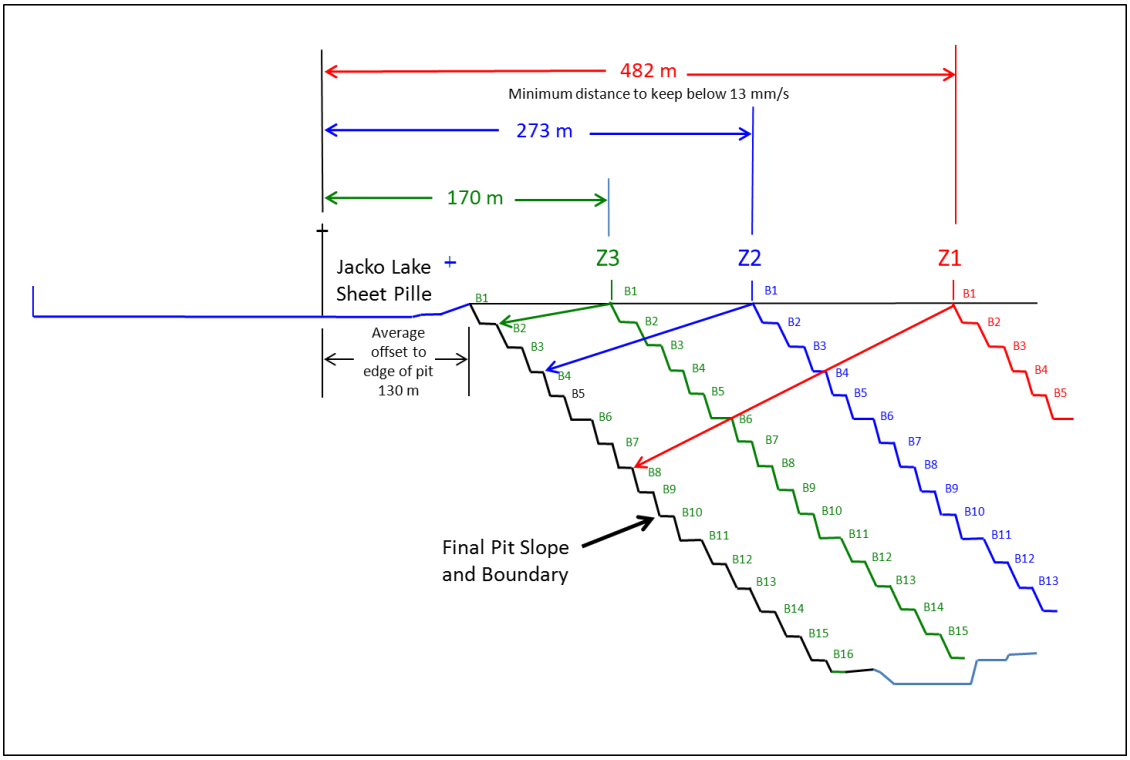


Figure 3.23 – Cross section of blast zones approaching Jacko Lake at the final pit boundary.

3.3 Cautionary Notes When Using Explosive Decking

One of the most effective and practical ways of reducing the vibration levels at any distance from a point of concern is to reduce the maximum amount of explosives per delay, as illustrated in Figure 3.31. But the amount of explosive reduction/delay must be at least 30 – 35% to be effective, unless blasting is close-in within 100 m of a critical point of concern. For example, reducing the explosives/delay by 10% from 1000 Kg to 900 Kg will not make a significant difference in the final vibration amplitude.

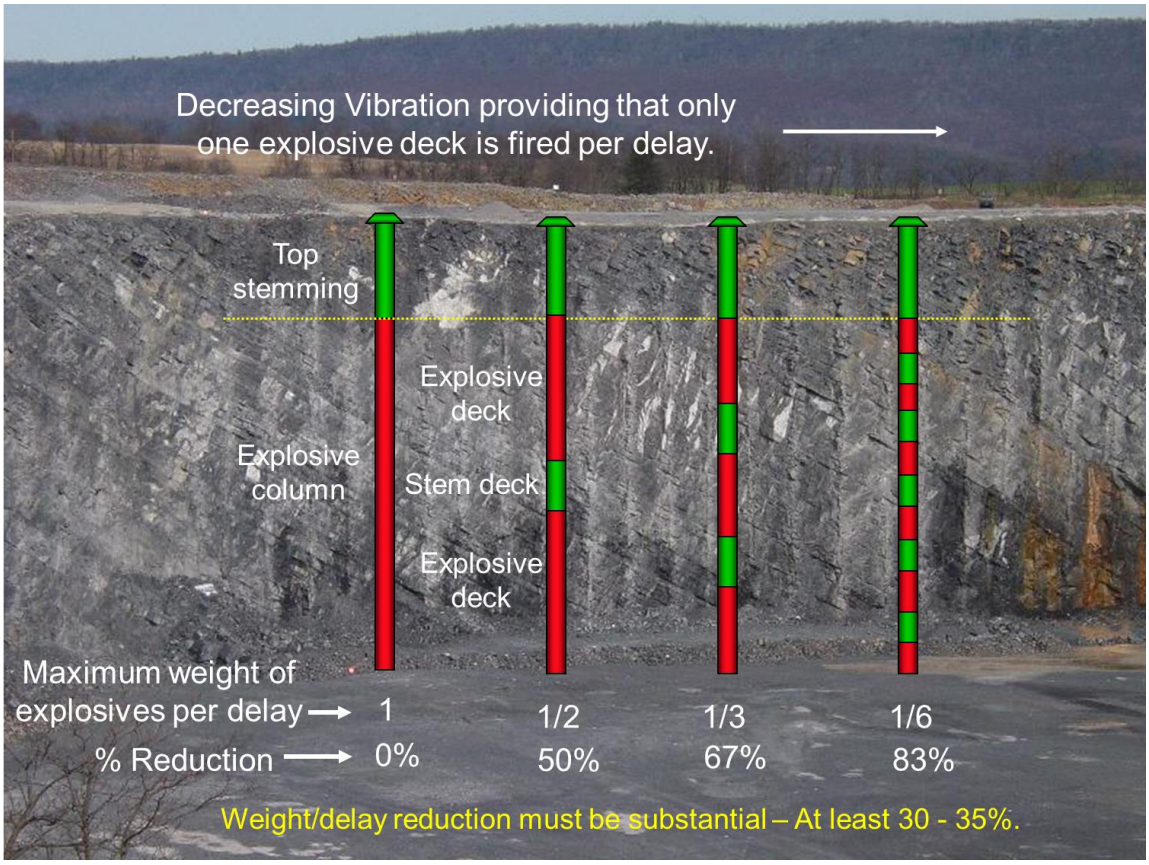


Figure 3.31 – Explosive decking is a very effective way of reducing the vibration levels.

However, the proper explosive deck designs must be used in dry and wet holes. Figure 3.32 illustrates Hole A loaded with a full column explosive and a Hole B loaded with two explosive decks. Whenever an explosive column detonates, disturbances in the form of shock, stress and gas pressure fronts will continue to travel into the top stemming zone.

In the case of Hole A with the full column explosive, the disturbances will continue to travel up into the top stemming for some distance until they are arrested. If the top stemming column was

too small, vibration will continue through the stem deck increasing risk of the stemming material being blown out.

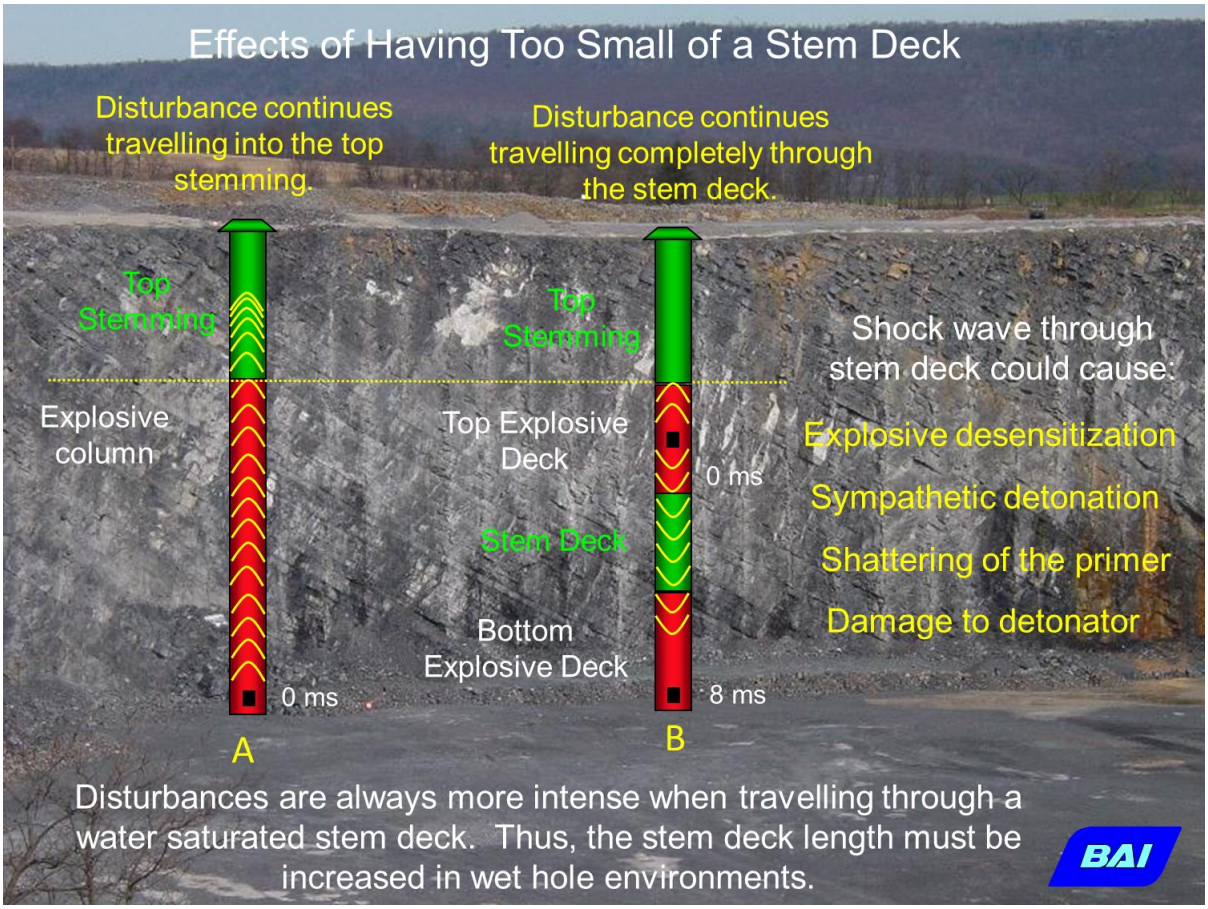


Figure 3.32 – Effects of having too small of a stem deck.

In the case of the Hole B loaded with two explosive decks in Figure 3.32, the same disturbances occur within the stem deck, which separates the upper and lower explosive decks. If the stem deck is too small, the disturbances can cause a host of performance problems, such as explosive desensitization, sympathetic detonations, shattering of the cast primers, and detonator damage. If the stem deck is in a water saturated environment, all of these problems will be further aggravated. Thus in a water saturated blast environment, it is very important that the stem deck columns are increased to eliminate these potential decking problems. The same concerns would apply in Hole B, if the two explosive decks were fired bottom up.

Figure 3.33 illustrates a graph of the minimum stem deck column required between two adjacent explosive decks for various hole diameters in both dry and wet holes. This was developed by BAI over many years of testing and monitoring explosive decking applications worldwide.

For example, if a stem deck was going to be used in a dry 311 mm hole, the minimum stem deck should be approximately 2.2 m. If the stem deck was going to be used in a wet 311 mm hole, the minimum stem deck would now need to be increased to approximately 3.3 m, to eliminate performance problems related to explosive decking.

Because 90% of holes at the Ajax mine are expected to be drilled in wet blast environments, all blast designs using explosive decking for vibration and fragmentation controls have been based on the wet hole curve in Figure 3.33.

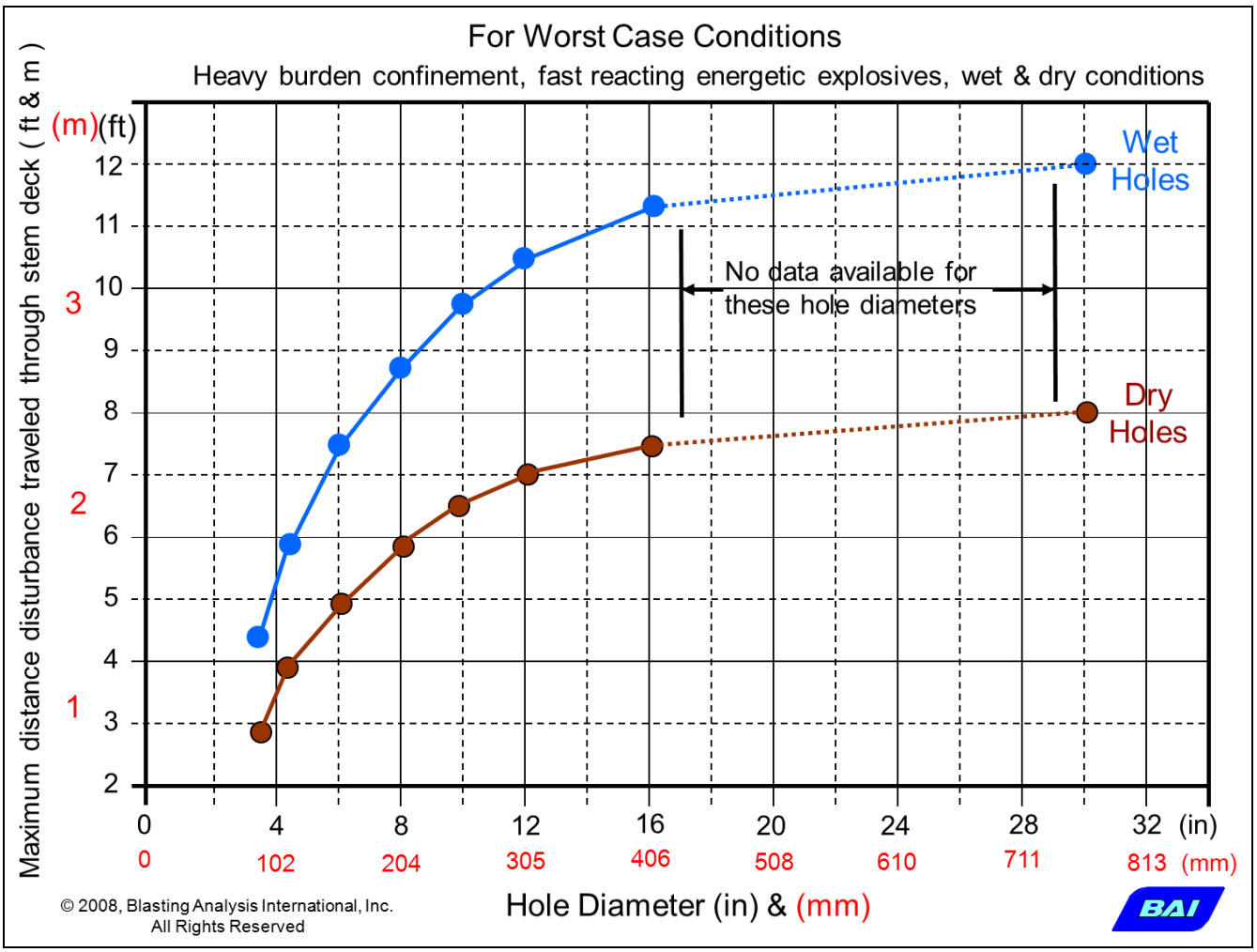


Figure 3.33 – Minimum stem deck column required for various hole diameters in dry and wet holes.

3.4 Cautionary Notes When Using Stem Charges

A top stemming of 6 m in a 311 mm hole, in a 15 m bench, represents 40% of the blast volume or tonnage which has no explosive in it which can result in poor fragmentation in the collar zone.

One of the most effective ways of improving the fragmentation in the collar (top stemming zone) is to put a small stem charge right into the stemming column, as illustrated in Figure 3.41, Holes A and B.

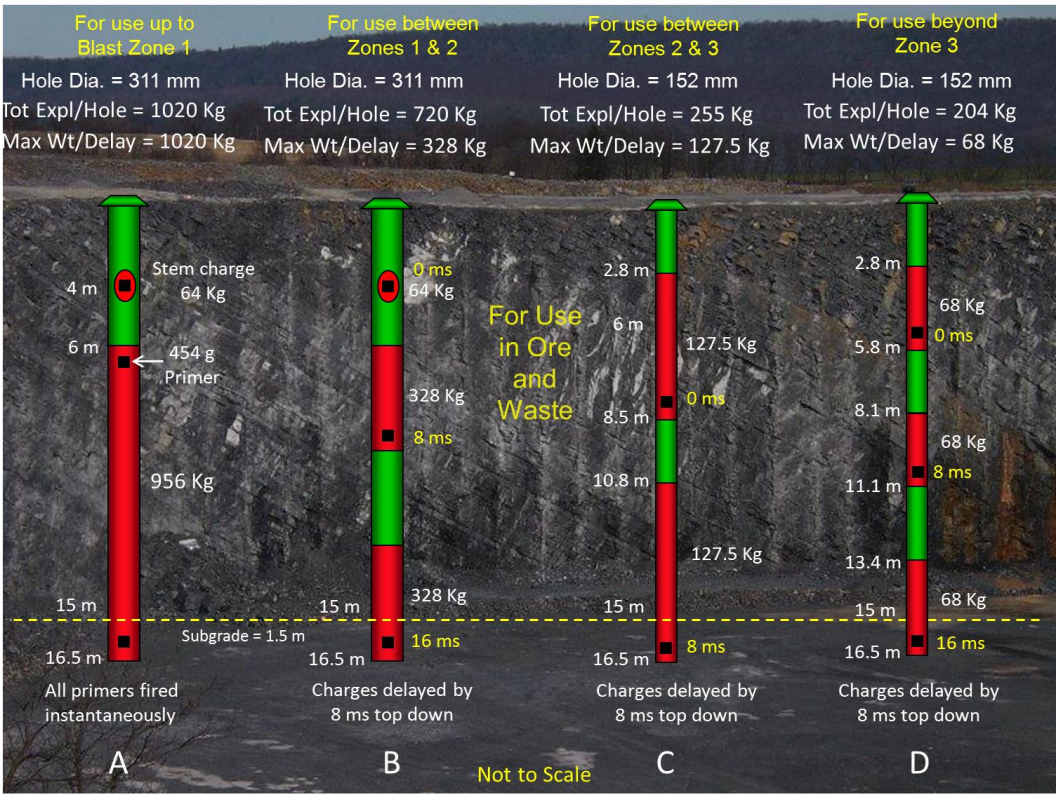


Figure 3.41 – Stem charges must be fired instantaneously with the main charge or fired top down in an explosive decking application.

Note in Figure 3.41 (Hole A) that the stem charge and main explosive column are fired instantaneously with electronic detonators. In Figure 3.42 (Hole B), note that the stem charge and explosive decks are delayed by 8 ms for vibration controls, but the stem charge and explosive decks are delayed top down. If this delay sequence is not adhered to when using a stem deck, there will be a high probability that the main explosive column or decked charge below the stem charge could blow the stem charge out of the hole before it detonates.

4.0 PREDICTED GROUND VIBRATIONS AND AIRBLAST LEVELS AT ALL POINTS OF CONCERN BEYOND THE FINAL PIT BOUNDARY

4.1 Predicted Ground Vibration and Airblast at All Areas of Concern

Figure 4.11 illustrates a plan view of the final pit outline, in relation to all areas of ground vibration and airblast concerns.

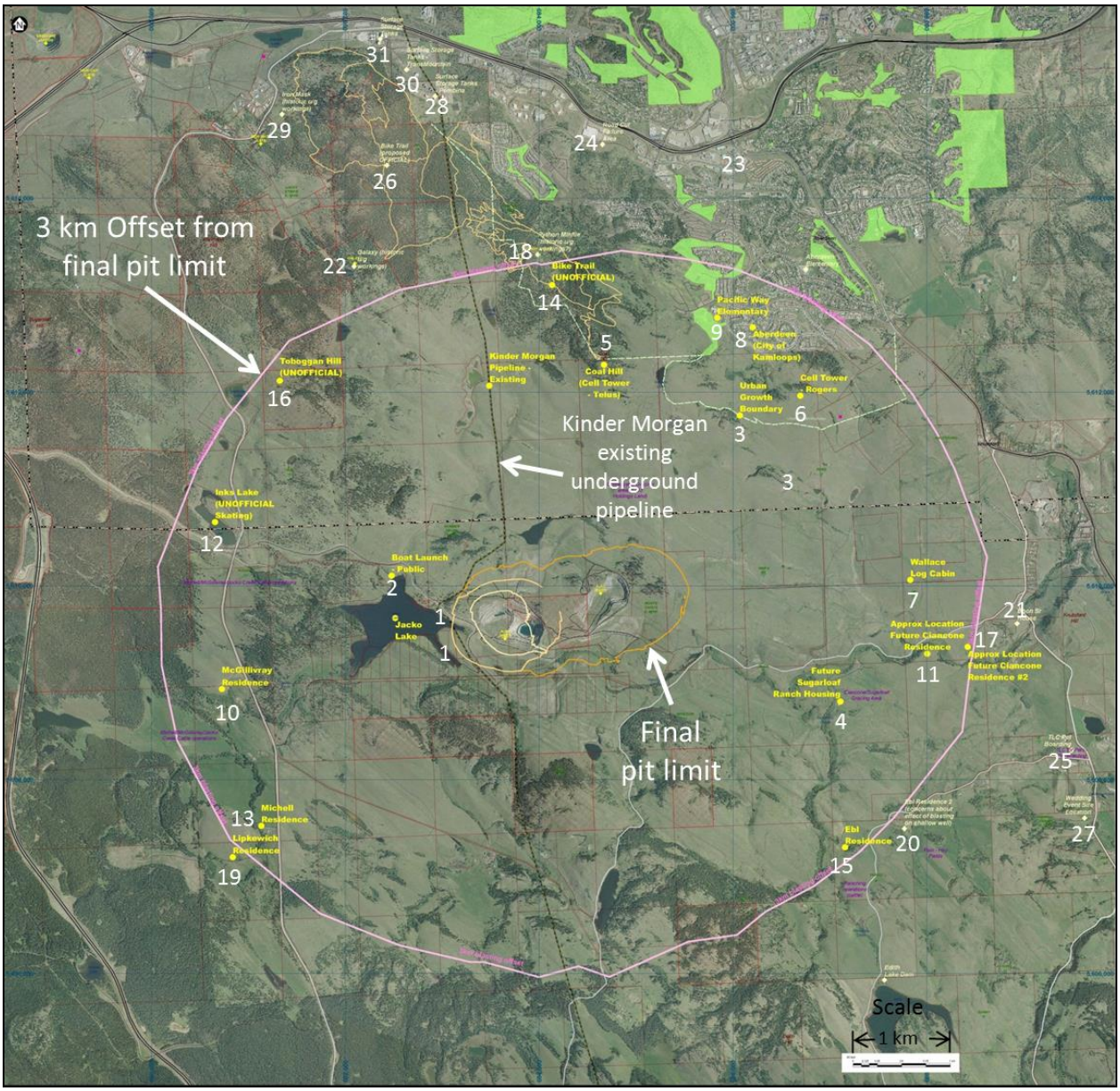


Figure 4.11 – Plan view of final pit boundary in relation to all areas of ground vibration and airblast concerns.

Table 4.11 lists the predicted ground vibration and airblast levels in increments of 100 m to 3000 m for the Zone 1 blasts, starting at the final pit boundary. The same data are illustrated graphically for the predicted ground vibration and airblast levels in Figures 4.11 and 4.12, respectively.

Table 4.11 - Predicted Ground vibration and Airblast Levels in Increments of 100 m.

Predicted Vibrations & Airblast			
From Pit Boundary in Increments of 100 m			
For Zone 1 Blasts With 311 mm Holes			
	Maximum		
Distance	Weight of	Predicted	
From	Esplosives	Ground	
Final Pit	Per	Vibration	Predicted
Boundary	Delay	Amplitude	Airblast
(m)	(kg)	(mm/s)	(dBL)
100	1020	184.05	140
200	1020	60.71	133
300	1020	31.73	129
400	1020	20.03	127
500	1020	14.01	125
600	1020	10.47	123
700	1020	8.18	121
800	1020	6.61	120
900	1020	5.47	119
1000	1020	4.62	118
1100	1020	3.97	117
1200	1020	3.45	116
1300	1020	3.04	115
1400	1020	2.70	115
1500	1020	2.42	114
1600	1020	2.18	113
1700	1020	1.98	113
1800	1020	1.81	112
1900	1020	1.66	112
2000	1020	1.53	111
2100	1020	1.41	111
2200	1020	1.31	110
2300	1020	1.22	110
2400	1020	1.14	110
2500	1020	1.07	109
2600	1020	1.00	109
2700	1020	0.94	108
2800	1020	0.89	108
2900	1020	0.84	108
3000	1020	0.80	107

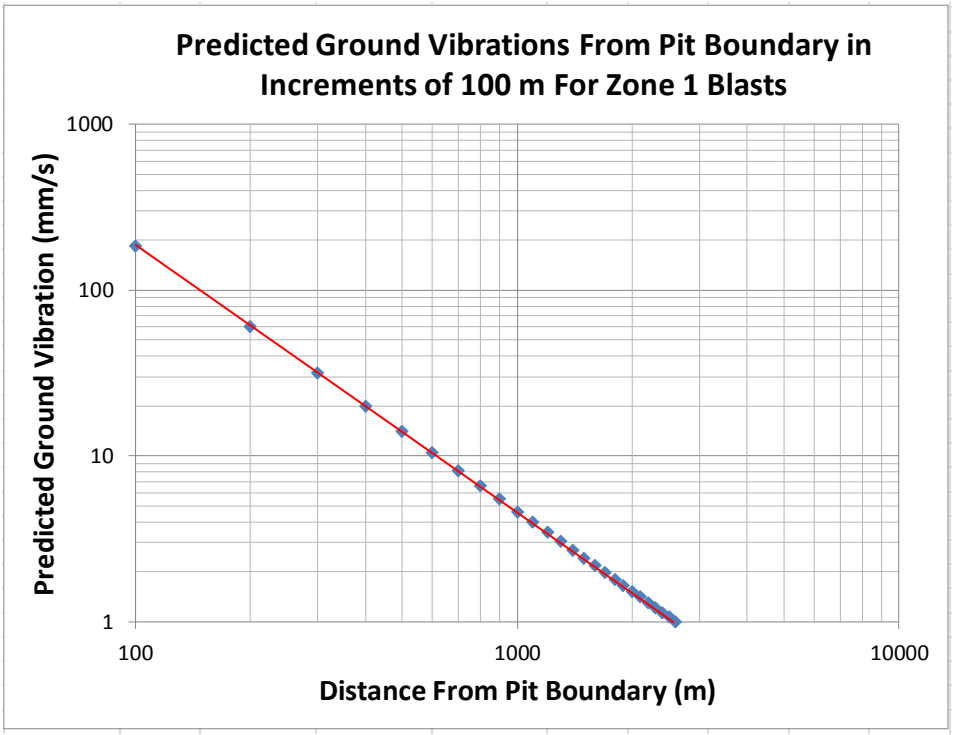


Figure 4.11 – Predicted ground vibration levels from pit boundary in increments of 100 m for Zone 1 blasts.

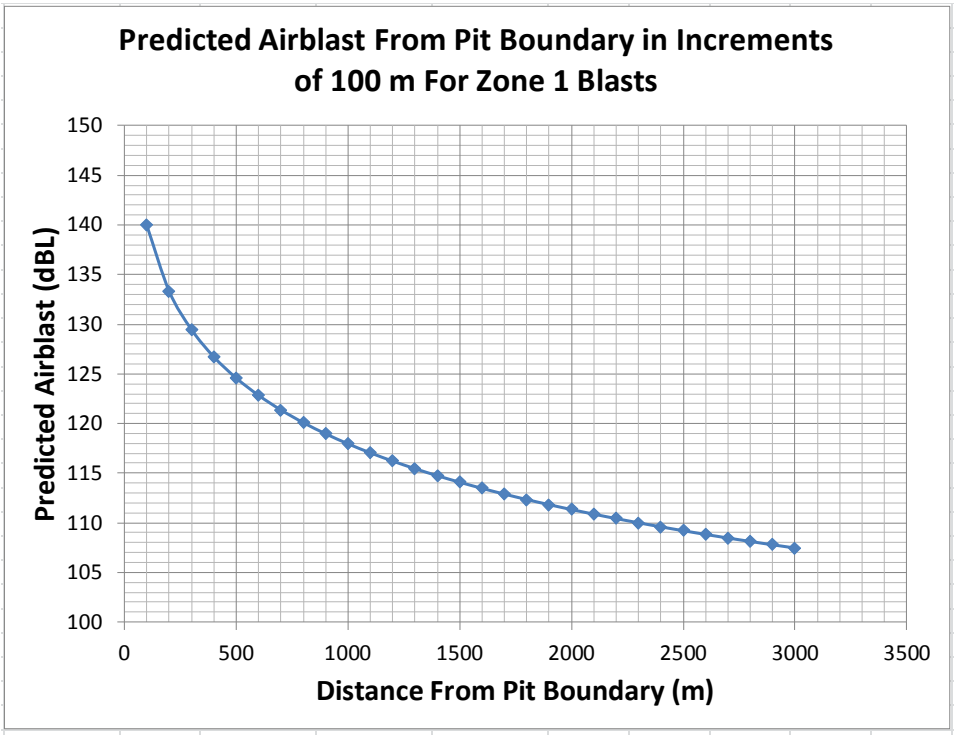


Figure 4.12 - Predicted ground vibration levels from pit boundary in increments of 100 m for Zone 1 blasts.

Table 4.12 lists the predicted ground vibration and airblast results for each area of concern beyond the final pit boundary. The map identifier numbers correlate with those in Figure 4.11, and they are ordered from the closest point of concern to the farthest point of concern. For example, Jacko Lake with map identifier No. 1 would be closest to the blasts, and the Surface Storage Tanks with map identifier No. 31 would be located farthest from the blasts.

To be conservative in all of the predictions, the distance to each point of concern was always taken from the final pit boundary, and all blasts were assumed to be fired with 1,020 kg of explosives, except for the blasts approaching Jacko Lake.

Table 4.12 – Predicted Vibration/Airblast Levels Ordered by Distance from Pit Boundary

		Ground Vibration Predictions					Airblast Predictions			
Map Identifier	Structures and Areas of Concern	PDF @ 50% Arbitrary Scaled Units	Actual Distance From Final Pit Boundary (m)	Maximum Weight of Esplosives Per Delay (kg)	Predicted Ground Vibration Amplitude (mm/s)	Maximum Allowable Ground Vibration Amplitude (mm/s)	*FS Factor of Safety For No Vibration Damage	Blast Confinement Constant	Maximum Allowable Airblast For No Structural Damage (dBL)	Maximum Targeted Airblast to Minimize Annoying Effects	Predicted Airblast Amplitude (dBL)
1	**Jacko Lake Fish Spawning Areas	6	100 - 160	65 - 328	Varies	13	1.4 - 2.0	**Refer to Section 3.0 for Safe Damage Criteria Used			
2	Jacko Lake Boat Launch Area	28	718	1020	7.86	100	13	1.0	133	120	121
3	Future Residences at Kamloops City Urban Growth Boundary	64	1641	1020	2.09	19	9	1.0	133	120	113
4	Future Sugarloaf Ranch Housing	73	1872	1020	1.70	19	11	1.0	133	120	112
5	Coal Hill - Telus Cell Tower	74	1897	1020	1.66	25	15	1.0	133	120	112
6	Rogers Cell Tower	83	2128	1020	1.38	25	18	1.0	133	120	111
7	Wallace Log Cabin	90	2308	1020	1.21	51	42	1.0	133	120	110
8	Residences at Current City of Kamloops Boundary	93	2385	1020	1.15	19	17	1.0	133	120	110
9	Elementary Pacific Way School	96	2462	1020	1.09	19	17	1.0	133	120	109
10	McGallivary Residence	96	2462	1020	1.09	19	17	1.0	133	120	109
11	Future Ciancone Residence No. 1	100	2564	1020	1.02	19	19	1.0	133	120	109
12	Inks Lake Skating (Unofficial)	102	2615	1020	0.99	100	101	1.0	133	120	109
13	Mitchell Residence	105	2692	1020	0.95	19	20	1.0	133	120	108
14	Proposed Bike Trail (Unofficial)	108	2769	1020	0.91	100	110	1.0	133	120	108
15	Ebl Residence No. 1	110	2821	1020	0.88	19	22	1.0	133	120	108
16	Toboggan Hill (Unofficial)	110	2821	1020	0.88	100	114	1.0	133	120	108
17	Future Ciancone Residence No. 2	115	2949	1020	0.82	19	23	1.0	133	120	108
18	Python Minfile Historic Underground Workings	121	3103	1020	0.76	250	331	1.0	133	120	107
19	Lipkewich Residence	123	3154	1020	0.74	19	26	1.0	133	120	107
20	Ebl Residence No. 2 for Water Well	123	3154	1020	0.74	19	26	1.0	133	120	107
21	Boon SR House	133	3410	1020	0.65	19	29	1.0	133	120	106
22	Galaxy Historic Underground Workings	135	3462	1020	0.63	250	394	1.0	133	120	106
23	Royal Inland Hospital	155	3974	1020	0.51	19	37	1.0	133	120	105
24	Roadcut Failure Zone in Kamloops	163	4179	1020	0.47	100	213	1.0	133	120	104
25	TLC Pet Boarding	165	4231	1020	0.46	19	41	1.0	133	120	104
26	Proposed Bike Trail (Official)	168	4308	1020	0.45	100	224	1.0	133	120	104
27	Wedding Event Site Location	182	4667	1020	0.39	19	48	1.0	133	120	103
28	Surface Storage Tanks - Pembina	190	4872	1020	0.37	51	139	1.0	133	120	103
29	Iron Mask Historic Underground Workings	200	5128	1020	0.34	250	740	1.0	133	120	102
30	Surface Storage Tanks - TransMountain	203	5205	1020	0.33	51	155	1.0	133	120	102
31	Surface Storage Tanks	217	5564	1020	0.30	51	172	1.0	133	120	102
					1.09						108
	* Factor of Safety for commercial bridges is typically between 1.5 - 2.0										
	**Ground vibrations will be kept under 13 mm/s,and airblast will be kept under 100kPa, by reducing the amount of explosives/delay as the blasts get closer to Jacko Lake.										

Each structure and location in Table 4.12 has been assigned a maximum allowable vibration amplitude and a factor of safety to compare the predicted results. Factor of safety is a term describing the structural capacity of infrastructure beyond the expected or actual loads. Basically, the factor of safety is how much stronger the system is than it usually needs to be for an intended load or in this case, vibration. Note that the factor of safety to eliminate structural damage to any home, industrial structure or tower ranges between 9 and 740 depending on a number of

variables. To put this into some perspective, the factor of safety used to design public bridges is between 1.5 and 2.0.
In reference to the predicted airblast levels in Table 4.12, each structure and location has also been assigned a maximum allowable airblast level and a targeted airblast level, for comparison purposes.

Note that the predicted airblast levels for all homes, industrial structures and towers were all well below the structural damage (133 dBL) and annoyance levels (120 dBL). Refer also to Table 2.51.

Table 4.13 is the same data listed in Table 4.12, but is ordered according to the type of structure and area.

Table 4.13 – Predicted Vibration/Airblast Levels Ordered by Type of Structure and Area

		Ground Vibration Predictions						Airblast Predictions			
Map Identifier	Structures and Areas of Concern	PDF @ 50% Arbitrary Scaled Units	Actual Distance From Final Pit Boundary (m)	Maximum Weight of Esplosives Per Delay (kg)	Predicted Ground Vibration Amplitude (mm/s)	Maximum Allowable Ground Vibration Amplitude (mm/s)	*FS Factor of Safety For No Vibration Damage	Blast Confinement Constant	Maximum Allowable Airblast For No Structural Damage (dBL)	Maximum Targeted Airblast to Minimize Annoying Effects	Predicted Airblast Amplitude (dBL)
	Commercial Utility Structures										
31	Surface Storage Tanks	217	5564	1020	0.30	51	172	1.0	133	120	102
30	Surface Storage Tanks - TransMountain	203	5205	1020	0.33	51	155	1.0	133	120	102
28	Surface Storage Tanks - Pembina	190	4872	1020	0.37	51	139	1.0	133	120	103
6	Rogers Cell Tower	83	2128	1020	1.38	25	18	1.0	133	120	111
5	Coal Hill - Telus Cell Tower	74	1897	1020	1.66	25	15	1.0	133	120	112
	Industrial Grade Structures										
9	Elementary Pacific Way School	96	2462	1020	1.09	19	17	1.0	133	120	109
27	Wedding Event Site Location	182	4667	1020	0.39	19	48	1.0	133	120	103
23	Royal Inland Hospital	155	3974	1020	0.51	19	37	1.0	133	120	105
	Residences and Similar Structures										
10	McGallivary Residence	96	2462	1020	1.09	19	17	1.0	133	120	109
7	Wallace Log Cabin	90	2308	1020	1.21	51	42	1.0	133	120	110
11	Future Ciancone Residence No. 1	100	2564	1020	1.02	19	19	1.0	133	120	109
17	Future Ciancone Residence No. 2	115	2949	1020	0.82	19	23	1.0	133	120	108
4	Future Sugarloaf Ranch Housing	73	1872	1020	1.70	19	11	1.0	133	120	112
15	Ebl Residence No. 1	110	2821	1020	0.88	19	22	1.0	133	120	108
13	Mitchell Residence	105	2692	1020	0.95	19	20	1.0	133	120	108
19	Lipkewich Residence	123	3154	1020	0.74	19	26	1.0	133	120	107
20	Ebl Residence No. 2 and Water Well	123	3154	1020	0.74	19	26	1.0	133	120	107
25	TLC Pet Boarding	165	4231	1020	0.46	19	41	1.0	133	120	104
21	Boon SR House	133	3410	1020	0.65	19	29	1.0	133	120	106
	Open Recreational Areas										
26	Proposed Bike Trail (Official)	168	4308	1020	0.45	100	224	1.0	133	120	104
14	Proposed Bike Trail (Unofficial)	108	2769	1020	0.91	100	110	1.0	133	120	108
16	Toboggan Hill (Unofficial)	110	2821	1020	0.88	100	114	1.0	133	120	108
12	Inks Lake Skating (Unofficial)	102	2615	1020	0.99	100	101	1.0	133	120	109
2	Jacko Lake Boat Launch Area	28	718	1020	7.86	100	13	1.0	133	120	121
1	**Jacko Lake Fish Spawning Areas	6.25	100 - 160	65 - 328	Varies	13	1.4 - 2.0	Refer to Section 3.0 for Safe Damage Criteria Used			
	Kamloops City Boundaries and Roadcut Failure Area										
8	Residences at Current City of Kamloops Boundary	93	2385	1020	1.15	19	17	1.0	133	120	110
3	Future Residences at Kamloops City Urban Growth Boundary	64	1641	1020	2.09	19	9	1.0	133	120	113
24	Roadcut Failure Zone in Kamloops	163	4179	1020	0.47	100	213	1.0	133	120	104
	Historic Undergorund Workings										
22	Galaxy Historic Underground Workings	135	3462	1020	0.63	250	394	1.0	133	120	106
29	Iron Mask Historic Underground Workings	200	5128	1020	0.34	250	740	1.0	133	120	102
18	Python Minfile Historic Underground Workings	121	3103	1020	0.76	250	331	1.0	133	120	107

* Factor of Safety for commercial bridges is typically between 1.5 - 2.0

**Ground vibrations will be kept under 13 mm/s,and airblast will be kept under 100 kPa, by reducing the amount of explosives/delay as the blasts get closer to Jacko Lake..

Table 4.14 lists the same data in Tables 4.11 and 4.12, but the predictions are ordered from the most restrictive vibration threshold to the least restrictive. Note that the aquatic life in Jacko Lake stipulates the most restrictive damage threshold at 13 mm/s. Because the vibration stipulation at Jacko Lake dictates the blast designs which could be used, it guarantees that no damage will occur in the drywall of residential or commercial structures, because the damage threshold for drywall is 19 mm/s. Refer also to Table 2.11.

Table 4.14 – Predicted Vibration and Airblast Levels Ordered the Most Restrictive Vibration Damage Threshold to the Least Restrictive

		Ground Vibration Predictions						Airblast Predictions			
Map Identifier	Structures and Areas of Concern	PDF @ 50% Arbitrary Scaled Units	Actual Distance From Final Pit Boundary (m)	Maximum Weight of Esplosives Per Delay (kg)	Predicted Ground Vibration Amplitude (mm/s)	Maximum Allowable Ground Vibration Amplitude (mm/s)	*FS Factor of Safety For No Vibration Damage	Blast Confinement Constant	Maximum Allowable Airblast For No Structural Damage (dBL)	Maximum Targeted Airblast to Minimize Annoying Effects	Predicted Airblast Amplitude (dBL)
1	**Jacko Lake Fish Spawning Areas	6	100 - 160	65 - 328	Varies	13	1.4 - 2.0	**Refer to Section 3.0 for Safe Damage Criteria Used			
9	Elementary Pacific Way School	96	2462	1020	1.09	19	17	1.0	133	120	109
27	Wedding Event Site Location	182	4667	1020	0.39	19	48	1.0	133	120	103
23	Royal Inland Hospital	155	3974	1020	0.51	19	37	1.0	133	120	105
10	McGallivary Residence	96	2462	1020	1.09	19	17	1.0	133	120	109
11	Future Ciancone Residence No. 1	100	2564	1020	1.02	19	19	1.0	133	120	109
17	Future Ciancone Residence No. 2	115	2949	1020	0.82	19	23	1.0	133	120	108
4	Future Sugarloaf Ranch Housing	73	1872	1020	1.70	19	11	1.0	133	120	112
15	Ebl Residence No. 1	110	2821	1020	0.88	19	22	1.0	133	120	108
13	Mitchell Residence	105	2692	1020	0.95	19	20	1.0	133	120	108
19	Lipkewich Residence	123	3154	1020	0.74	19	26	1.0	133	120	107
20	Ebl Residence No. 2 and Water Well	123	3154	1020	0.74	19	26	1.0	133	120	107
25	TLC Pet Boarding	165	4231	1020	0.46	19	41	1.0	133	120	104
21	Boon SR House	133	3410	1020	0.65	19	29	1.0	133	120	106
8	Residences at Current City of Kamloops Boundary	93	2385	1020	1.15	19	17	1.0	133	120	110
3	Future Residences at Kamloops City Urban Growth Boundary	64	1641	1020	2.09	19	9	1.0	133	120	113
6	Rogers Cell Tower	83	2128	1020	1.38	25	18	1.0	133	120	111
5	Coal Hill - Telus Cell Tower	74	1897	1020	1.66	25	15	1.0	133	120	112
31	Surface Storage Tanks	217	5564	1020	0.30	51	172	1.0	133	120	102
30	Surface Storage Tanks - TransMountain	203	5205	1020	0.33	51	155	1.0	133	120	102
28	Surface Storage Tanks - Pembina	190	4872	1020	0.37	51	139	1.0	133	120	103
7	Wallace Log Cabin	90	2308	1020	1.21	51	42	1.0	133	120	110
26	Proposed Bike Trail (Official)	168	4308	1020	0.45	100	224	1.0	133	120	104
14	Proposed Bike Trail (Unofficial)	108	2769	1020	0.91	100	110	1.0	133	120	108
16	Toboggan Hill (Unofficial)	110	2821	1020	0.88	100	114	1.0	133	120	108
12	Inks Lake Skating (Unofficial)	102	2615	1020	0.99	100	101	1.0	133	120	109
2	Jacko Lake Boat Launch Area	28	718	1020	7.86	100	13	1.0	133	120	121
24	Roadcut Failure Zone in Kamloops	163	4179	1020	0.47	100	213	1.0	133	120	104
22	Galaxy Historic Underground Workings	135	3462	1020	0.63	250	394	1.0	133	120	106
29	Iron Mask Historic Underground Workings	200	5128	1020	0.34	250	740	1.0	133	120	102
18	Python Minfile Historic Underground Workings	121	3103	1020	0.76	250	331	1.0	133	120	107

* Factor of Safety for commercial bridges is typically between 1.5 - 2.0.

**Ground vibrations will be kept under 13 mm/s, and airblast will be kept under 100kPa, by reducing the amount of explosives/delay as the blasts get closer to Jacko Lake.

A 1 – 2 mm/s ground vibration at the residential homes is equivalent to the vibrations of a grown up walking briskly across an uncarpeted floor. Given also that the factor of safeties are very high at all residential homes, commercial structures and business facilities, it is highly unlikely that the blasting will cause any cosmetic or structural damage.

4.2 Effects of Temperature, Humidity and High Wind Velocities on Homes

Something that many homeowners are not aware of is that, the daily/seasonal changes in humidity, temperature, wind, and heavy precipitation at homes, are at least one order of magnitude higher than the vibrations expected from the blasts, as listed in Table 4.21.

Table 4.21 – Equivalent Vibrations in Homes Caused by Environmental Changes

Non-Blasting Seismic Sources in Homes	Measured Vibrations (mm/s)	Source
Daily environmental strains on homes from changes in humidity, temperature, wind and precipitation.	25 - 81	USBM - 1981
Cyclic temperature and humidity changes.	20 - 66	Dowding , Northwestern University1996
Wind at 80 km/hr. acting on homes.	28 - 170	Leeds University

If homes are not designed with the proper vibration damping factors, they would not be able to withstand any dynamic forces and/or daily environmental changes, without experiencing some physical damage.

4.3 Effects of Blasting on Wild Life, Domesticated Animals and the TLC Pet Boarding Facility

Research into the effects of ground vibration, airblast and noise on animals is relatively scarce. In general, most animals pay very little attention to human activities or man-made disturbances, unless the activities are truly threatening, and are accompanied by some kind of visual and/or odor stimuli.

Many animals live quite happily in extremely noisy environments. Some examples of this would be:

- Rodents in factories, subways and ships.
- Fish in waterways with constant shipping activities.
- Birds and mammals on and around air fields, or heavily travelled highways.
- Wild life living on or around active military training bases with explosives and bombs, (Larkin R.P., 1996).

Experiments with sonic booms (but with no accompanying visual or odor stimuli) showed that domestic and wild species of animals were unaffected from the effects of repeated sonic booms

(Cassady & Lehman, 1967, Welch, 1970). Some of the animals would be startled by the initial new disturbances, but within a few days all of the animals quickly learned to ignore the sonic booms, because there was no immanent fear to flee.

Similar studies on zoo animals (Oriard 2002) were done when blasting for subway tunnels very nearby. Results showed that, at first, the animals would look up or appear nervous for a few seconds. But by the eighth blast, the animals became quite habituated and paid little or no attention to any of the subsequent blasts. Once the blasting became routine, many of the zoo animals even sleep right through the blasting.

In reference to the TLC Pet Boarding Facility, which is located approximately 4,231 m from the pit boundary, the predicted ground vibration level is 0.46 mm/s, and the predicted airblast level is 109 dBL. Both of these levels are so low, that the blasting would have no detrimental effects on the pets.

Many farms around the world are often situated adjacent to mines with very active blasting operations. Having worked in 26 countries over the last 35 years, the author is not aware of any damage claims pertaining to farm animals and birds being stressed, which resulted in less milk production from cows, less egg production from chickens, or that the blasting hampered their normal growth cycles.

5.0 SEISMOGRAPH SETUP, RECORD KEEPING AND LINEAR REGRESSION ANALYSIS

5.1 Suggested Seismograph Monitoring Setup

Seismic and airblast monitoring at strategic locations around the mine are required for compliance, verification and for legal purposes in resolving potential disputes. Figure 5.11 illustrates BAI'S recommendation for the six seismographs and weather station setups. Assuming that blasting will start in the West side of the pit, a linear array of three permanent seismographs (S1 – S3) should be set up from the pit edge towards the City of Kamloops in the Aberdeen area, because Kamloops is the major population area around the mine. Data from the seismic array will also be used for predictive linear regression analysis, as the blast locations move around the pit. Note that a weather station is also be placed at the S1 location at the pit boundary.

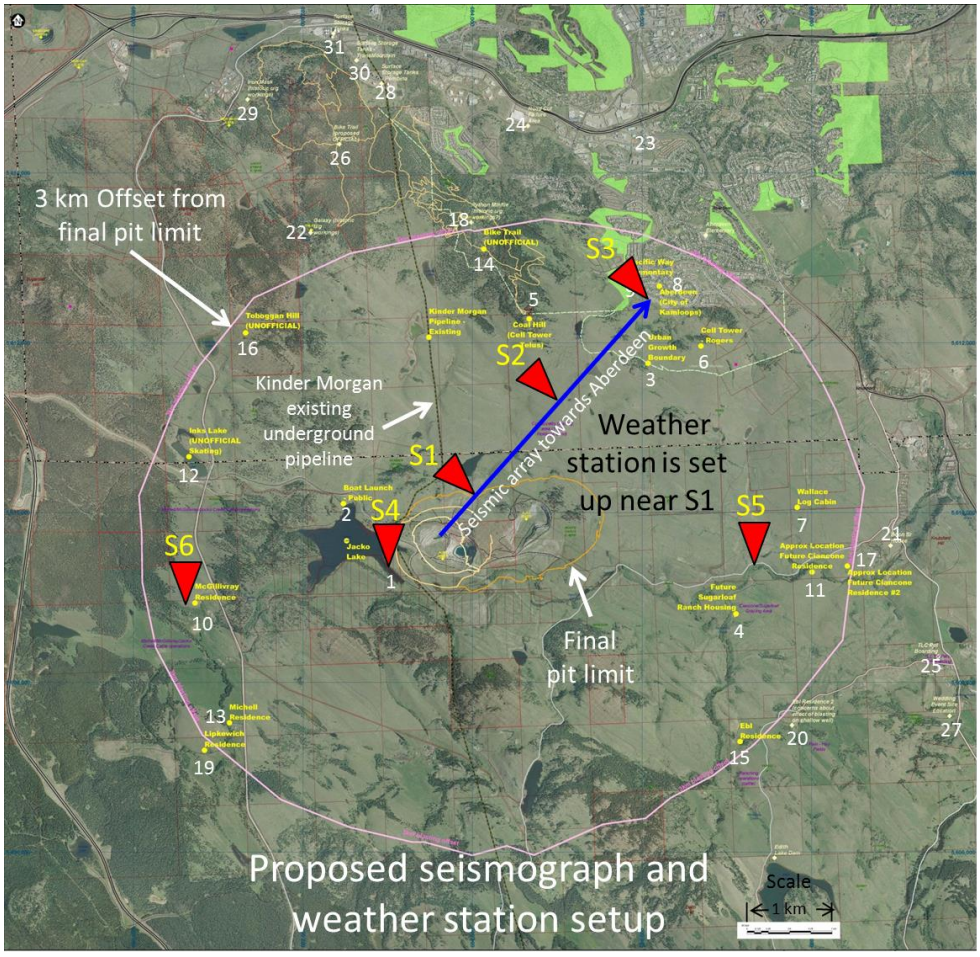


Figure 5.11 – Suggested seismograph and weather station setup for Ajax mine.

The fourth permanent seismograph should be set up near the SE arm of Jacko Lake to verify that all blasts, close to and approaching the lake, comply with the maximum allowable 13 mm/s, as stipulated by the DFO during the fish spawning period. Seismographs S5 and S6 should be portable to have the flexibility of monitoring the closer-in homes as needed in the Easterly and Westerly directions. Should the need arise, S5 and S6 will also accommodate linear predictive analyses in those two directions.

All seismographs should operate 24 hrs/day to record, not only the blast events, but also to record all of the non-blasting seismic/airblast activities in the community, such as ambient levels, electrical storms, local traffic, and roving livestock, etc. It would be best to have an independent contractor do the seismic/airblast monitoring.

5.2 Blast Design, Seismic, Airblast and Weather Records

Table 5.21 lists the recommended blast design, seismic, airblast and weather information to record for each blast. This information will be invaluable to show compliance, be transparent to the surrounding communities, resolve any disputes as to what took place on the blasts, spot potential problems early on, and to analyze trending for changing conditions and operating costs.

Table 5.21 – Necessary Information to Record for Each Blast

Necessary Information to Record for Each Blast		
General Information	**Seismic and Airblast Information**	**Blast Information (Con't)**
Shot Number	Radial amplitude (mm/s)	Primer size (g)
Ore or Waste	Radial frequency (Hz)	Burden (m)
Shot Date	Vertical amplitude (mm/s)	Spacing (m)
Shot Time	Vertical frequency (Hz)	Hole depth (m)
Pit number or mining phase number	Transverse amplitude (mm/s)	Subgrade (m)
Seismograph operator	Transverse frequency (Hz)	Top stemming (m)
Seismograph serial number	Airblast (dBL)	Top stemming
Date seismograph last calibrated	Airblast frequency (Hz)	Number of Explosive decks/hole
Seismic trigger level (mm/s)		Separation between explosive decks
Acoustic trigger level (dBL)	**Blast Information**	Deck delays (ms)
Seismograph location	Shot Coordinate (Northing)	Hole delays (ms)
Seismograph distance from blast (m)	Shot Coordinate (Easting)	Row delays (ms)
	Material (Ore or Waste)	Amount of explosives/deck (kg)
Weather Information	Total number of holes/blast	Amount of explosives/hole (kg)
Temperature	Number of rows in blast	Maximum weight of explosives/hole (kg)
Wind speed (km/h)	Number of holes/row	Total amount of explosives in blast (kg)
Wind direction	Dry or wet hole	Total amount of drill meters in blast (m)
Sky (clear, cloudy, raining, etc.)	Type of explosive(s)	BCM in blast (m^3)
Inversion height (m)	Explosive density	Powder (kg/t)
	Initiation system	Cost/tonne ($/t)

From BAI'S experience in dealing with court cases involving blast damage claims, almost 100% of the cases are lost due to poor/inadequate records, questionable data, and/or missing critical information. Thus, it is advisable to establish good record keeping protocols before any blasting takes place. One of the best ways to do this is to put the data and information listed in Table 5.21 into an appropriate spreadsheet, because if any information/data are missing they will be easily identifiable in the blank cells.

5.3 Linear Regression Analysis for Seismic Data

Linear regression is a powerful predictive analytical tool to predict the vibration levels in the community, closer than where the measurements were taken, farther away than where the measurements were taken, or anywhere in between, within reasonable tolerances. When the seismic measurements are taken carefully and the linear regression analysis is done correctly, the predictions will be better than any computer modelling, providing that the data is updated regularly and some of the earlier data is discarded. This is why it is very important to maintain good blast and seismic records. Figure 5.31 illustrates an example graphic analysis for linear regression.

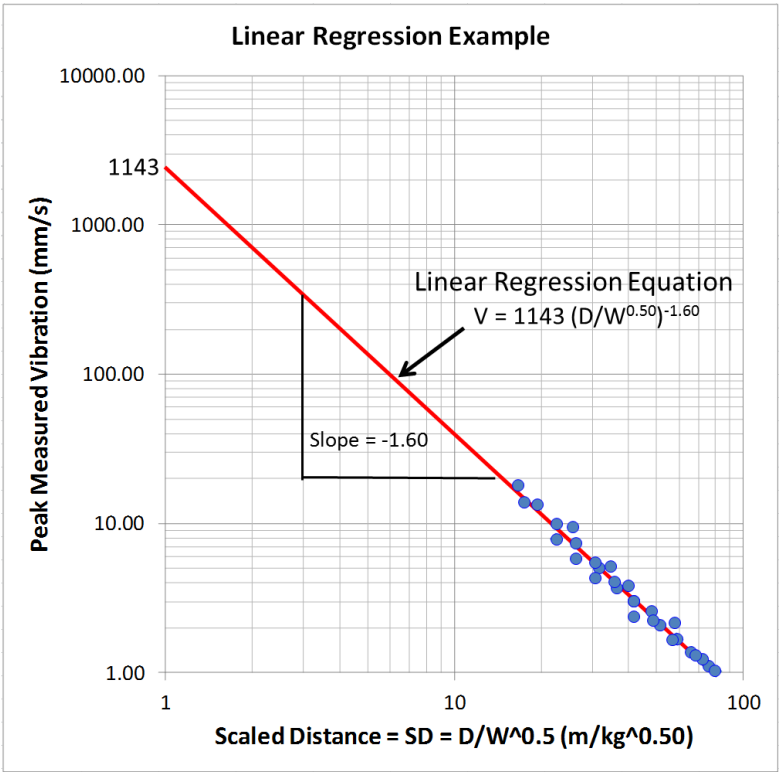


Figure 5.31 – Linear regression example. Plot of peak measured ground vibration vs scaled distance (SD). SD = D/($W^{0.5}$)

The regression graph in Figure 5.31 is a plot of the measured peak vibration levels versus scaled distance on a log-log scale. This could have hypothetically been developed from seismic measurements taken from the three seismograph array (S1 to S3) illustrated in Figure 5.11. For statistical significance, a minimum of 30 measured points will be required.

Scaled distance (SD) relates the distance (D), and the maximum weight of explosives per delay (W) as $D/(W^{1/2})$. This normalizes the data in order to compare "apples to apples", because each blast is expected to be at different distances from the seismograph location, and the blasts could have different maximum weights of explosives/delay.

The numerical values 1143 and -1.60 are the site attenuation constants, based on the measured seismic data. The "1143" is the y-intercept on the log-log graph at x= 1.0. The "-1.60" is the slope on the log-log graph.

Similarly, predictive regression equations can be developed in the Easterly direction towards the future Ciancone homes, future Sugarloaf Ranch Housing, and the Wallace cabin, as well as in the Westerly direction towards the McGillivray residence, if required.

6.0 PREDICTED FRAGMENTATION DISTRIBUTIONS

6.1 Jacko Lake and Processing Plant Requirements

A total of 31 fragmentation runs were done using a combination of drill patterns, top stemmings, stem charges, full column loads, and explosive decks with 311 and 152 mm holes. Table 6.11 lists a summary of the fragmentation predictions and their accompanying blast design details in both the ore and mine rock areas, in order of the 100% passing size.

Table 6.11 – Predicted Fragmentation Distributions in Order of the 100% Passing Size

Run No.	Blast Zone	Material	Hole Diam. (mm)	Bench Height (m)	Hole Depth (m)	Drill Pattern B x S (m x m)	Top Stem. (m)	Subgrade (m)	Stem Charge Mass (Kg)	No. of Expl. Decks Per Hole	No. of Primers Plus Dets. Per Hole	Max. Weight Expl. Per Delay (Kg)	Total Expl. Per Hole (Kg)	Powder Factor (Kg/t)	100% Passing Size (mm)
R4	Up to Z1	Ore	311	15	16.5	7.0 x 7.0	6	1.5	64	1	3 + 3	1020	1020	0.489	690
R4a	Up to Z1	Ore	311	15	16.5	8.5 x 8.5	6	1.5	64	1	3 + 3	1020	1020	0.331	990
R2	Up to Z1	Ore	311	15	16.5	9.0 x 9.0	6	1.5	64	1	3 + 3	1020	1020	0.296	1100
R3	Up to Z1	Ore	311	15	16.5	7.0 x 7.0	6	1.5	None	1	2 + 2	956	956	0.458	1450
R1	Up to Z1	Ore	311	15	16.5	8.0 x 8.0	6	1.5	None	1	2 + 2	956	956	0.351	1870
R8	Z1 - Z2	Ore	311	15	16.5	7.0 x 7.0	6	1.5	64	2	3 + 3	328	720	0.345	930
R6	Z1 - Z2	Ore	311	15	16.5	8.0 x 8.0	6	1.5	64	2	3 + 3	328	720	0.264	1200
R7	Z1 - Z2	Ore	311	15	16.5	7.0 x 7.0	6	1.5	None	2	2 + 2	328	656	0.314	1990
R5	Z1 - Z2	Ore	311	15	16.5	8.0 x 8.0	6	1.5	None	2	2 + 2	328	656	0.240	2610
R13	Z2 - Z3	Ore	152	15	16.5	4.0 x 4.0	2.8	1.5	None	2	2 + 2	127.5	255	0.375	850
R13a	Z2 - Z3	Ore	152	15	16.5	4.6 x 4.6	2.8	1.5	None	2	2 +2	127.5	255	0.283	1110
R15	Beyond Z3	Ore	152	15	16.5	3.7 x 3.7	2.8	1.5	None	3	3 + 3	68	204	0.350	890
R15a	Beyond Z3	Ore	152	15	16.5	4.2 x 4.2	2.8	1.5	None	3	3 + 3	68	204	0.271	1130
R10	Up to Z1	Waste	311	15	16.5	8.5 x 8.5	6	1.5	64	1	3 + 3	1020	1020	0.304	1050
R10d	Up to Z1	Waste	311	15	16.5	8.7 x 8.7	6	1.5	64	1	3 + 3	1020	1020	0.290	1100
R9a	Up to Z1	Waste	311	15	16.5	8.0 x 8.0	6	1.5	None	1	2 + 2	956	956	0.321	1980
R9	Up to Z1	Waste	311	15	16.5	8.5 x 8.5	6	1.5	None	1	2 + 2	956	956	0.285	2230
R10a	Up to Z1	Waste	311	15	16.5	9.0 x 9.0	6	1.5	64	1	3 + 3	1020	1020	0.271	2510
R10b	Up to Z1	Waste	311	15	16.5	9.5 x 9.5	6	1.5	64	1	3 + 3	1020	1020	0.243	2800
R10c	Up to Z1	Waste	311	15	16.5	10 x 10	6	1.5	64	1	3 + 3	1020	1020	0.219	3120
R12	Z1 - Z2	Waste	311	15	16.5	7.5 x 7.5	6	1.5	64	2	3 + 3	328	720	0.275	1130
R12a	Z1 - Z2	Waste	311	15	16.5	8.0 x 8.0	6	1.5	64	2	3 + 3	328	720	0.242	1280
R12b	Z1 - Z2	Waste	311	15	16.5	8.5 x 8.5	6	1.5	64	2	3 + 3	328	720	0.214	1440
R12c	Z1 - Z2	Waste	311	15	16.5	9.0 x 9.0	6	1.5	64	2	3 + 3	328	720	0.191	1620
R12d	Z1 - Z2	Waste	311	15	16.5	9.5 x 9.5	6	1.5	64	2	3 + 3	328	720	0.171	1810
R12e	Z1 - Z2	Waste	311	15	16.5	10 x 10	6	1.5	64	2	3 + 3	328	720	0.155	2020
R11	Z1 - Z2	Waste	311	15	16.5	7.0 x 7.0	6	1.5	None	2	2 + 2	328	656	0.283	2110
R14	Z2 - Z3	Waste	152	15	16.5	4.6 x 4.6	2.8	1.5	None	2	2 + 2	127.5	255	0.259	1170
R14a	Z2 - Z3	Waste	152	15	16.5	4.8 x 4.8	2.8	1.5	None	2	2 + 2	127.5	255	0.238	1280
R14b	Z2 - Z3	Waste	152	15	16.5	5.0 x 5.0	2.8	1.5	None	2	2 + 2	127.5	255	0.220	1390
R14c	Z2 - Z3	Waste	152	15	16.5	5.2 x 5.2	2.8	1.5	None	2	2 + 2	127.5	255	0.203	1620
R16	Beyond Z3	Waste	152	15	16.5	4.2 x 4.2	2.8	1.5	None	3	3 + 3	68	204	0.248	1200
R16a	Beyond Z3	Waste	152	15	16.5	4.4 x 4.4	2.8	1.5	None	3	3 + 3	68	204	0.226	1310
R16b	Beyond Z3	Waste	152	15	16.5	4.6 x 4.6	2.8	1.5	None	3	3 + 3	68	204	0.207	1440
R16c	Beyond Z3	Waste	152	15	16.5	4.8 x 4.8	2.8	1.5	None	3	3 + 3	68	204	0.190	1570

The detailed fragmentation distributions for each run are presented and cross referenced in Appendices A and B. The original runs R1 to R16 are included in Appendix A. The additional runs R10a – R10d, R12a – R12e, R14a –R14c, R15c, and R16a – R16c are included in Appendix B.

All of the blast designs in Table 6.11 for the ore and mine rock will comply with the DFO vibration/airblast requirements to protect aquatic life in Jacko Lake. Protecting the aquatic life in Jacko Lake took priority over the blast designs, due to the DFO stipulations.

The next stage was to select the best blast designs for use in the ore and mine rock with some compromises. Table 6.12 lists the blast designs selected for the ore and mine rock. The ore blast designs (R2, R6, R13 and R15a) were the most suitable for the plant fragmentation, because they came closest to the 100% passing size of 1100 mm. Refer to Appendices A and B for the detailed fragmentation distributions.

Table 6.12 – Selected Blast Designs for Use in Ore and Mine rock

Blast Zone	Selected Blast Designs for Ore	Selected Blast Designs for Mine rock
Up to Zone 1	R4a	R9a
Z1 to Z2	R6	R12e
Z2 to Z3	R13	R14c
Beyond Z3	R15a	R16c

For the best mine rock blasts, it was not so obvious because in order to achieve the same 100% passing size of 1100 mm as the ore blasts, while desiring more course fragmentation in the distribution, the drill patterns needed to be increased.

Increased drill patterns result in lower powder factors, and hence generate than a larger 100% passing size by default, due to the assumed structural joint sets, and because no more changes can be made in the top stemming in both the 311 and 152 mm holes. This also reduces the risks related to flyrock and airblast magnitude. Unfortunately with a 15 m bench, and the necessity of explosive decking to satisfy the DFO stipulations in Jacko Lake, it doesn't leave much room to change any other blast design variables. Thus, mine management will need to determine the maximum size of the mine rock fragmentation required, versus the drill pattern, powder factor, and the resulting cost/tonne. BAI does not recommend a powder factor much lower than 0.20 Kg/tonne in the mine rock.

But regardless of how good the blast designs are, there will always be some oversize to contend with at the mine. The oversize will usually originate in the collar zones of holes loaded without a stem charge, from all corners within the blast blocks, and sometimes along the floors from the structural orientation. Thus, impact hammers are recommended to reduce oversize material. Secondary drilling and blasting or shaped charges are often used to reduce oversize but are not necessarily recommended due to community concern with noise and vibration from additional blasting operations.

7.0 PRESPLITTING AND HIGHWALL CONTROLS

7.1 Importance and Role of Presplitting

When properly implemented, presplitting along the final highwalls and/or along critical blast zones, serves many critically important functions such as:

1. Improving the integrity of the final highwalls for the life of mine.

2. Allowing for inclined bench faces, without any back break.

3. Improving the effectiveness of safety berms to stop loose rock and debris from bouncing down the highwalls and into the pit.

4. Improving the safety for people who have a need to work near the crests or directly underneath the highwalls.

5. Acting as an effective dewatering mechanism to keep the water table below the active blast block.

6. Acting as an effective attenuator for ground vibrations being transmitted into the highwall from the large production blasts.

7. Protecting major haul roads or other structures in the pit, which are temporary, but may need to remain operational and safe for employees to work around for many years.

8. Assisting in maintaining a stable base for mine rock dumps.

7.2 Suggested Presplit Design Parameters for Different Hole Diameters

Table 7.21 lists the recommended presplit design parameters for 152 mm (6-in), 194 mm (7 5/8-in), and 270 mm (10 5/8-in) holes, with a preference towards the 152 mm (6-in) hole diameter. In general, the smaller the presplit hole diameter, the better the presplit wall result, particularly in areas with complicated structural geology.

Table 7.21 – Presplit Design Suggestions for 152 mm (6-in), 194 mm (7 5/8-in), and 270 mm (10 5/8-in) Holes

Hole Diameter	152 mm(6-in)	194 mm (7 5/8-in)	270 mm (10 5/8-in)
Presplit Hole Spacing	2.0 m	3.0 m	4.5 m
Powder Factor 1	1.9 Kg/m	2.8 Kg/m	3.7 Kg/m
Powder Factor 2	0.81 Kg/m^2	0.94 Kg/m^2	0.83 Kg/m^2
Presplit Hole Depth	16 m	16 m	16 m
Total Expl./Presplit Hole	30 Kg	45 Kg	60 Kg

In Table 7.21 the presplit hole depths include one meter of subgrade. Presplit powder factor 1 refers to the amount of explosive load per linear meter of the presplit hole depth. Presplit powder factor 2 refers to the amount of explosive load per square surface area of the presplit plane between holes.

Figure 7.21 illustrates a plot of presplit powder factor versus presplit hole diameter, with corresponding presplit hole spacing.

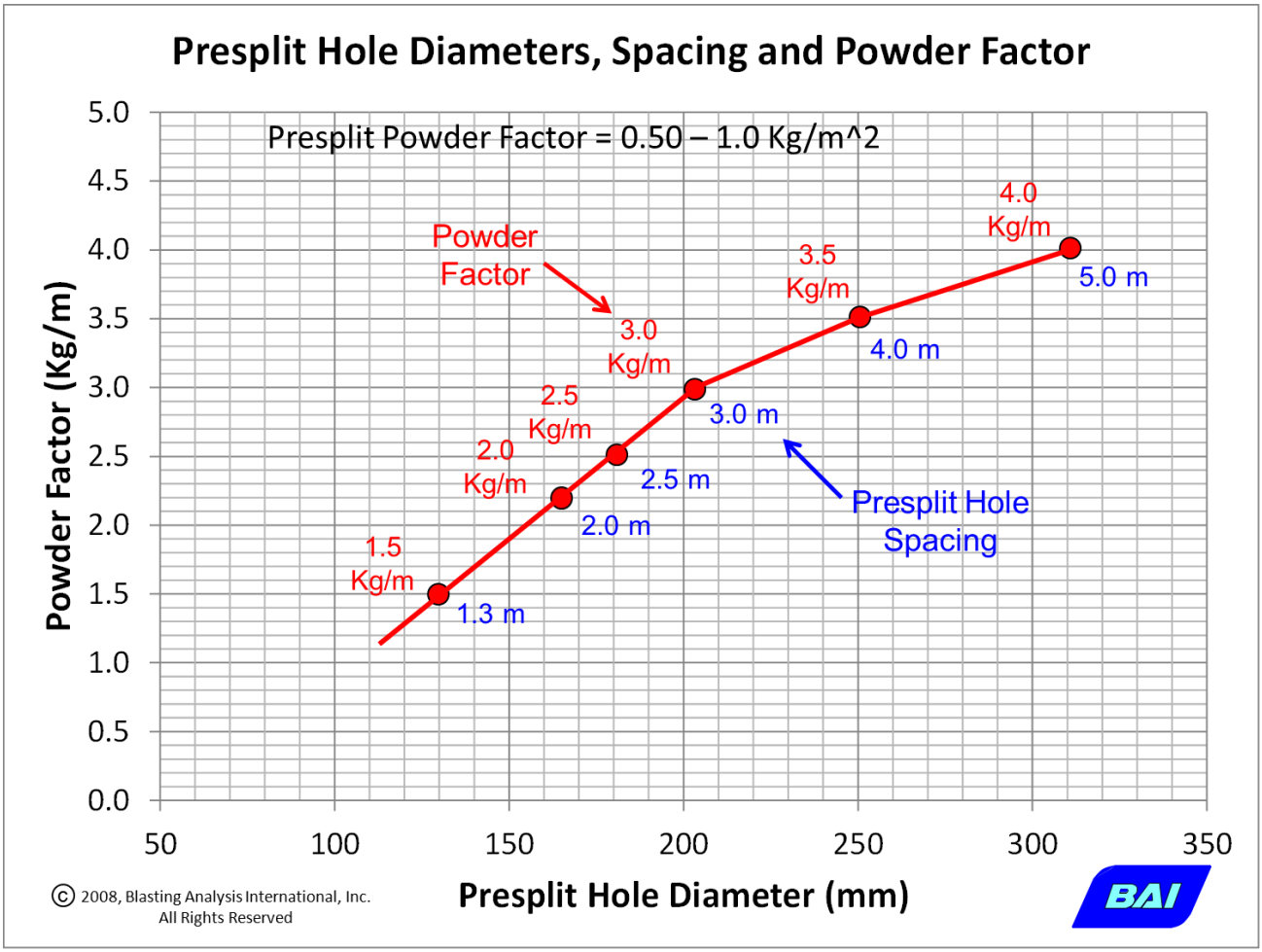


Figure 7.21 – Presplit powder factor versus hole diameter with suggested hole spacing.

Figure 7.22 illustrates different presplit hole loads compared to a fully loaded production hole. All of the presplit hole loads (A to F) will result in good presplit results, the type of explosive used is irrelevant, and how the explosive is distributed within the holes does not matter when properly implemented.

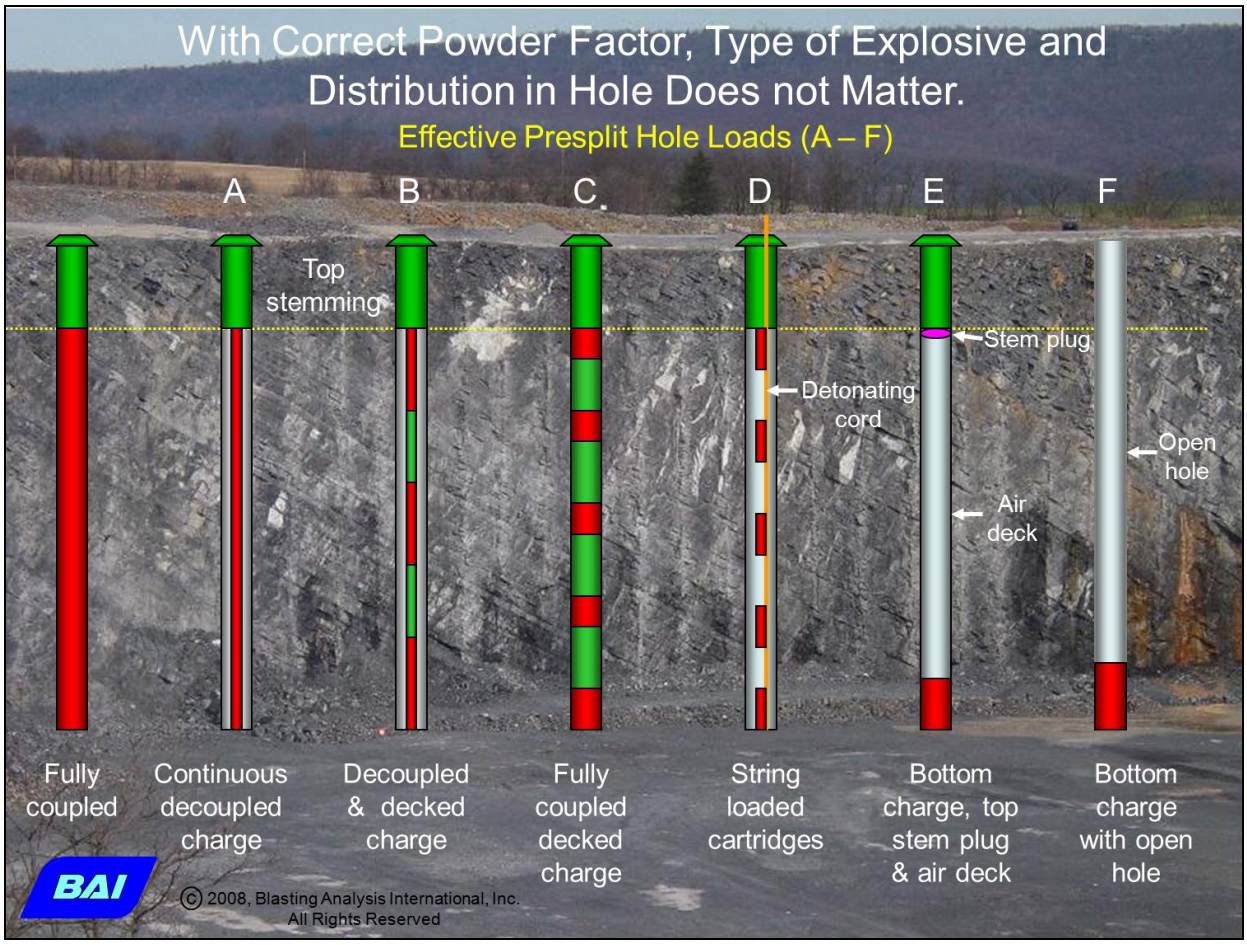


Figure 7.22 – Examples of different presplit hole loads. All hole loads will produce good presplit results, when properly implemented.

A single bottom charge will suffice for presplit hole depths of 25 m or less, such as that illustrated in Figure 7.22, Holes E and F. This charge does not need to be right at the hole bottom to achieve good results. Placing the charge anywhere in the bottom third of the hole will work just as well.

BAI recommends the presplit load illustrated in Figure 7.22 E, with a 1.5 – 2.0 m top stemming to minimize the airblast impact. The presplit hole load illustrated in Figure 7.22 F is not recommended.

7.3 Suggested Buffer Hole Design Parameters

Figure 7.31 illustrates the suggested buffer hole design using 152 mm (6-in) with 311 mm (12 ½ -in) production holes. Note that the same calculations will apply to any size of buffer and/or production diameter hole.

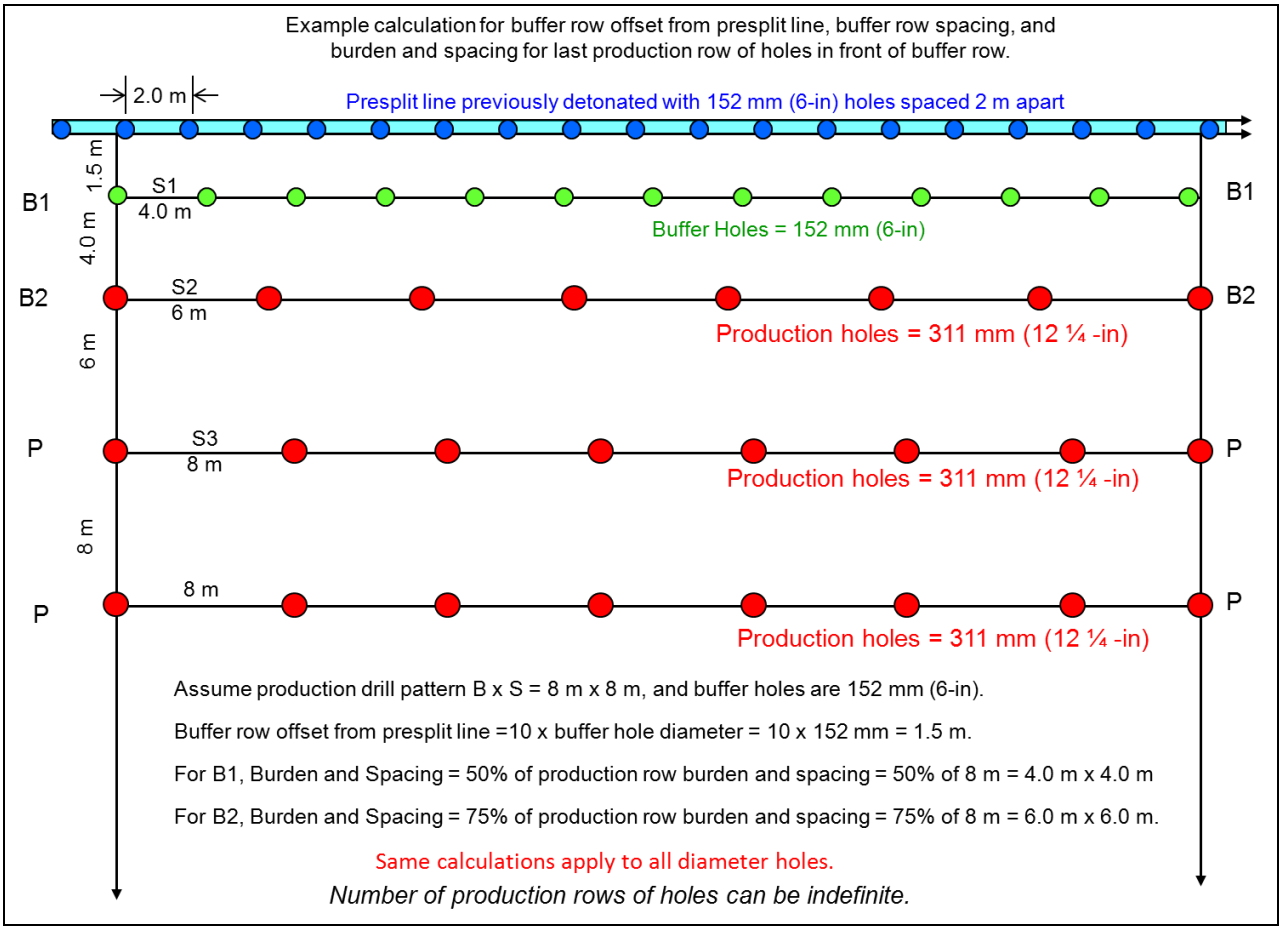


Figure 7.31 – Suggested buffer hole design and calculations.

Figure 7.32 illustrates a cross section of the buffer hole design from Figure 7.31. Note that the buffer holes in B1 use a full column load, but with reduced burden and spacing according to that outlined in Figure 7.31. The only place where explosive decking is used in the buffer and production holes is when blasting towards Jacko Lake. Buffer row B2 uses the production size hole diameters, with the burden and spacing also slightly reduced according to that outlined in Figure 7.31. The objective of gradually and incrementally reducing the burdens and spacings in B2 and B1 is to provide more forward relief to avoid back break into the formerly presplit highwall.

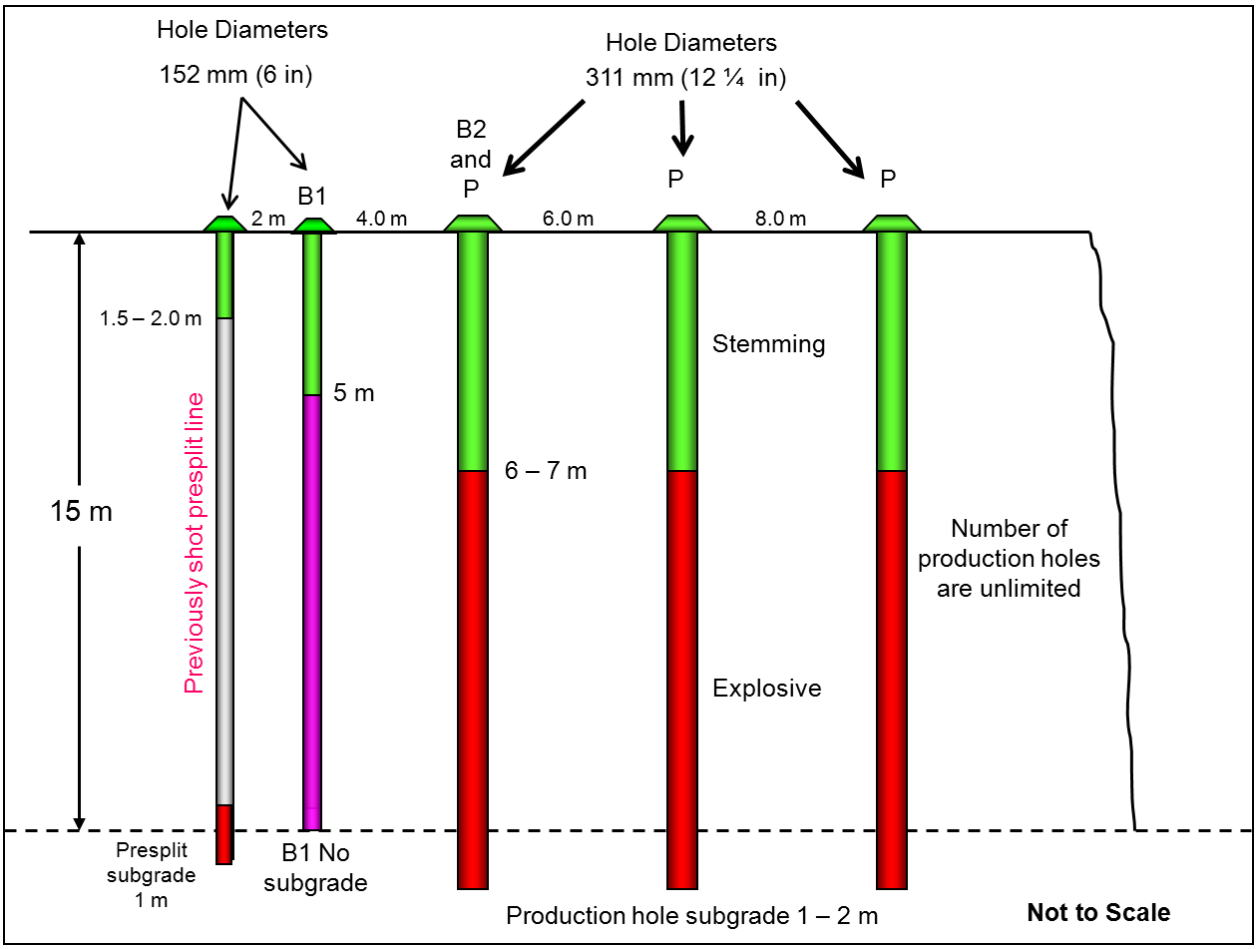


Figure 7.32 – Cross section of the presplit, buffer and production hole loads from Figure 7.31.

7.4 Other Important Things to Note Regarding Presplitting and Buffer Hole Designs

To achieve consistently good presplit highwalls, BAI recommends the following:

1. All field controls regarding accurate drilling and proper loading techniques in wet holes must be in place. Refer to Section 8.0 for more details.

2. The rock must be conducive to presplitting. If the UCS (Uniaxial Compressive Strength) of the rock is much less than 40 MPa, presplitting will usually be a mine rock of time because it simply will not work. The presplit may look good immediately after blasting, but in time, it will eventually unravel. In these rock conditions, it would be better to use trim or buffer blasting, whereby the last buffer or production row of holes replaces the presplit line.

3. When using large diameter holes in highwalls which are less than 8 -10 m, it is usually not worth the effort economically to presplit.

4. Geotechnical information for known and/or past problematic areas in the pits along dykes and major joint contacts, which could be undercut by the presplit plane, should be identified and marked in the field. This information should then be provided to the planning group for use in the blast designs, and for safety to flag potentially unsafe areas for people and equipment.

5. A blast plan should be provided for all presplit areas with detailed drilling and loading instructions for the drillers, blasters and field foremen. Any deviations from the presplit plans should be pre-approved by the planning group. Also, one presplit design for the entire mine might not be sufficient, if the rocks or blast environments are different.

6. Emphasize that the presplit holes must be drilled with 0.50 to a maximum of 1.0 m subgrade below the targeted floor. If this is not done, the intent and function of the buffer row of holes next to the presplit will be completely negated. The presplit subgrade is needed to assist the buffer holes in breaking cleanly to the presplit plane, and to eliminate frozen wedges along the toes of the highwall. Do not exceed a subgrade of more than one meter, because the presplit shot could shift the entire blast block, particularly in water saturated blast environments.

7. Assure that the presplit holes are drilled to the correct depth. Then measure the presplit hole depths well in advance of loading them, so that if short or lost holes are identified, appropriate actions can be taken to remedy the problems. Finally, the presplit holes should always be re-measured again just prior to loading.

8. Always attempt to fire the presplit line in advance of the blast, before any of the production holes are drilled and/or loaded, when the presplit line is an integral part of the blast block. This will eliminate damaging any buffer and/or production holes from ground shifts, explosive desensitization and sympathetic detonations, which could result from the presplit shot. Never tie in the presplit to fire before the production shot on the same blast block, unless the presplit is quite far removed from the blast area, with an appropriate safety distance. Refer to Figures 7.41 to 7.43.

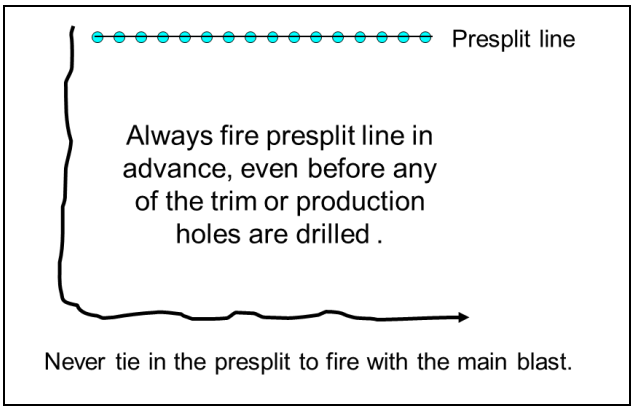


Figure 7.41 – Fire presplit line in advance of blast block

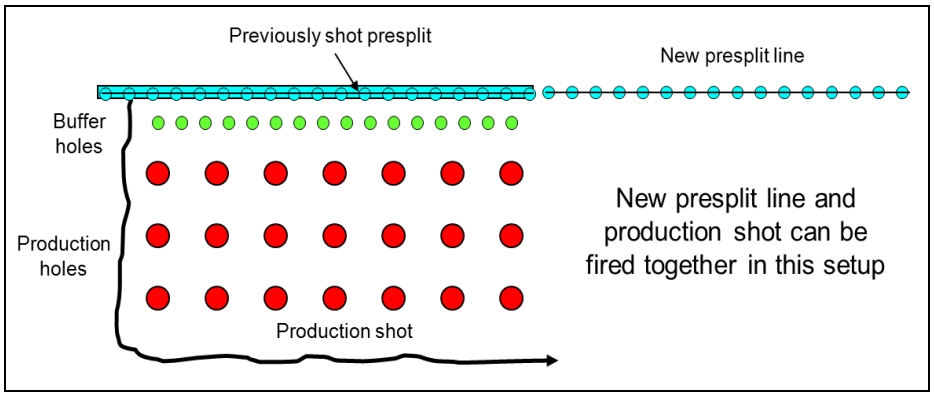


Figure 7.42 – In this setup, the presplit could be fired with the main blast.

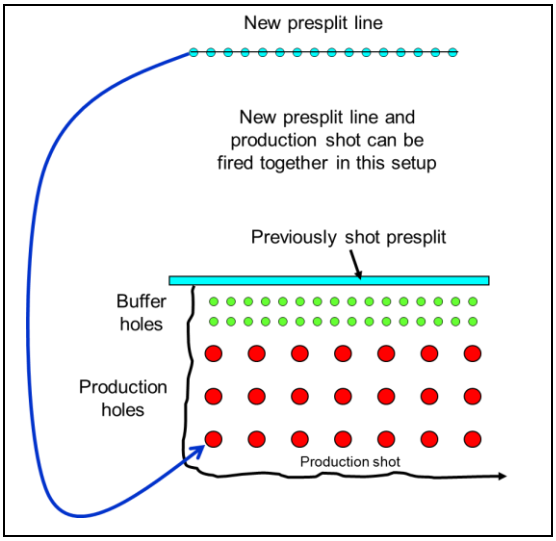


Figure 7.43 - In this setup, the presplit could also be fired with the blast.

9. Fire all of the presplit holes instantaneously, since this will always produce the best results. Electronic detonators, compatible downline detonating cord or special instantaneous pyrotechnic detonators are recommended for this purpose. The best option is the electronic detonators, even if they are only used for presplitting, because the integrity of the highwalls is critical to assure the mine life, and the safety of people and equipment working around the base of the highwalls.

10. Do not use standard in-hole pyrotechnic detonators such as the 350, 500 or 750 ms in the presplit holes, because the inherent delay scatter will not achieve the required instantaneous hole detonations. These in-hole delays do not always result in poor presplit results, but sooner or later a disastrous presplit wall will result.

11. When vibrations are a concern with the presplit line, then groups of presplit holes should be delayed with the shortest tolerable delay, to minimize cumulative amplification effects. The maximum number of presplit holes would usually be dictated by the amount of explosives typically used in one production hole, assuming that one production hole per delay was being used to control the vibrations.

12. Consideration should be given to presplitting double benches at once, if the geotechnical data and overall pit slope angle supports this. For presplit holes over 25 m, two charges are necessary, where 60% of the total charge amount is placed at the hole bottom, and 40% of the total charge amount is placed approximately half way up the hole. A presplit charge distribution of 50%/50% of the total presplit charge quantity is also acceptable. Both charges within each presplit hole will need to be fired instantaneously. Do not use in-hole pyrotechnic delays for this purpose. If two charges are not used, overhangs along the crest and collar zone can be expected, because a single charge concentrated at the hole bottom will not generate enough borehole pressure in the top part of the hole near the crest.

    Figures 7.44 to 7.46 illustrate example presplit hole loads where two presplit charges were required in highwalls which were between 40 to 55 m.

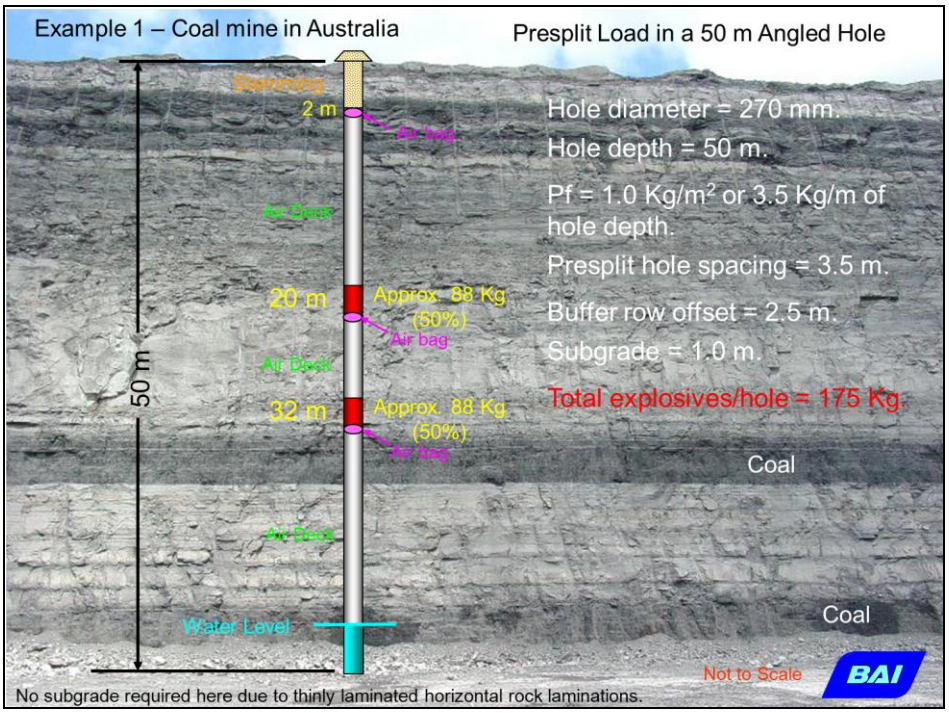


Figure 7.44 – Presplit design example in a 50 m highwall, with two charges per presplit hole. Airblast was a concern here, so a 2 n top stemming was used in each presplit hole. Image not from Ajax mine.

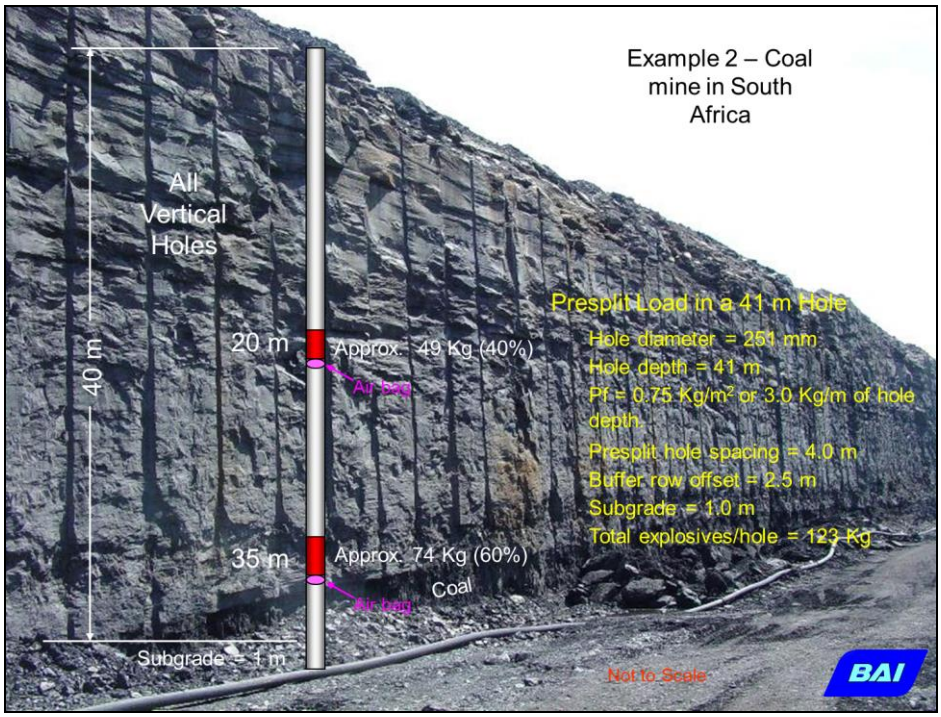


Figure 7.45 - Presplit design example in a 40 m highwall, with two charges per presplit hole. Image not form Ajax mine.

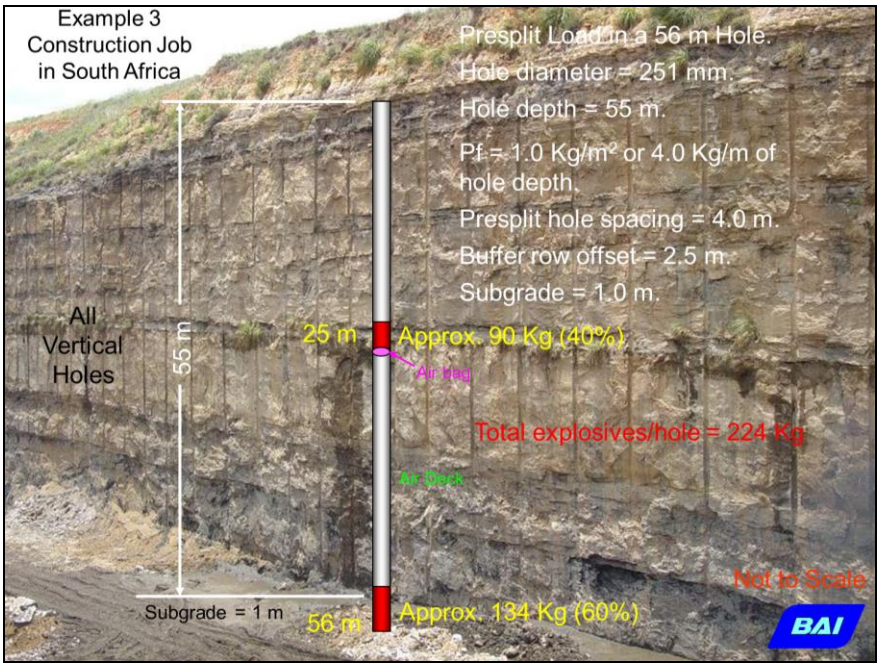


Figure 7.46 - Presplit design example in a 55 m highwall, with two charges per presplit hole. Image not from Ajax mine.

13. In very wet hole conditions, the total presplit charge will need to be reduced by 25 - 50% of the total charge mass normally used in dry holes. Refer to Figure 7.47.

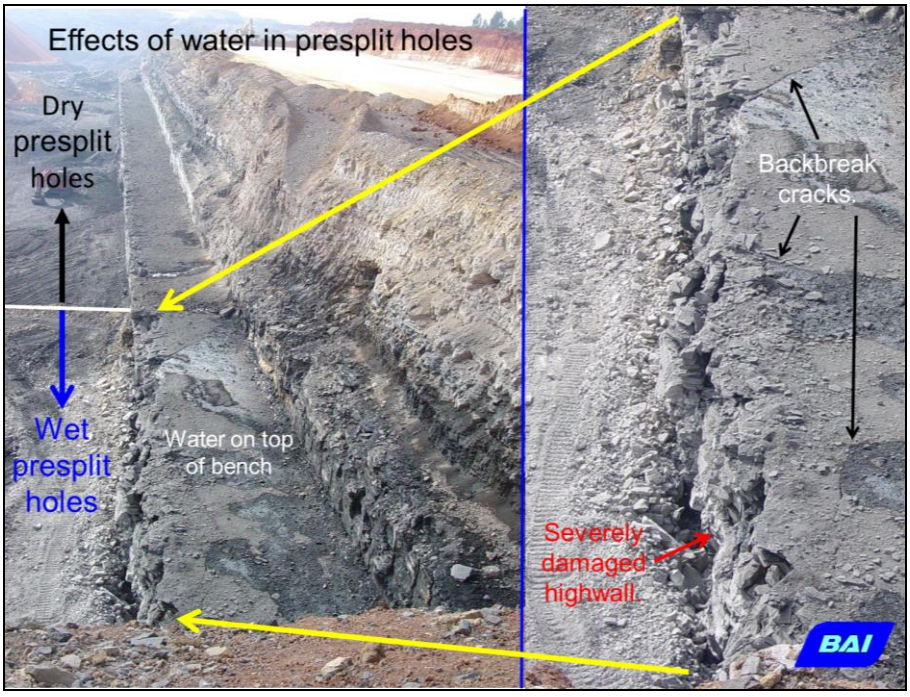


Figure 7.47 – Effect of not reducing the presplit powder factor by 25 – 50% in water saturated blast environments.

14. A good starting point for the offset distance of the buffer row of holes next to the presplit plane is approximately 10 times the diameter of the buffer hole diameter. So, if a 152 mm (6-in) diameter hole is used for the buffer holes, the offset should be around 1.5 m.

15. Regardless of whether one or two charges are used per presplit hole, it is strongly recommended that the charges are placed in water resistant protective socks or bags, as illustrated in Figure 7.48. This eliminates any explosive contamination, and it assures that the exact presplit charge amount gets to the proper location within the hole, especially in wet hole conditions. One must remember that presplit charges are relatively very small, but they are relied upon to perform an extremely important function. The chances of an augured, small, gas sensitized presplit charge from surface making it 16.5 m to the bottom of a hole without any loss, degradation or contamination is very slim. Figure 7.49 illustrates what can happen when this is not done.



Figure 7.48 – Protective socks are recommended for presplit charges in both wet and dry holes.

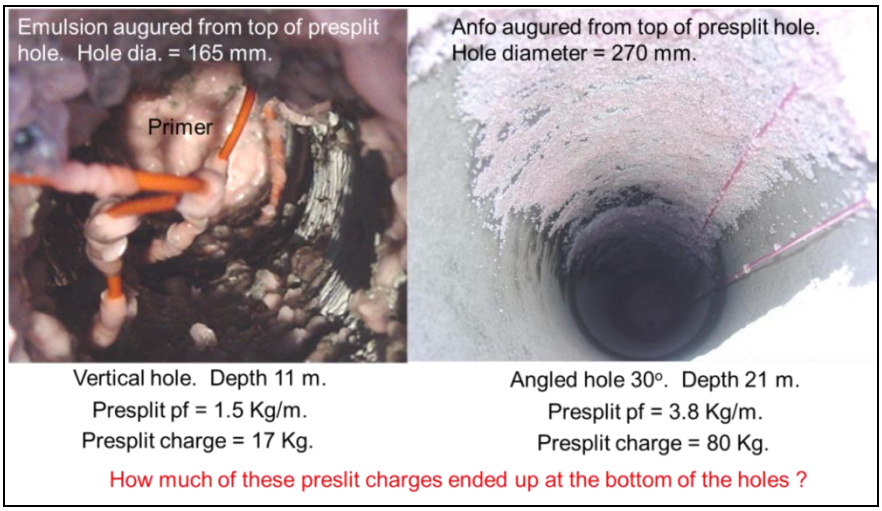


Figure 7.49 – Effects of auguring emulsion from top of a vertical presplit 165 mm diameter hole, and from auguring Anfo from the top of an angled 270 mm diameter hole.

7.5 Point Summary of Presplitting Guidelines

Table 7.51 lists a point form summary of all the key presplitting guidelines. If all of the above mentioned recommendations are properly implemented, and presplit problems are still encountered, then it is strongly suggested that the explosives are checked for quality and performance, particularly for gas sensitized products which may need to sleep in wet holes for extended periods.

Table 7.51 – Summary of Key Presplitting Guidelines

Presplitting Guidelines for Medium to Large Diameter Holes
1 - Cp of rock must be at least 40 MPa (6,000 psi).
2 – Need good drilling controls.
3 – PF between 0.50 and 1.0 Kg/m^2 or 1.5 and 4.0 Kg per linear depth of hole.
4 – Wet holes – Reduce PF by 25 to 50%.
5 – Always fire presplit line in advance.
6 – Fire presplit holes instantaneously.
7 - Drill presplit holes with 0.50 – 1.0 m subgrade below targeted floor or coal seam.
8 - Buffer hole offset = 10 x buffer hole diameter.
9 - Use full column explosives in buffer holes. No air decks or explosive decks except near Jacko Lake..
10 – Holes over 25 m, use a mid-column and bottom hole charge, fired instantaneously.
11 – Protect presplit charges from contamination.
12 – Assure presplit plane does not undercut joint system.

8.0 FIELD, PLANNNG AND ENGINEERING CONTROLS

8.1 Importance of Field Controls

For an explosive to deliver maximum energy release into the rock mass, the explosive column must be:

1) drilled to the correct depth;
2) suitably burdened and confined;
3) free of any contamination and/or dilution for its entire length; and
4) the primer must remain in the part of the explosive column where it was intended to stay at.

The lack of these field controls are responsible (from BAI'S worldwide experience) for approximately 75% of all blast related problems. Thus the first priority at the mine, above all else, should be to assure that all of the proper field controls and checks are in place, before any blasting begins. The best approach for planners, supervision and the blast crews is to take care of all blast requirements, objectives and potential problems in the primary blast design, on the first pass. Not later through unnecessary secondary unit operations. This is referred to as the Mine-to-Mill concept. This approach may initially take a little longer and cost a little more, but at the end of the day, it will always yields the best productivity and the lowest total mining system cost.

8.2 Drill Hole Depth Controls and Drill Cuttings Falling Back Into the Hole

A big problem experienced at many surface mines is drill cuttings falling back into the holes, when the drill bit is retracted out of the holes. The larger the drill cutting mound around the hole, and the finer the drill cuttings are, the more this problem is aggravated. Refer to Figure 8.21. Drill cuttings in wet holes are more problematic than dry holes.



Figure 8.21 – Large drill cutting mounds around the borehole collars can be problematic, because the drill cuttings could fall back into the holes causing short holes and/or they could plug up the hole, both of which would require the hole to be re-drilled. Image not from Ajax mine.

In addition to when retracting the drill bit out of the holes, many other things could also cause drill cuttings to fall back into the holes from:

1. Worker activity around the hole during explosive loading, sampling the drill cuttings, and/or during marking the hole for numbering, hole depth and water content.

2. Surface water and/or high winds eroding the drill cuttings back into the holes.

3. Not raising the dust flaps on the drills before moving to another hole.

4. Drilling a line of holes in the wrong direction or sequence.

5. Re-setting up over holes to be re-drilled, as illustrated in Figure 8.22.

6. Water rising on top of the explosive column during loading, and being trapped by the drill cutting mound around the hole. Refer to Figures 8.23 to 8.27.



Figure 8.22 – Drill cuttings could be pushed back into the holes when the dust flaps are not raised prior to moving the drill to another hole, drilling a line of holes in the wrong direction/sequence, and/or when setting up over holes to redrill them. At this mine, all of the holes had to be re-drilled on the blast. Image not from Ajax mine.

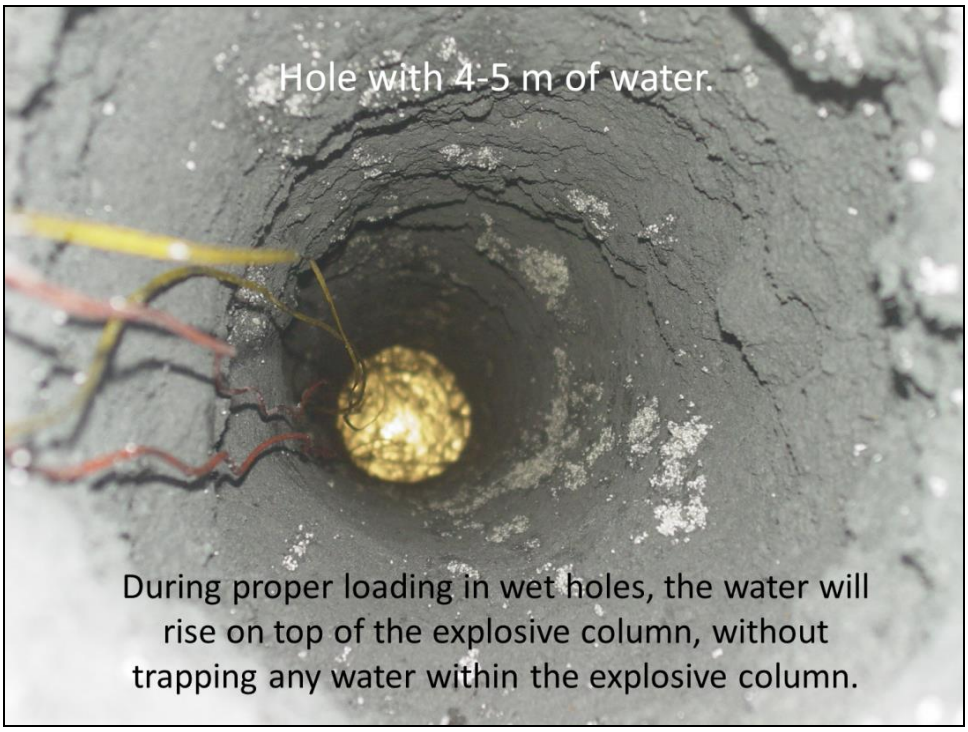


Figure 8.23 – During bulk explosive loading, water will rise on top of the explosive column. Image not from Ajax mine.



Figure 8.24 – Water rise reaches top of hole. Image not from Ajax mine.



Figure 8.25 – Water continues to rise into the drill cutting containment funnel. Image not from Ajax mine.



Figure 8.26 – As water rises further into the drill cutting containment funnel, the fine powdery drill cuttings become water saturated, and they are sucked back into the hole as the water continues to rise into the drill cutting funnel, during the loading process. Image not from Ajax mine.

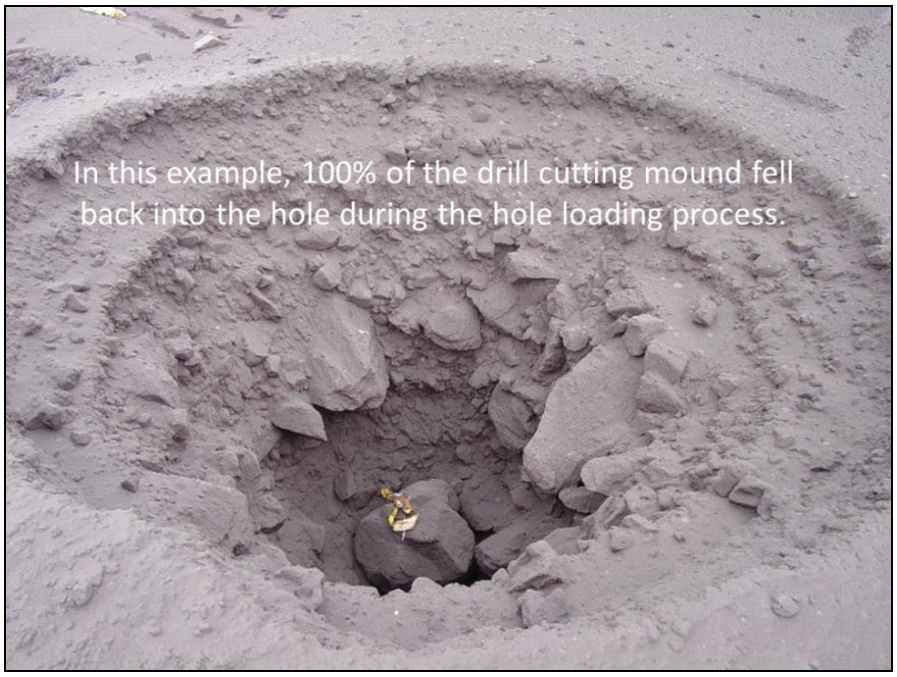


Figure 8.27 – Example of 100% of the drill cutting mound which was completely sucked back into the hole, during the bulk explosive loading process in a wet hole. Depending on the hole diameter and hole depth, this could represent an explosive dilution of between 5 and 12%. Explosive dilution will result in reduced explosive energy, and it is a major source of noxious fumes and nitrate residues. Image not from Ajax mine.

Drill cuttings falling back into the hole would result in short holes, plugged holes, and explosive contamination if water was present inside the hole. This would necessitate all of the short holes less than 0.50 m of the planned hole depth to be re-drilled. But if a drill was not readily available to re-drill the short holes, the hole would most likely be loaded as is. Under these procedures, poor blast results could be expected in the production, trim, and presplit blasts, regardless of how good the blast designs are.

The best permanent solution is always one that eliminates the problem at its source. There are six solutions for minimizing or eliminating drill cuttings from falling back down into holes:

1. **Drill maintenance.** First, make sure all of the drills are operating correctly, and that the drillers have been properly trained on the specific drills.

2. **Order cyclones on all drills**. Cyclones are available for small, medium and large diameter drills, as illustrated in Figures 8.28 - 8.210. These are the best permanent solution to eliminating drill cuttings from falling back down into the holes, and they also result in reasonable dust controls. Basically they act as powerful vacuums to displace the drill cuttings away from the hole collars.

3. **Order deflectors on all drills.** These systems use high pressure air nozzles to displace the drill cuttings ejected from the top of the hole against a metal or rubber plate deflector. The deflector displaces the drill cuttings away from the hole, but does not offer very good dust controls. But this system is more economical and easier to install than the cyclones.

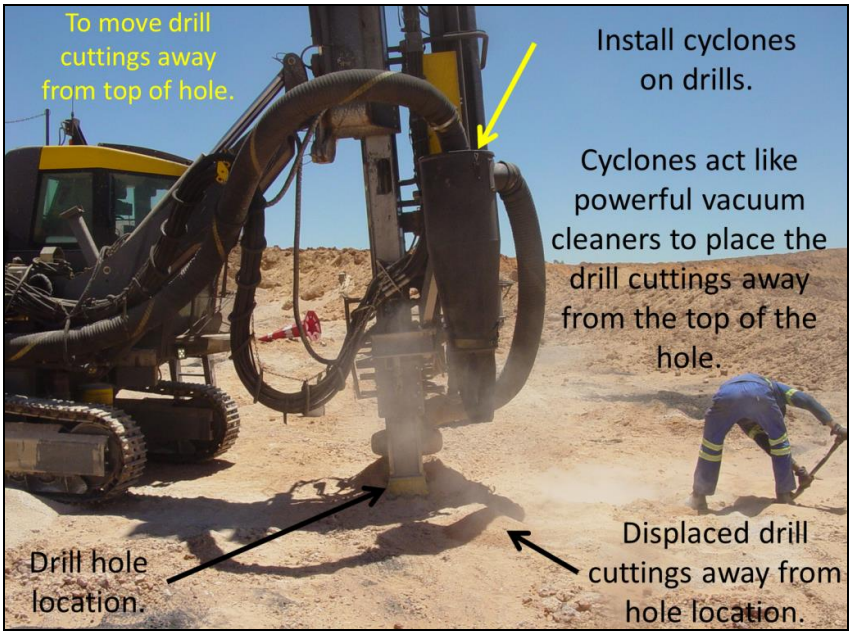


Figure 8.28 – Example of a cyclone installed on a small drill to displace the drill cuttings away from the top of hole. Cyclones are also available for medium and larger drills. Image not from Ajax mine.

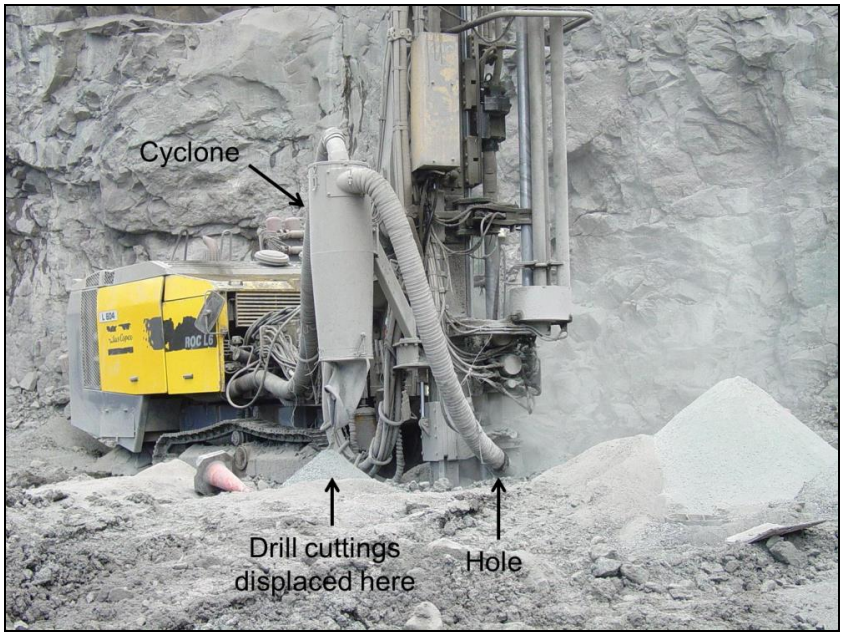


Figure 8.29 – Example of a cyclone installed on a medium sized drill. Image not from Ajax mine.

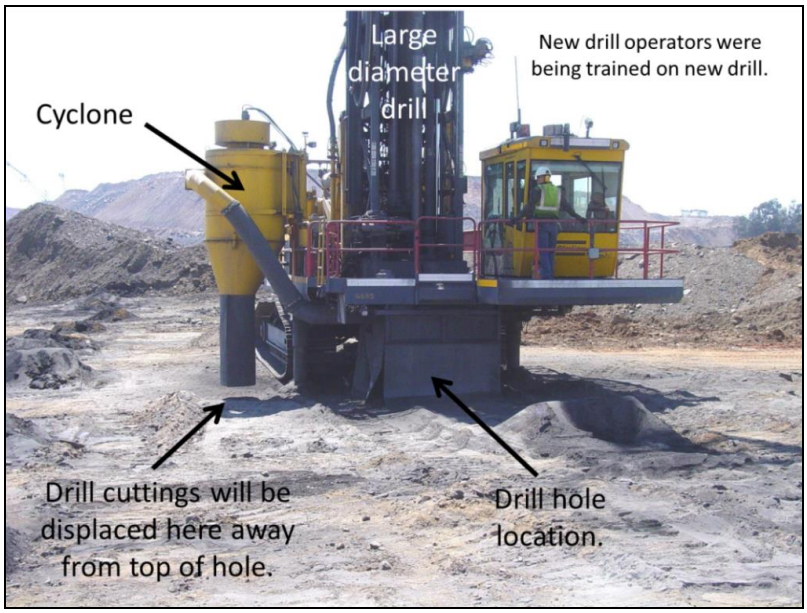


Figure 8.210– Example of a cyclone installed on a large drill. This drill was recently commissioned, and new operators were being trained on it. Image not from Ajax mine.

4. **Create a ditch at base of drill cutting mound.** Creating a ditch around the base of the drill cutting mound will channel the water away from the top of the hole, as illustrated in Figure 8.211. This system is the most economical in warm weather climates, but is ineffective in cold weather climates when the drill cuttings are frozen. To be effective, the ditch needs to be created before loading the wet holes.



Figure 8.211 – Man made ditch to channel water away from top of hole will help to minimize the drill cuttings from falling back into the hole. Image not from Ajax mine.

5. **Use cone plugs in hole collars.** Use cone plugs in all of the hole collars, as illustrated in Figure 8.212. These are ideal to minimize drill cuttings from falling back into hole from surface rain water, high winds, and worker activity around the top of the hole. But, they are not very effective when loading wet holes.



Figure 8.212 – Example of top cones used in collar of holes. Image not from Ajax mine.

6. **Use short length PVC casings in collar of hole.** Use short length PVC tubes in collar of hole, as illustrated in Figures 8.213 and 8.214. These tubes are very effective in eliminating drill cuttings and loose rocks around the collar of the hole (i.e. previous subgrade area) from falling back into the hole. They are also more effective when loading wet holes than the top cone plugs, but only when placing stemming between the PVC tube and the borehole wall, as illustrated in Figure 8.215.



Figure 8.213 – Example of top casing tubes used in collar of hole. Image not from Ajax mine.

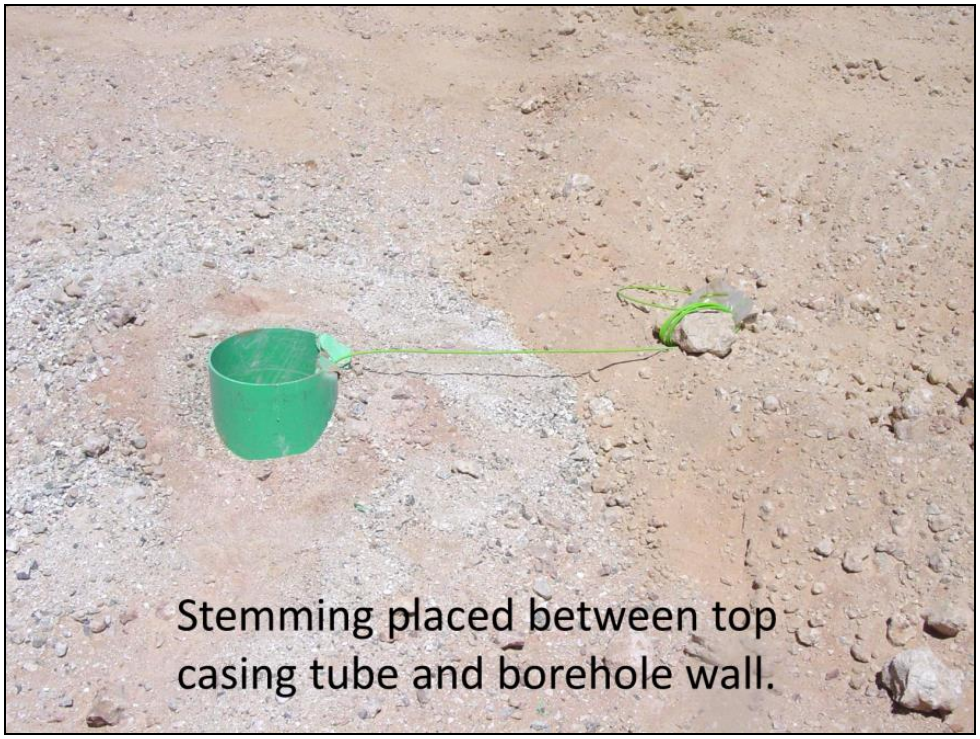


Figure 8.214 – Stemming must be placed between the tube casing and borehole wall, or the tubes could be ejected out of the holes during the shot sequence. Image not form Ajax mine.

7. **Use casings for entire length of hole.** In holes with very rough borehole conditions, where loose rocks can plug up the holes, use continuous length thin walled PVC tubes or SONO tubes, as illustrated in Figures 8.215 and 8.216. SONO tubes are generally more economical than PVC tubes, because they are manufactured with heavy cardboard that are coated with wax. Continuous length casings for the entire depth of the holes are ideal when the holes have to sleep for a long time in rough borehole conditions before they are loaded.

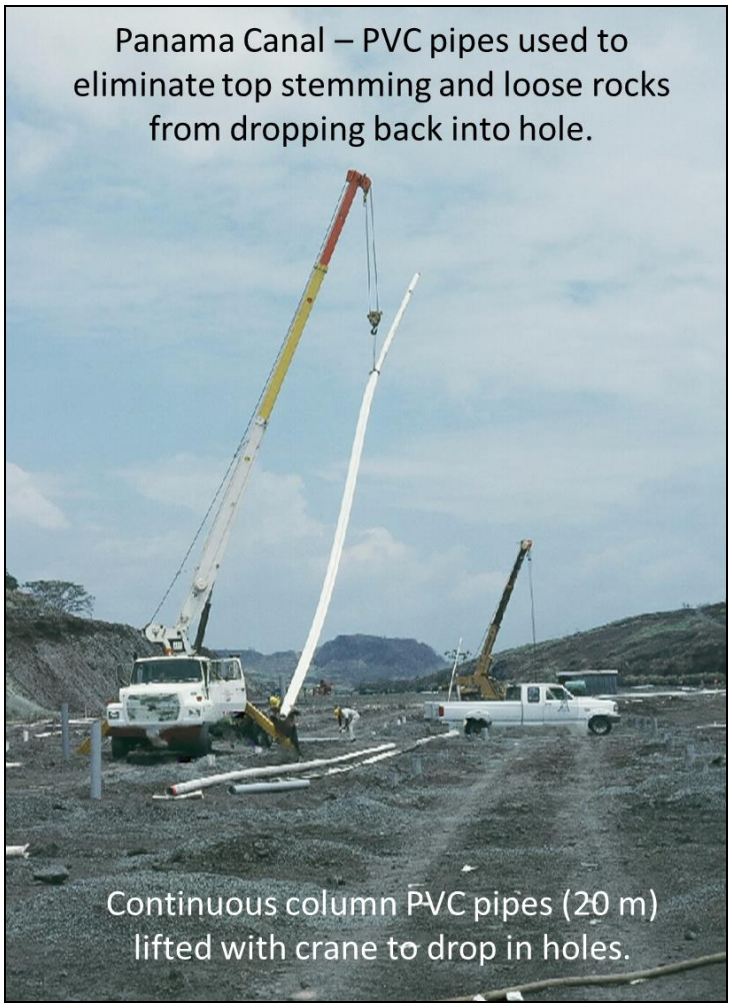


Figure 8.215 – Panama Canal Expansion. Example of a continuous length PVC casing for the entire hole depth. The PVC casings were placed into the holes soon after the holes were drilled. Continuous casings were also very effective in eliminating the emulsion explosive from seeping into large cracks in the rock. Image not from Ajax mine.

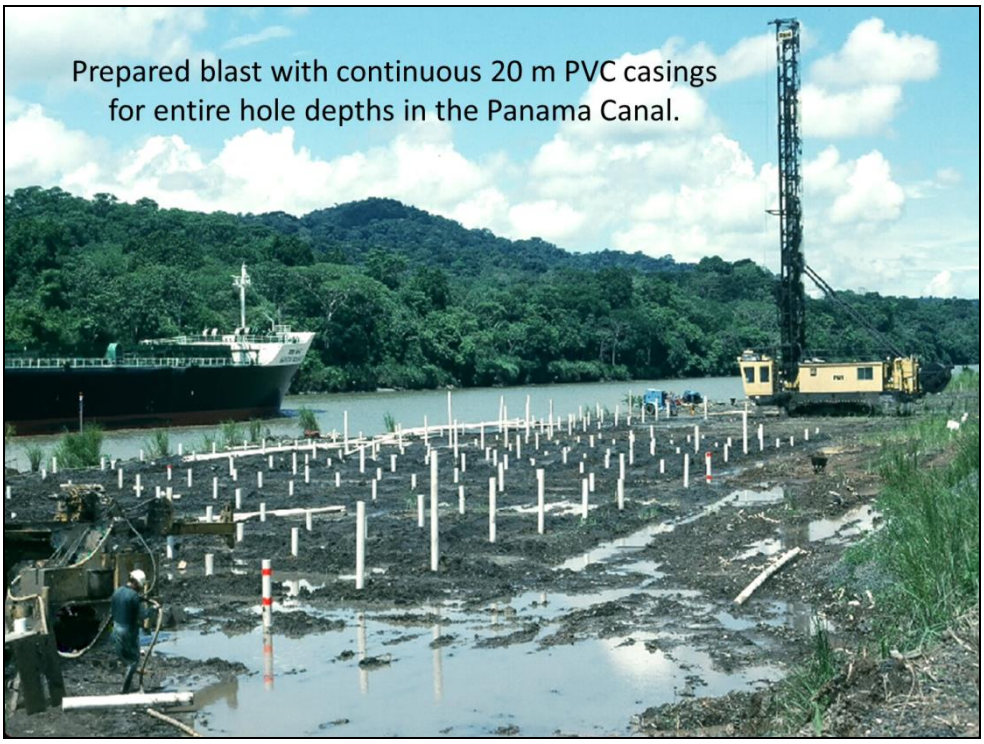


Figure 8.216 – Panama Canal Expansion. Example of a loaded blast using continuous length PVC pipes. Because the PVC pipes were a constant 20 m length, it was obvious that the drill hole depths varied by 1 - 2 m, which would create irregular floors along the bottom of the canal. This problem was eventually corrected with field checks and better supervision. Image not from Ajax mine.

BAI recommends cyclones on all of the drills as the best permanent solution. But, the drill operating parameters (i.e. rotation speed, pull down pressure, bailing velocity, etc.) should also be optimized to minimize regrinding the drill chips in wet holes.

8.3 Water Controls in Pits

Water control in the pit is critical, because it affects all phases of drilling, blasting and production. This becomes increasingly more important as the pit gets deeper, in view of the winter season, and the resulting water flows migrating into the pits during the spring and thawing periods. Thus, good planning for water controls around the pits should aim to keep the water gradients below the active blast blocks and the pit floor whenever possible. Water controls include:

1. Vertical dewatering wells in and around the pit perimeters. Vertical wells are very effective in the upper or shallower sections of the pits, where the rock/ore is usually more weathered and permeable. Refer to Figure 8.31.

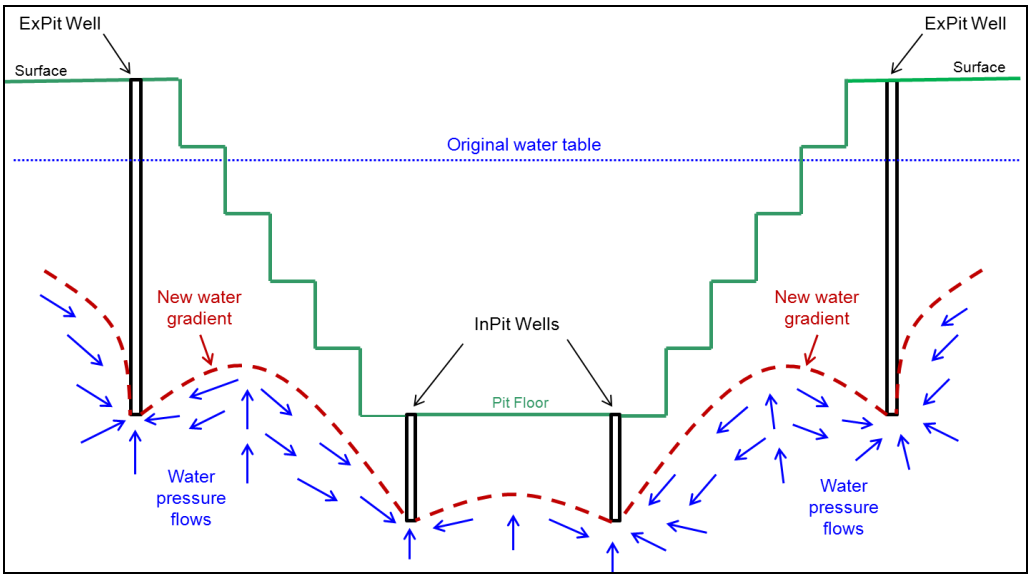


Figure 8.31 – Effect of InPit and ExPit water wells to keep the water gradients below the active blast blocks and the pit floor.

2. In the deeper parts of the pits, where the strata may be less permeable, several layers of sub-horizontal or inclined drain holes may be required at different elevations, as illustrated in Figure 8.32.



Figure 2.32 – Crew drilling horizontal and inclined drain holes along walls of pit. Image not from Ajax mine.

3. Trenches or French drains to channel surface water flows away from the active blast blocks.

4. Sumps in the lowest parts of the pit to act as a collection basin for surface and in-ground water. But for sump areas to be effective, they must be mucked out soon after being blasted, and they must be continually pumped out.

5. In very severe wet areas of the mine, blasting smaller shots (even if the blasts are only 1 – 3 rows) can act as an effective dewatering mechanism, until mining gets past the very bad areas.

If the water gradients can be forced below the active blast blocks by design, it will do wonders for the drilling, blasting and productivity. The best approach is to always eliminate problems at the source, because this will eliminate a host of performance problems up front. From BAI'S experience, surface mines which have effective dewatering programs in place, are usually the most efficient and profitable. Poor water controls in the pits contribute directly to:

1. Increased drilling costs by up to 40% and increased bit wear by up to 25%
2. Increased redrilled holes.
3. Poor and irregular floor conditions.
4. Explosive dilution and contamination.
5. Poor explosive performance and fragmentation.
6. Noxious fumes and nitrate residues.

8.4 Problems with Bulk Explosive Loading in Wet Holes

Auguring or pumping bulk explosives from the top of a dry hole generally does not pose performance problems for any type of explosive. But loading bulk explosives in wet holes requires special procedures, because incorrect loading can contaminate/dilute the explosive at the hole bottom, trap water within the explosive column, and it can cause the bottom hole primer to float up. Any of these situations may contribute to very poor fragmentation, deflagrations, low order detonations, misfires, oversize, noxious fumes, and nitrate residues. The problems and risks associated with loading in wet holes can be fully mitigated through the use of good field controls, attentive field supervision and good record keeping.

Figure 8.41 illustrates the effects of auguring or pumping explosives from the top of a wet hole. Water pockets and stringers will always be created throughout the entire explosive column. These will lower the overall explosive density, and performance problems can be expected.

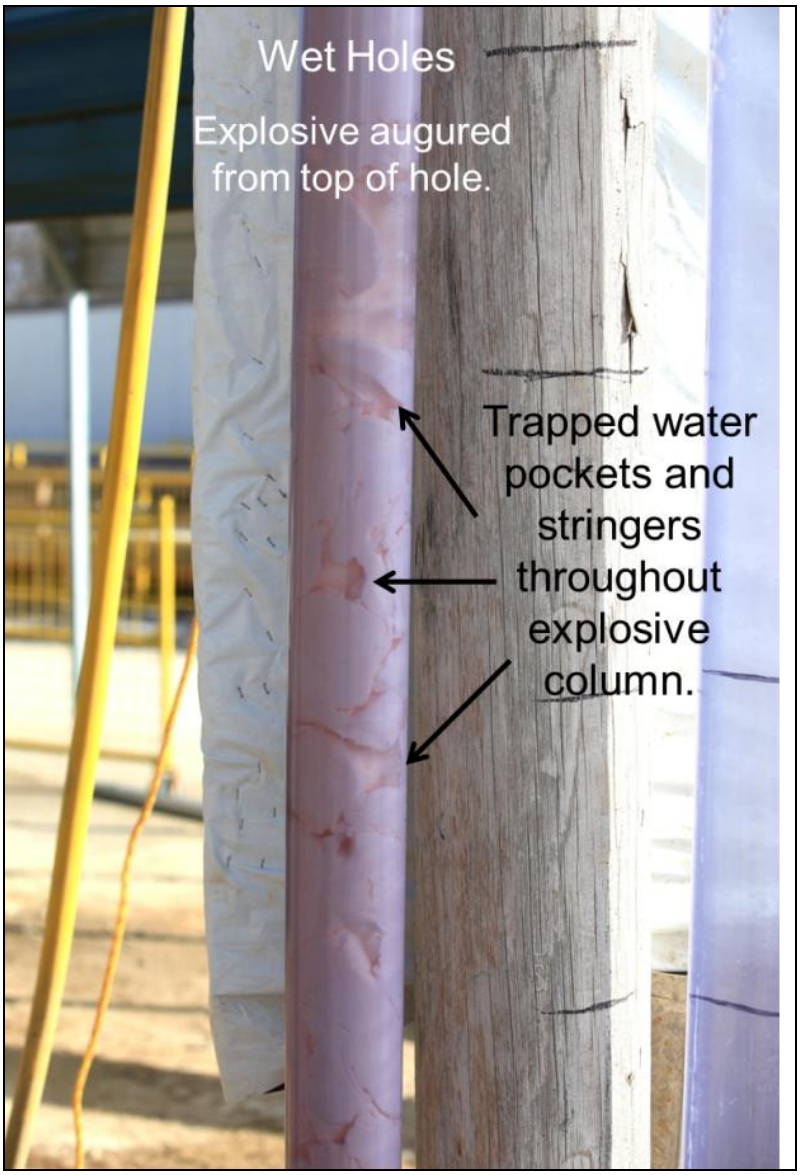


Figure 8.41 – Effects of auguring or pumping explosives from top of a wet hole. Digital image is courtesy of International Technologies, the Power Deck Company and Dyno Nobel.

8.5 Bulk Loading Explosives in Wet Holes

It is a given that whenever there is water in a hole, the bottom of the hole will contain a certain amount of mud, slimes and sediment, depending on the local precipitation, ground water, and how long the hole has slept since it was drilled, as illustrated in Figure 8.51, Hole A.

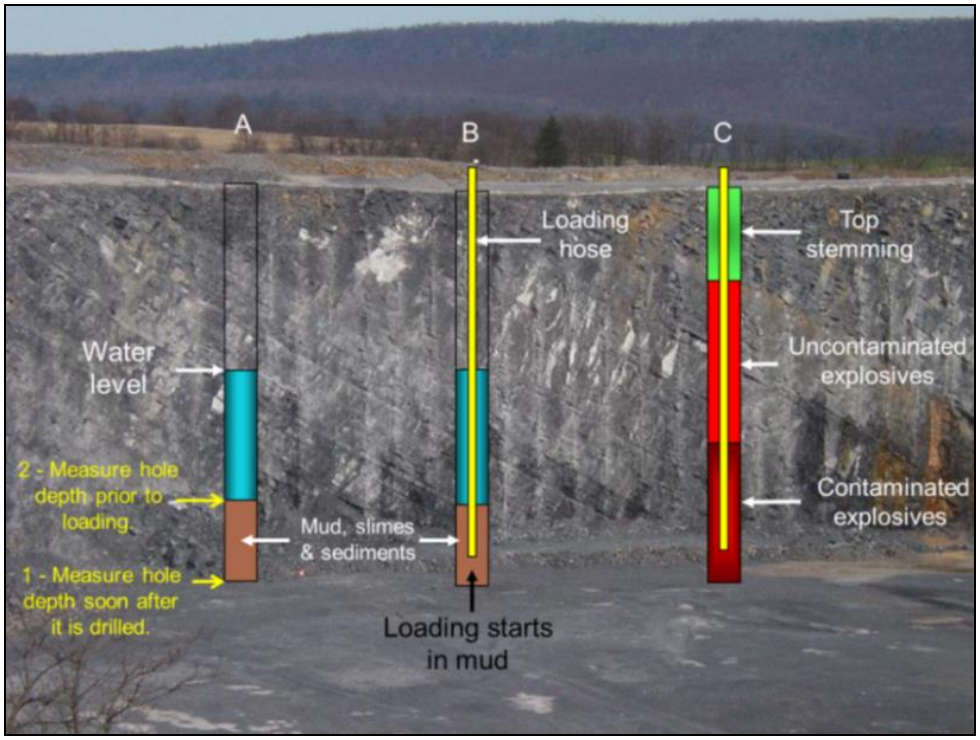


Figure 8.51 – Explosive dilution and contamination will occur if the loading hose starts loading in the mud/slime column at the hole bottom.

In holes which contain water and mud, the best procedure is to start pumping explosive just above the mud/slime sediment. If this is not done, and the pumping starts with the bottom of the loading hose inside or near the mud/slime column, the bottom section of the explosive column will become diluted and/or contaminated, as illustrated in Figure 8.51, Holes B and C.

In order to avoid lowering the hose into the mud column, one has to know what the mud column height is before beginning to load. The only way to know this is to measure the hole depths soon after the holes are drilled, and then again just prior to loading each hole, as illustrated in Figure 8.51, Hole A.

This is why it is very important to always measure the hole depths immediately after drilling, and then just prior to loading, so these two measurements could be compared to determine the height

of the mud column. Too many things could occur from the time the hole is drilled, to the time that the hole is actually loaded. Material could fall back into the hole from people working around the hole, during loading of the hole, from loose broken material inside the borehole wall, loose rocks around the collar of the hole, the drill relocating to the next hole in the wrong direction, water erosion from surface, and ground water, etc.

Once the length of a mud column has been accurately determined, the blast crew will need to be very careful where to place the discharge end of the hose before beginning to pump the explosives. The discharge end of the loading hose will need to be brought up just above the mud column before beginning to pump the explosives. If only a single bottom hole primer is used per hole, it becomes very challenging for the primer to initiate contaminated explosives.

8.6 Calibrating the Explosive Pumping Rate versus the Hose Retraction Rate

Figure 8.61 illustrates pumping explosives in a hole full of water. For wet holes, the explosive pumping rate and hose retraction rate should be calibrated, such that the water is displaced slowly and rides on top of the explosive column rise, but without trapping any water. This also applies to holes which have as little as only 0.50 m of water. A slow rate could get the hose stuck while loading in very deep holes, and a fast rate will trap water within the explosive column.

If the type of explosive, explosive viscosity, hose diameter, pumping rate and/or retraction rate is changed, everything will need to be re-calibrated. Many explosive suppliers have run into problems unknowingly, when they increased the hose diameter and pumping rate to increase the hole loading time, but did not re-calibrate everything.

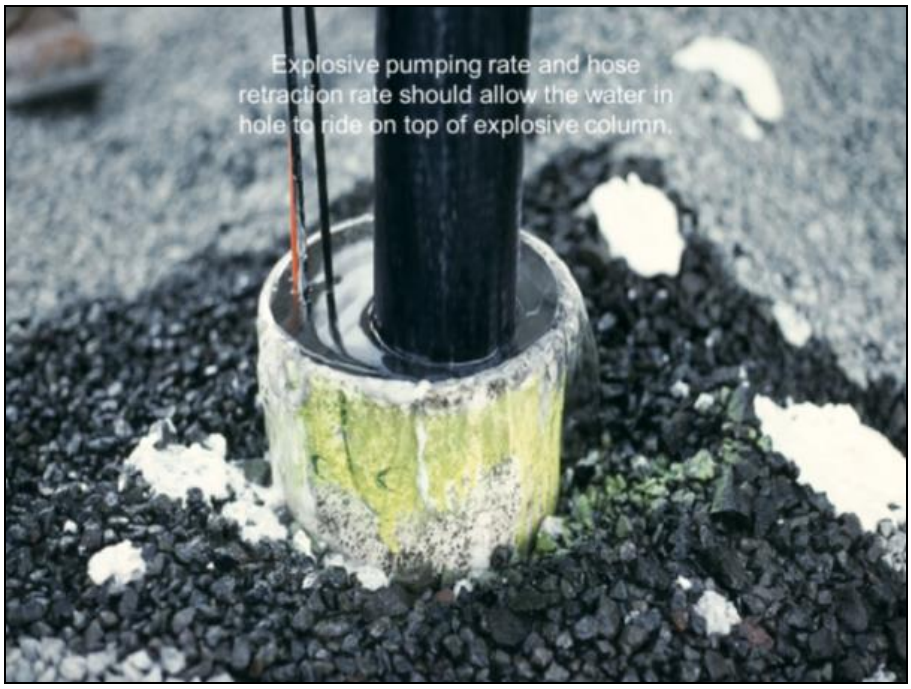


Figure 8.61 – Panama Canal Expansion. Explosive pumping rate should be calibrated against the hose retraction rate to allow the water to ride on top of the explosive column, without trapping any water. Image not from Ajax mine.

Figure 8.62 illustrates the resulting effects when the loading hose is retracted too fast up wet holes. Explosive bridging with large water gaps in the explosive, and trapped water pockets/stringers will remain throughout the entire explosive column. Severe performance problems can be expected with these conditions.

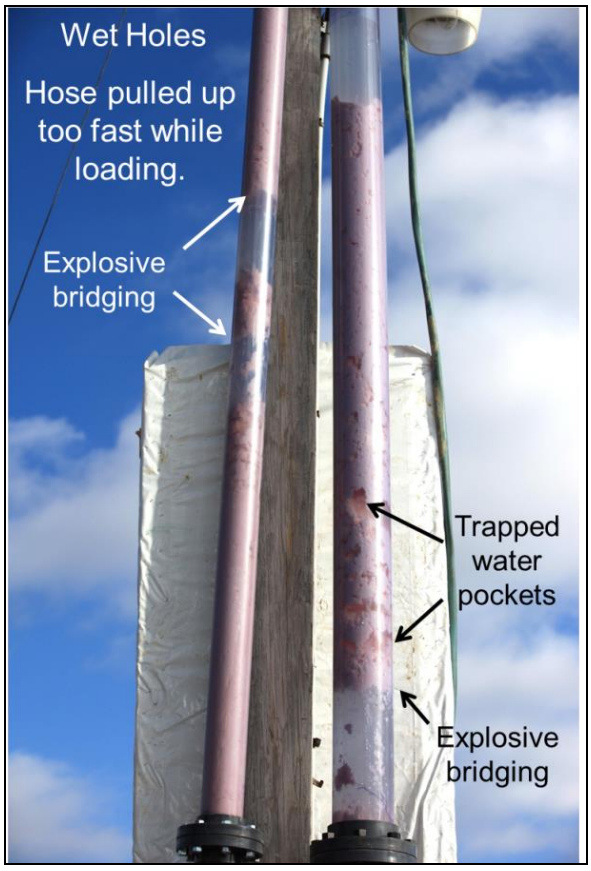


Figure 8.62 – Effects of retracting the loading hose too fast out of wet holes. Digital image is courtesy of International Technologies, the Power Deck Company and Dyno Nobel.

When explosives are actually pumped from the bottom of wet holes, never raise the hose up 0.50m to 1.5m from the hole bottom before starting to pump the explosives, as is commonly practiced worldwide. Figures 8.63 to 8.65 illustrate this practice.

1. Loading hose is lowered to the very bottom of the hole. Refer to Figure 8.63.

2. Slack occurs in hose when it reaches bottom of hole. Refer to Figure 8.64.

3. Loading hose is then raised 0.50 to 1.5 m above the hole bottom before starting to pump explosives. Refer to Figure 8.65.

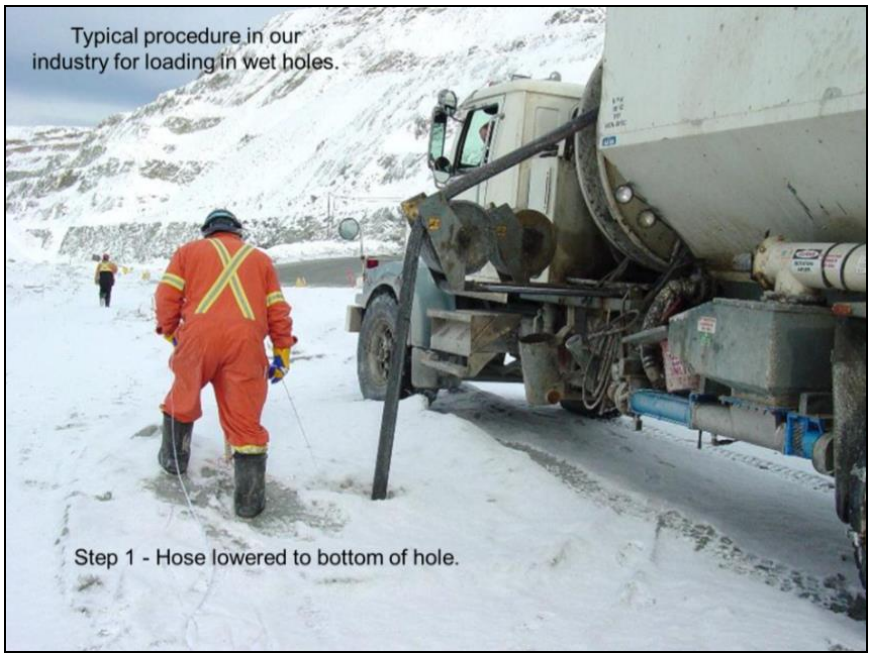


Figure 8.63 – Hose lowered to bottom of wet hole. Image not from Ajax mine.

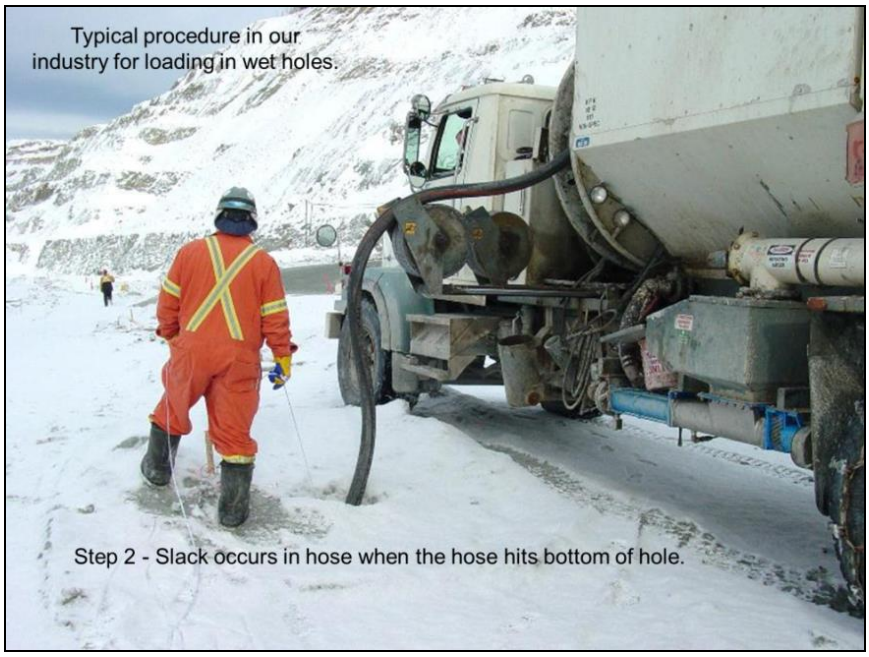


Figure 8.64 – Slack occurs in hose when it hits bottom of hole. If there was mud at the bottom of the hole, the loading hose would be pushed right through it. Image not from Ajax mine.

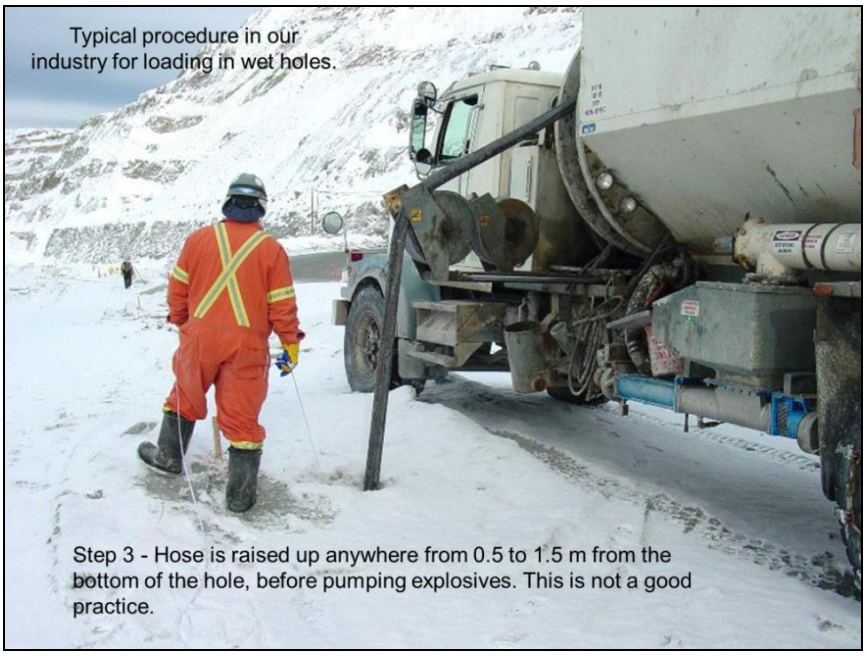


Figure 8.65 – Hose is then raised between 0.50 m and 1.5 m above the hole bottom before pumping explosives. In some mines, BAI has observed the hose raised over 3 m from the hole bottom before starting to pump explosives. But regardless of how high the hose is raised, this is definitely not a good loading practice in wet holes. Image not from Ajax mine.

Lowering the loading hose all the way to the bottom of a wet hole, and then raising it 0.50 m to 1.5 m before starting to pump the explosives can cause a host of performance problems such as:

1. Primers to float up and ride above the explosive column all the way up.
2. Water pockets and/or water stringers to be trapped within the explosive column.
3. Explosive bridging right at the discharge end of the loading hose, when the explosive begins to pump out the hose.
4. Explosive contamination and/or dilution.

Figure 8.66 illustrates the negative effects, when raising the hose end 0.50 to 1.5 m above the hole bottom in wet holes, before starting to pump the explosives. As soon as the pumped explosive is pushed out of the hose under pressure, it will immediately bridge in the hole right at the discharge end of the hose. Large water gaps formed between the bottom hole primer and explosive bridge point could result in deflagrations, low order detonations, misfires and/or complete detonation failures. Severe explosive performance and irregular floor problems can also be expected with this condition.



Figure 8.66 – Effect of pumping explosives in a wet hole when raising the hose end 0.50 to 1.5 m above the hole bottom. When pumping starts, the explosives will immediately bridge at the discharge end of the hose, leaving large water gaps between the primer and explosive bridge. Large water gaps could result in deflagrations, low order detonations or complete detonation failures. This condition would also severely challenge breakage at floor level. Digital image is courtesy of International Technologies, the Power Deck Company and Dyno Nobel.

Unless the trapped water in the gaps escapes through cracks in the rock, there will be absolutely no tell-tales on surface that any slumping of the explosive column occurred. Thus, pumping explosives in wet holes should always start at the very bottom of the hole, unless there is a mud column.

8.7 Primers Floating Up Explosive Column in Wet Holes

Another major problem when pumping explosives from the bottom of wet holes is related to primer float. This occurs regardless of whether there is mud at the hole bottom, from the initial output hose pressure. BAI has recorded primers to have floated all the way up to the top of the explosive columns. To assure that the primers remain at the hole bottom, they need to be weighed down with a non-sparking weight of sufficient mass, as illustrated in Figure 8.71.



Figure 8.71 - Primer weights and devices to keep primer from floating up when pumping explosives in wet holes. Images not from Ajax mine.

In Figure 8.71 (a), the primer weight consists of a small concrete block with a hole drilled through the center. Note that the primer also has a casted hole through it, where the weight is hung down from. But BAI recommends that the weight is placed much closer to the primer than that shown in Figure 8.71 (a).

In Figure 8.71 (b), the primer weight consists of a loose rock. Both the rock and primer are placed into some type of netting, which contains both together.

Figure 8.71 (c) illustrates a new commercial device to eliminate primer float. The device snaps around the primer and downlines, while allowing the explosives to be confidently pumped from the bottom of the hole.

The greatest energy release in the explosive column is always at the priming points. If the bottom hole primer floats to the top of the explosive column, detonation will start at the top of the hole and travel towards the bottom of the hole. By the time the detonation reaches the bottom of the hole, all useful energy to fragment at floor level will have been exhausted. Thus, for better breakage, the primer should be placed at or just above floor level.

8.8 Bottom Hole Primer Placement Regarding Safety Risks

There are many different thoughts and controversy regarding the safety of where the bottom hole primer should be placed. Some believe that the safest place to put the bottom hole primer is always in the subgrade, others believe the safest place is just above the floor elevation, and still others believe the safest place is 1 to 2 m well above the floor elevation. Refer to Figure 8.81.

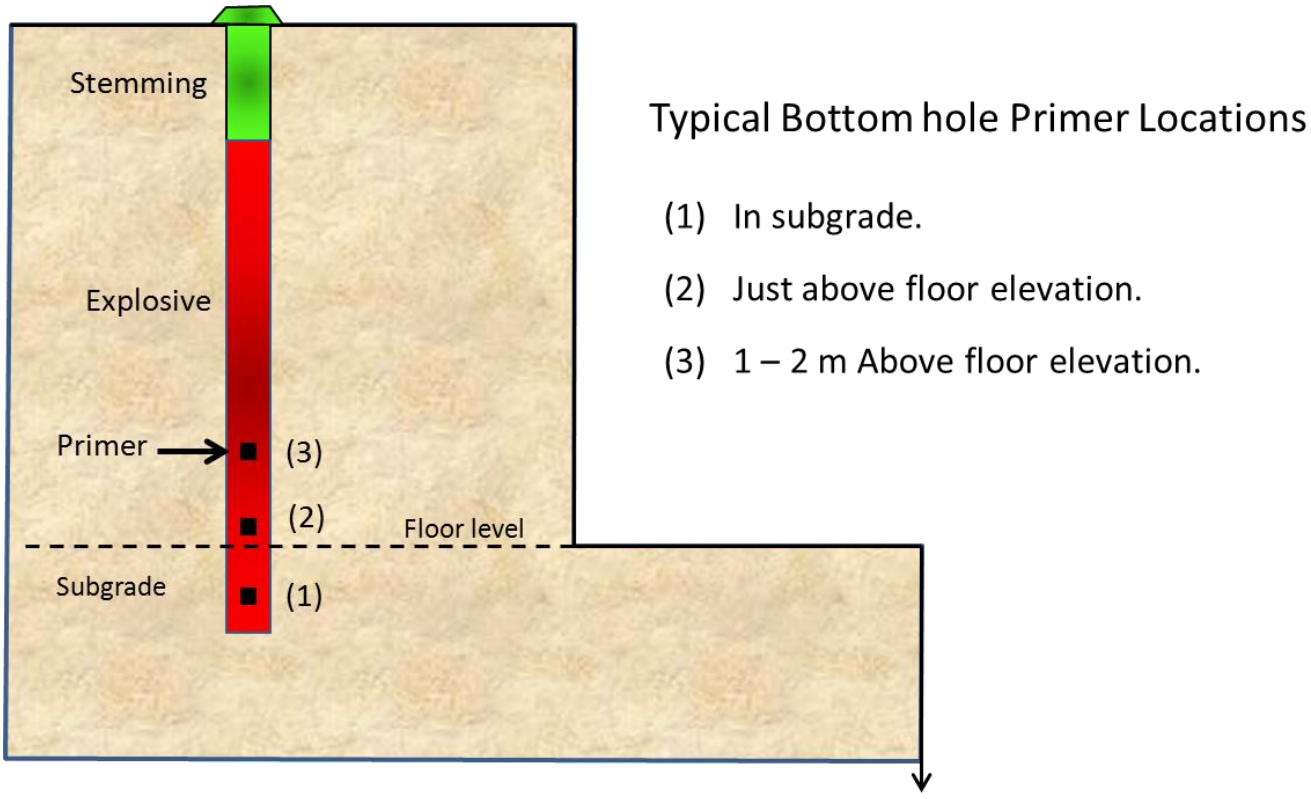


Figure 8.81 – Typical bottom hole primer locations are in the subgrade, just above floor elevation, and 1 – 2 m above floor elevation.

There are not very many good historical safety statistics on where the safest place is to place the bottom hole primer, in the event of a misfire. The reason is that many countries do not have to report such accidents or close calls, even though in some countries it is actually regulated where to place the primer. In some cases, the regulations were adopted from underground operations, which do not necessarily apply to surface blasting operations. In non-regulated countries, the primer location is often determined by the mine operator's experiences regarding misfires, close-calls, and/or unplanned accidental detonations. And, there are compelling arguments for each bottom hole primer location, because accidents have occurred from all bottom hole primer locations to some degree.

BAI's opinions regarding placement of the bottom hole primer are listed as follows:

1. First, the objective of any blasting operation is to eliminate the potential of all misfires with reliable explosive/primer and detonator products, applicable blast designs, well trained blast crews and good field supervision.

2. Second, it is always prudent to use (as a minimum) a top and a bottom primer which are fired instantaneously in the same hole. This will reduce the probability of misfires substantially, regardless of where the bottom hole primer is placed. In very deep, wet and/or rough borehole depths of greater than 20 m, three priming points may be required, where a top, mid-column and bottom hole primer are used in the same hole. In Pennsylvania, USA, there is a regulation in some blasting sectors, that any hole over 5 m must have at least two detonator/primer assemblies in the same hole. However, the regulation does not specify where the two priming points need to be in the hole.

3. The greatest energy release within an explosive column is always at the primer point. Thus for the greatest fragmentation breakage along the floor, the bottom hole primer should be placed just above the floor elevation. In wet holes, the bottom hole primer must be weighed down with a non-sparking weight, so that it does not raise up into the explosive column during the bulk loading process. Placing the primer in the subgrade will not result in any better floor breakage, but it will create new fractures in the subgrade. New fractures in the confined subgrade area will result in looser, blockier material and oversize, which increases the risk of flyrock and airblast in the collar zone of the next underlying bench.

4. All explosives, primers and detonators are designed to detonate given the correct stimuli such as sufficient shock, impact, heat, friction and electrostatic discharges. Under normal manufacturing, transportation, storage, and use, the explosives are not designed to detonate unexpectedly.

5. In order of sensitivity to shock and impact forces, detonators would be the most sensitive, followed by the primers, and then the blasting agents.

6. Placing the primer above floor grade will minimize the primer ending up in a mud column or in contaminated/diluted explosives at the bottom of the hole, which is usually in the subgrade area. This will provide better explosive performance.

7. If the bottom hole primer is placed anywhere above the floor level and a misfire occurs, the chances are very high that the emulsion explosive would be more dispersed within the muck pile, and dispersed blasting agents within the muck pile have very low probability of an accidental detonation on impact from shovel or front end loader bucket teeth. There would also be a good chance that the cast primer is broken up into small pieces within the muck pile.

8. A misfire with the bottom hole primer in the subgrade would be completely hidden, and it would be difficult to spot unless there were obvious telltales that a misfire had occurred in the form of visible unshot material, high floors, and/or intact downlines, etc. The risk of hidden misfires in the subgrade reinforces the need to place bottom hole primers immediately above the floor.

   The term misfire is defined as the complete or partial failure of explosive material to detonate as planned. Misfires can result in serious mine worker safety hazards. Risks associated with misfires are well known to the mining industry. The British Columbia *Occupational Health and Safety Regulation* contains legal requirements that must be met by all workplaces under the inspection jurisdiction of WorkSafeBC. Part 21 of the regulation includes required misfire procedures to reduce risks to mine worker safety.

   Although all misfires pose serious safety hazards, the effects of a misfired primer in 1 to 2 m of explosives in the subgrade of a large diameter hole will always be greater, than a single primer being impacted by a shovel or front end loader in the muck pile.

9. Thus, BAI recommends that the bottom hole primer is placed just above the floor elevation, because this is the best compromise between safety and good breakage along the floor. A top and bottom primer within the explosive column is also recommended to reduce the overall risk. But, a top and bottom primer fired instantly with electronic detonators will also improve the fragmentation.

8.9 Explosive Dilution from Drop Height Impact of Stemming

Explosive contamination/dilution in the upper part of the explosive column can occur when the top stemming is dropped into the hole. On impact, some of the stemming particles will sink further down into the explosive column, and they will displace the top part of the explosive column to migrate up into the stemming zone. How far the stemming sinks into the explosive column depends on the stemming particle size, the drop height, and the explosive viscosity, as illustrated in Figure 8.91.

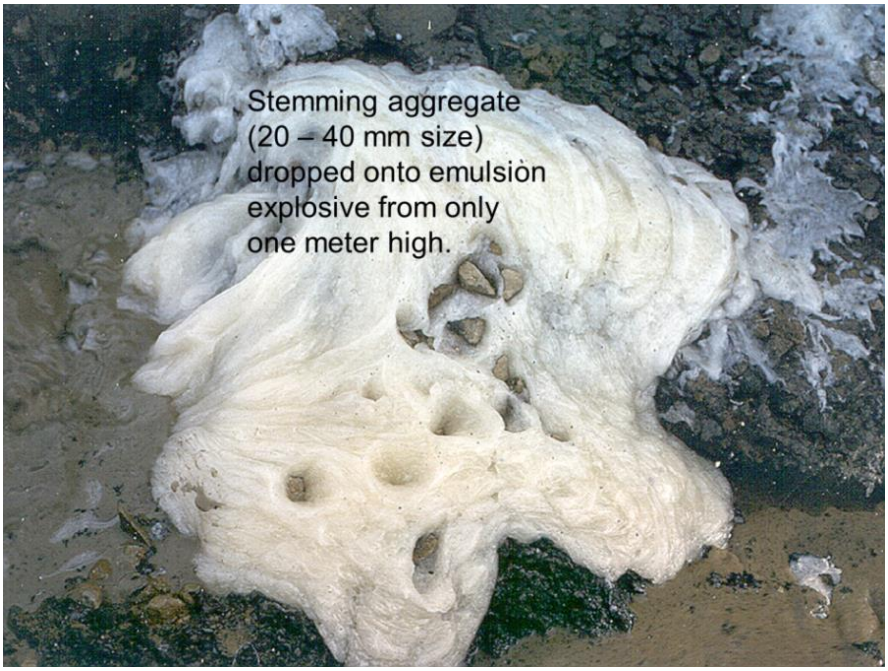


Figure 8.91 – Effect of dropping stemming aggregate (20 – 40 mm size) onto an emulsion explosive from only one meter high. At higher drop heights, the stemming particles would penetrate much deeper into the top part of an explosive column. Image not from Ajax mine.

In some cases, BAI has measured the sink distance into the top part of the explosive column to be up to 3 m. This contaminated top part of the explosive column will deflagrate or detonate at low order. This type of explosive contamination can result in:

1. Poor overall fragmentation.
2. Oversize material in the collar zone.
3. Flyrock and increased airblast magnitude.
4. Noxious fumes.
5. Nitrate residues.

These risks can be fully mitigated through the use of good field controls. One way to eliminate explosive dilution in the top part of the explosive column, from the drop impact of stemming is to use a plug on top of the explosive column, as illustrated in Figure 8.92. The type of plug, as illustrated in Figure 8.93, does not matter, although each manufacturer will claim their plug is better than their competitors.

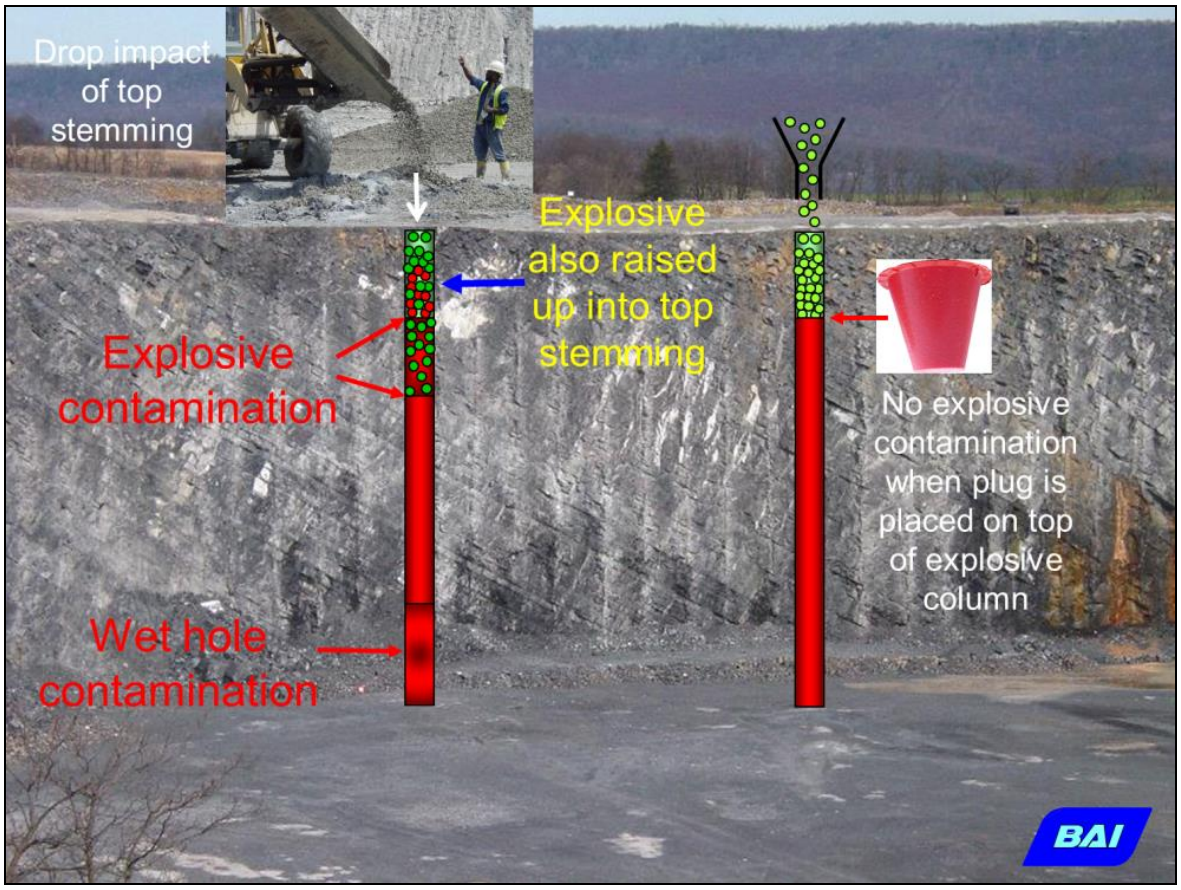


Figure 2.92 – Example of a hole plug to eliminate top stemming contamination.

Claims made by each plug manufacturer that their plug confines the explosive gasses better, and thus results in better fragmentation is false. By the time the explosive has finished detonating, all of the fragmentation will have been completed in full, well before any displacement of the broken rock takes place. However, the fragmentation in the collar zone will be better, but only because the explosive contamination in the top part of the explosive column has been eliminated by the plug, and not from achieving better confinement in the collar zone.

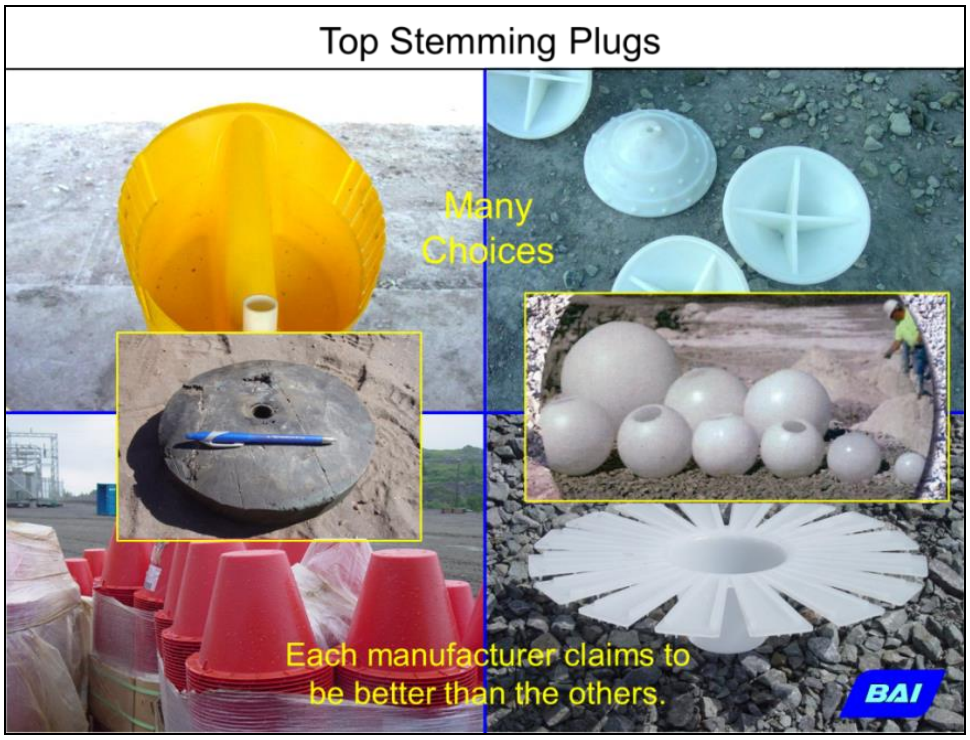


Figure 2.93 – The type of plug used in the top part of the explosive column does not matter.

8.10 Irregular Floors

Figure 8.101 illustrates a section in a pit with irregular floor elevations. The irregular floor had both significant high and low spots, where the differences in elevation were between 1 – 2 m. Irregular floors indicate that something is out of order regarding the field controls, loading procedures used in wet holes, explosive contamination at the hole bottom, and/or with incorrect final hole depths. Uneven floors require more drilling around the high spots, create water puddles in the low spots, and increase the wear and tear on heavy equipment. All of these factors affect productivity. If uneven floors are not corrected, each subsequent bench will usually get progressively worse.

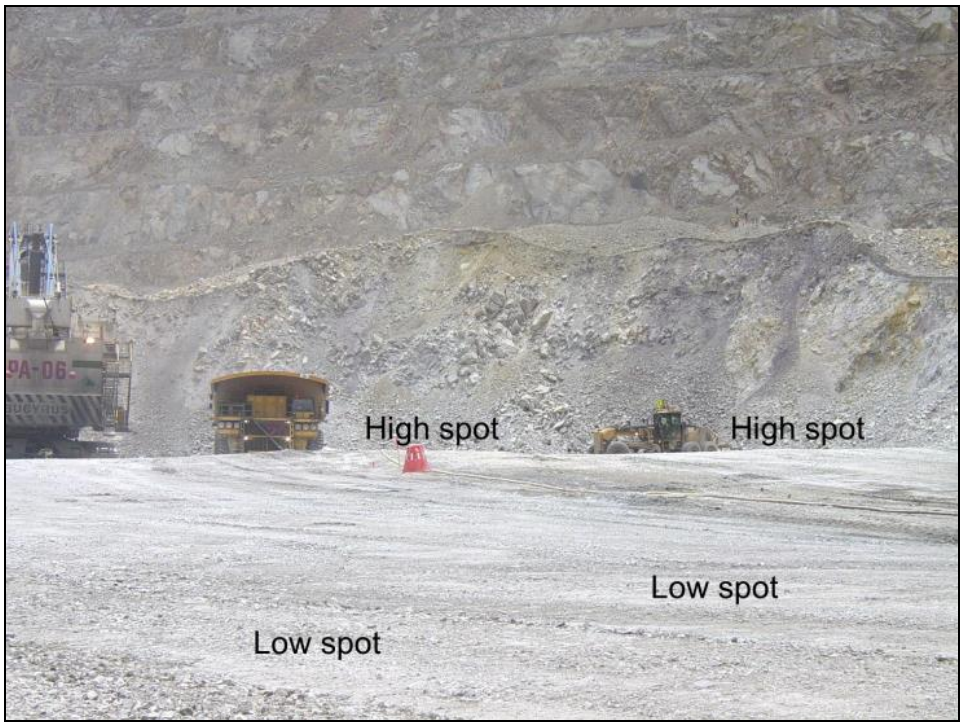


Figure 8.101 – Section of pit floor with varying high and low spots.
Image not from Ajax mine

Uneven and irregular floors can be caused by any of the following, but usually in combination:

1. Drill cuttings falling back into hole.
2. Incorrect final hole depths for both over drilling and short holes.
3. Redrilled holes which could channel explosive energy into the adjacent lost hole.
4. Improper hole loading in wet holes.
5. Contaminated/diluted explosives at the hole bottom in wet holes.
6. Primers floating up into the explosive column.
7. Poor floor grade controls.
8. Type of excavator such as a back hoe versus a front end loader.

9.0 INCOMPLETE DETONATIONS AND MITIGATIONS

Incomplete detonations can be caused by explosive formulation problems, poor field controls, and improper loading techniques used in wet holes. Anything in the blast designs, field controls and loading techniques, which take away from achieving a full order detonation for the entire explosive column, can contribute to fume problems.

9.1 Noxious Fumes

The kinetics of the chemical reactions that occur during explosive detonation can result in the production of carbon dioxide and oxides of nitrogen (NO, NO_2, NO_3). Complete detonations do not result in harmful concentrations of these gases. However incomplete detonations can create concentrations that are harmful. The hazards of these gases to employees are well known to the mining industry which has resulted in regulation and standard procedures to reduce the concentration of fumes associated with blasting in underground and surface mining operations. Fumes do not necessarily result in poor blast results, but they do raise a red flag that something is out of order, and they need to be eliminated. Heavy fume concentrations can be fatal for mine employees, depending on the combined fume concentration, exposure time, and proximity to the blast. Importantly, when the planners, blast crews and field supervision design blasts to assure a full order detonation for the entire explosive column, the generation of noxious fumes at harmful concentrations is <u>not possible</u>.

The concentration of fumes reaching the community would pose very little, if any, health and safety risks, because the fumes would dissipate well below dangerous levels within short distances. Furthermore the probability that dangerous concentrations would occur from blasts after using recommended procedures to ensure complete detonation are very low.

The most common contributors known to cause noxious fumes to a lesser or greater extent are:

1. Poor explosive formulation.
2. Poor quality controls in explosive manufacturing.
3. Lack of gassing checks and explosive density tests.
4. Poor field controls through lack of supervision.
5. Poor drilling controls.
6. Drill patterns too small for the rock conditions.
7. Explosive column disruptions from ground shifts during the shot sequence.
8. Partial explosive desensitization anywhere in the explosive column.

9. Water saturated blast environment.
10. Diluted/contaminated explosives anywhere in the explosive column.
11. Inadequate loading techniques in wet holes.
12. Not weighing the primer down with a non-spraking weight.
13. Excessive sleep times for the explosives and detonator downlines.
14. Soft, weathered, highly fissured rocks with very low compressive strengths.
15. Chemical reactions of the explosives with certain rock/soils.

Noxious fumes that represent worker safety risks can be prevented by ensuring a full order detonation for the entire length of the explosive column. Noxious fumes will not occur with a full order detonation, unless there are unusual chemical reactions with the ore or mine rock composition. To date, no explosive/ore/mine rock reactions have been noted.

From the above mentioned list, it is BAI's opinion that the major causes of the noxious fumes are related to poor bulk loading techniques in wet holes, explosive contamination at the hole bottom, primer float, and bridging within the explosive column.

Effective mitigation measures to eliminate noxious fumes on the blasts are:

1. Stringent quality control checks will be place at the explosives manufacturing facility.
2. Strict field controls will be implemented as outlined in Section 8.0, when loading wet holes.
3. Explosive contamination in the top section of the explosive column, resulting from the drop impact of stemming fragments onto a low viscosity product, will be eliminated by using an appropriate hole plug on top of the explosive column, as outlined in Section 8.9.
4. Gassing and cup density tests will be conducted every 10^{th} loaded hole to flag potential problems early on.
5. Multiple priming points will be used, where necessary, to accommodate internal ground shifts that can cause explosive column disruptions.
6. Drill patterns for all hole diameters will always be above the dead pressing threshold for gas sensitized explosives in both dry and wet holes.

If fume problems persist after implementation of the above listed Item No's 1 – 6, then all of the other factors listed in Section 8.1 will need to be re-assessed and critically reviewed. As a last resort, if noxious fumes continue, multiple primers will be used within the explosive column, and/or atomized aluminum (80 mesh) will be added to the explosive formulation. These last two options will generally eliminate all noxious fumes, even in very soft ground, as was successfully

done in the oil sands of Alberta, the coal fields of Wyoming, and in the soft rock sections along the Panama Canal.

9.2 Nitrate Residues

Nitrate residues from the blasting originate from unreacted ammonium nitrate in the explosives during the detonation process and from spillages. Any unreacted or partially reacted ammonium nitrate, which results in low order detonations, deflagrations, explosive contamination, explosive bridging, desensitization, explosive column disruptions, and under-priming etc., will increase nitrate residues.

In reference to the detonation process, the solutions to minimize/eliminate nitrate residues are identical to that for eliminating noxious fumes, as outlined in Section 8.0. But any explosive spillages on a blast are a direct function of the field procedures, equipment apparatus, hole loading methods and supervision, as illustrated in Figures 9.21 and 9.22.



Figure 9.21 – (a) Explosive spillage on bench top. (b) – Explosive spillage from cup density tests. Images not from Ajax mine.

Figure 9.22 illustrates a number of holes in a blast block which had explosives stuck on the inside of the borehole collars. This occurred because loading was always done with the hose end inserted only near the top of the holes. None of the holes were loaded with the hose end starting at the hole bottoms. It could also be caused from not waiting for the dripping explosives from the end of the hose to stop, before proceeding to the next hole.

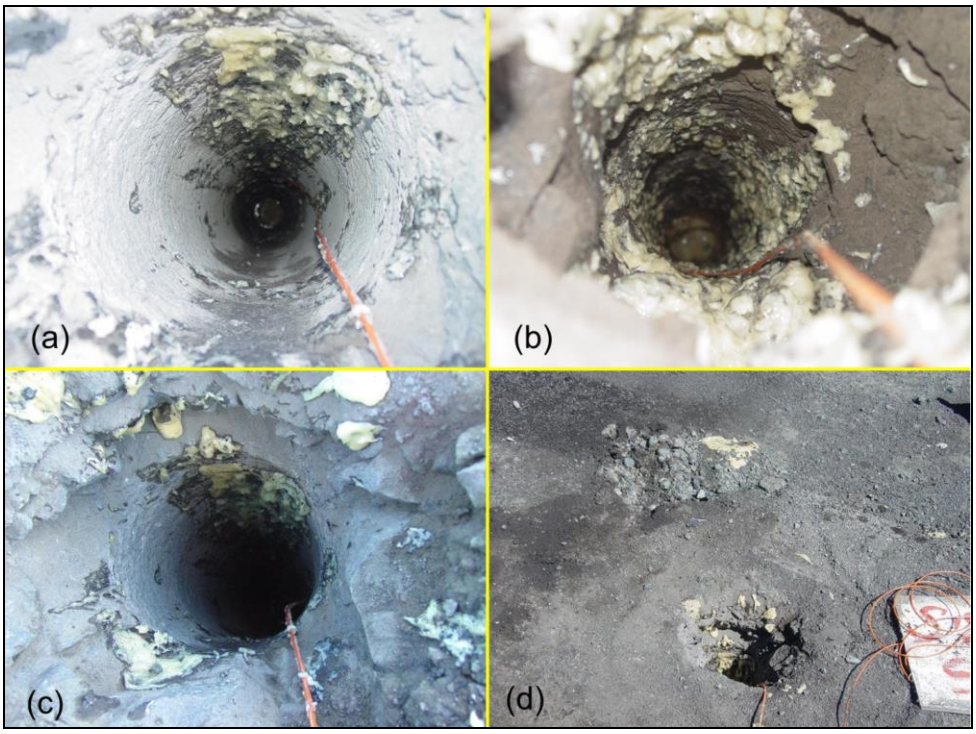


Figure 9.22 – Explosive spillage in collar zone of holes. On this blast block, all of the holes were loaded the same way, and thus contained explosives in all of the hole collars. Images not from Ajax mine.

Emulsion formulations contain anywhere from 70 to 85% ammonium nitrate, either in solution or granular form, so any reduction in the explosive spillages will reduce the nitrate residues substantially. Mitigation measures to eliminate nitrate residues are:

1. Implement the recommendations to eliminate noxious fumes outlined in Sections 8.0 and 9.1, to assure a full order detonation for the entire explosive.
2. Implement strict procedures to eliminate all surface spillage of the explosives on the bench top, and in the inside hole collars.
3. Before moving to the next hole, the blaster will assure that all of the explosives in the loading hose has stopped dripping, otherwise there will be more spillage on the bench top. Some operators will place a cap at the hose end before moving from hole to hole, when using very low viscosity bulk explosives, with a high water content for pumping.
4. To eliminate explosive dilution in the top part of the explosive column, from the drop impact of stemming, hole plugs on top of the explosive column will be used, as outlined in Section 8.9.

10.0 BLAST NOTIFICATIONS, OPERATIONAL SAFETY AND BLAST CLEARANCE PROCEDURES

10.1 Blast Notifications

When blasting in open-unfenced areas, where people and livestock could potentially traverse towards the blast zones, special attention needs to be given to the blast notifications in the community, the blast preparation site, warning signals leading up to the shot time, placement of the blast guards and the blast clearance procedures. Some things to be aware of are:

1. Identify people and businesses within a 3 km radius of the blast zones, which could be more sensitive to the blasting, such as people with PTSD (Posttraumatic Stress Disorder) or animal in kennels, etc. These parties should be provided the choice of being notified on the day of the blast, so they could take appropriate actions, if necessary. Because the ground vibration and airblast impacts in the communities are expected to be negligible, most parties will eventually opt out of being notified in advance.

2. Establish a blasting time-window to blast on any particular day, because people like consistency, but not surprises. In general, the best time-windows to blast is during periods of high ambient activity in the communities, such as during the lunch hour or during traffic rush hour. From a productivity standpoint, the best time windows could be during shift changes, which may or may not coincide with the highest ambient noise levels in the communities.

3. The blasting window should not be an exact time to provide the blast crew some flexibility, if last minute problems are encountered. For example, the time window could be between Noon and 12:30 P.M and/or 4:30 – 5:00P.M. The larger the time window, the better it is for the blast crews, but once a time window is agreed upon, it must stay consistent. If people become accustomed to blasting during the established time windows, they will get accustomed to associating the event with the blasting, and not some other unknown disturbance, which could cause false alarms. However it is unlikely many, if any, people will be able to perceive the majority of blasts due to distance and other attenuating factors.

4. On the blast day, the blasting time-window, blast location and established warning signals should be clearly posted at all entrances into the mine, so that employees, subcontractors and visitors could plan their work schedule and activities accordingly.

10.2 Safe Blasting Distances for Equipment and People

Given the current recommended blast designs for the ore and mine rock, a reasonably conservative safety radius for equipment is 250 m, and 500 m for people. Refer to example in Figure 10.2.

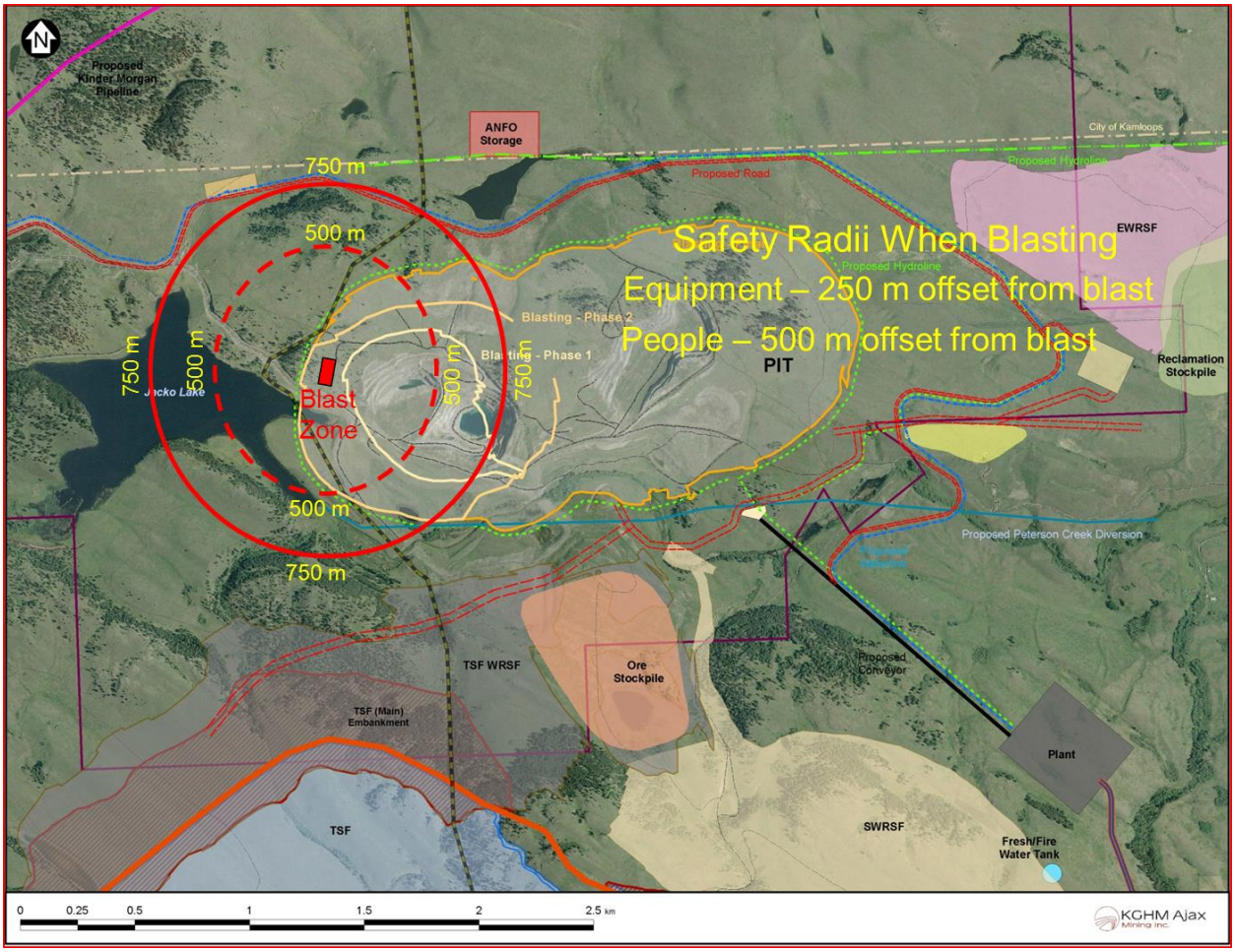


Figure 10.21 – Example safety radii for equipment and people.

A few things to be aware of are:

1. Safe blasting distances must be maintained and enforced at all times, with no exceptions to anyone.

2. Before explosives are brought onto the blast site, all entrances onto the blast area must be roped off, with the appropriate "Danger – Explosives" signage. Only qualified personnel are allowed to go onto the blast site.

3. The safety radius of 250 m for equipment and 500 m for people, apply only to when the blast area is being cleared to fire the blast. They do not apply when the blast area is being loaded.

4. If the drill logs indicated that something unusual was experienced during drilling of the blast, such as clay seams, large voids, vugs and excess re-drilled holes, etc., the safety radii should be increased 100% for both the equipment and people.

10.3 Clearing the Shot Area in Preparation to Blast

Clearing the shot area in preparation to blast must be more formalized and stringent, with a previously prepared check list of who to notify, what areas to clear, and where to place the blast guards. All blast guards should have a radio for reliable and clear communication with the blaster in charge. A few things to be aware of are:

1. Verify that people and businesses in the communities, who wanted to be notified in advance, have been notified.

2. Each blast guard must inform the blaster in charge when he/she has reached its guarding location, and that there are no distractions at the guard location, which could compromise someone inadvertently getting past the blockage point.

3. Blast guards watching open areas for the public and/or livestock, etc. must be particularly attentive, because there will be no way to communicate with them on a timely basis and/or to stop their movement, and thus the shot may have to be aborted if public are present in within the shot area.

4. The blaster in charge and all blast guards must have the ability to abort any blast at any time.

5. Particular attention must be given to activities in Jacko Lake. It is recommended that recreational activities in Jacko Lake be suspended prior to each blast, and that all recreational users are cleared from the recommended 500 m safety radius.

6. Clearing Jacko Lake will need to be done from different vantage points, because small boats next to the edge of a high land outcrop will not be seen by one observer standing only a few meters away on top of the outcrop.

7. Areas near the blast zone which are often overlooked or missed during the shot clearance in preparation to blast are in portable toilets, tool sheds, storage areas, guard shacks, and people sleeping or resting lying down in their vehicles who are not visible.

8. After all of the guards have verified their guarding positions, the blaster in charge needs to systematically call each guard, through the check list, to assure that everything is a "go", and to assure that the guard is on the correct radio frequency before commencing the blast count down.

10.4 Warning Signals, Blast Count down and Radio Communications

Once the blaster in charge has verified a "go" with each blast guard, the following count down procedures are recommended, starting five minutes before firing the blast:

1. The blaster in charge announces on the radio "5 minutes to blast time".

2. Immediately thereafter, load sirens are activated to run continuously for two minutes. The sirens should project the sound in four directions (North, South, West and East).

3. After the 2 minute sirens have stopped, the blaster announces "3 minutes to blast time", and issues a command for radio silence on all radio frequencies. At this stage, the only people allowed to communicate on the radios are the blaster in charge and his blast guards. In the event of an emergency, the blasting crew must have the absolute ability to abort the shot at any time and to be able to communicate with everyone undisturbed.

4. Then the blaster in charge will announce:

    i. "1 minute to blast time"
    ii. "30 seconds to blast time"
    iii. Countdown starts from 10 sec to 0 sec with no announcement.

5. But, the blaster in charge does not fire the blast at 0 sec. He will wait for another 10 full silent seconds before actually firing the blast. The reason for this is to assure that no one was trying to abort the blast during the verbal 10 second countdown communication when the radio was locked in use.

When the "Radio Silence" command is given three minutes prior to the blast time, some employees could miss the announcement, because the radios could have been turned off, the volume could have been lowered, or they may not have been near their radios, etc. To eliminate this problem, a continuous background beeping signal should be imbedded in all mine radios during the three minute radio silence, regardless of what frequency the radios are operating on. The beeping signal should be load enough to be annoying, but still allow people to talk on the radio. This way, if someone turned on their radio to talk, the background beeping signal will immediately alert them that a radio silence is in effect.

A point form summary of the blast count down is:

1. 5 Minutes – Sirens activated and run continuously for 2 minutes.
2. 3 Minutes – Blaster in charge announces "3 minutes to blast time" and requests "Radio Silence".
3. 1 Minute – Blaster in charge announces " 1 minute to blast time"
4. 30 Seconds – Blaster in charge announces " 30 seconds to blast time"
5. 10 Seconds – Count down starts 10 seconds to 0 seconds – ***But blast is not fired***.
6. ***Wait another 10 seconds in silence, then fire blast***.

10.5 Post Blast Clearance Procedures

The "All Clear" signal should only be given after the blaster in charge has physically inspected the blast area. Everyone else, including blast guards, should remain guarding the same locations as they were prior to firing the blast. If during the inspection, obvious signs of misfires, smoldering materials, fumes or fires are noticed within the muckpile, the shot area should be immediately evacuated for at least 30 minutes, before anyone is allowed on or near the shot area.

If deep red-orange-brown fumes are noticeable after the shot, clearance into the shot area should not be given until the noxious gasses have adequately dispersed. The probability that dangerous concentrations would occur from blasts after using the recommended blast designs and field procedures described in Sections 8.0 and 9.0 are very low.

However in the event of an incomplete detonation and propagation of noxious fumes in the immediate blasting area, it is prudent for blasters to monitor the wind direction so they are upwind of the blast pattern. In the event wind direction changes and blasters are downwind of noxious fumes, some protection can be found inside of a vehicle, drill rig, or other heavy equipment, etc. with the windows rolled up and the A/C unit shut off, until the fumes have

dissipated. As mentioned, the presence of noxious fumes indicates that something in the explosive formulation, blast design, field procedures and/or blast environment requires mitigative actions to prevent noxious fumes prior to the next blast.

Flyrock is defined as small rock fragments propelled from the immediate blast area by the force of explosion. Flyrock can take a few minutes to fall, depending on their initial velocity, ejection angle, mass and shape. Flyrock poses serious health and safety risks to mine employees which are well documented in the mining industry and represented in regulation. As a result many procedures have been developed to prevent flyrock beyond the immediate blast area and protect blasting personnel within the blasting area. If blasters fire the blast within the 500 m safety radius, they must have adequate cover for any falling debris, and they must stay under cover for at least two minutes after firing the blast, before going out into the open.

If any misfires are found in the muck pile after the blast, they must be dealt with carefully and with much discretion, because the hazardous situation will remain until the unshot explosives are removed and properly disposed of. There are no standard procedures on how to deal with misfires, because each situation is unique to the explosive products, initiation system, blasting accessories, the blast environment, and the nature of the misfire. The best way to reduce the employee safety risk associated with misfires is proper field controls and planning to prevent them.

However, example misfire procedures will be included as part of blast management planning to ensure that all misfires are handled commensurate with the BC *Occupational Health and Safety Regulation* and site specific standard operating protocols. The regulation includes guidance and requirements for the refiring and removal of misfires. Because there is increased risk with refiring misfired explosives the safety radius for employees is recommended to be tripled to prevent injury related to changes in explosive confinement conditions.

11.0 LIGHTNING HAZARDS, SAFE DISTANCES AND EVACUATION PROCEDURES

11.1 Some Facts about Lightning and Safety of Explosives, Primers and Detonators

Lightning is a very powerful electrostatic discharge which can travel up to 96,560 Km/Hr. (60,000 Miles/Hr.) at temperatures reaching 2,776 ^{o}C (50,000 ^{o}F). This temperature is five times greater than the temperature of the sun, and can cause tremendous airblast and noise in the communities. Lightning is also very unpredictable, and it is not true that lightning will always strike the highest point in the immediate area, as BAI experienced many times during the expansion of the Panama Canal.

No explosive, primer or detonator is safe from lightning, including electronic detonators. There is a false sense of security and many misunderstandings that electronic detonators are safe from a direct or indirect lightning strike. Electronic detonators are much safer than conventional electric detonator systems from extraneous sources, but being safe from lightning is completely false. BAI is aware of one incident where lightning hit an unmanned drill on the blast, and many of the unconnected electronic detonators, which were placed on the ground next to the collar of the holes, detonated prematurely. The blast crew was preparing to evacuate the blast area, but did not evacuate soon enough. Fortunately no injuries or fatalities resulted from this incident.

11.2 Evacuation Procedures for Electrical Storms Moving Towards a Blast Area.

A clear evacuation plan for electrical storms must be in place before any blasting commences at the mine. This applies only to when explosives are brought onto the blast area, regardless of whether any holes are loaded or not. Table 11.21 lists BAI's distance recommendations for notifying employees of an impending electrical storm and when to evacuate. Some important things to be aware of with the recommended action plan and evacuation procedures:

1. Sufficient warning time must be provided to allow for an orderly evacuation.

2. Be aware that an electrical storm could change direction and speed very quickly.

3. A ground to cloud lightning bolt could have a lateral offset along the ground of over 15 Km, depending on the cloud to ground height.

Table 11.21 – BAI Recommendations

Current Storm Distance Guidelines	Recommended Action Plan and Procedures
40 Km	- Mine controller informs everyone at the mine of an impending electrical storm, advising on storm direction and speed.
30 Km	- Mine controller informs everyone that the storm has moved closer, and that a possible evacuation and shut down are possible.
20 - 25 Km	- Command given to evacuate blast area. - Everyone in blast area must immediately stop whatever they are doing and evacuate to a safe distance of 750 m away. This must be non-negotiable. - Explosive bulk trucks are moved to an isolated area in pit, or they remain in blast area, providing the bulk trucks are separated by a safe distance between them, as listed in Table 11.32.

11.3 Recommended Safe Distances for Employees from Bulk Explosive Trucks

During the evacuation for an electrical storm, the explosive trucks should be parked in an isolated area inside the pit, if it is unsafe to return to their loading docks. The amount of explosives carried on a bulk truck will vary depending on the truck design, capacity, explosive type and haulage distance. But for large mining operations, a typical bulk truck can usually haul between 10,000 and 20,000 kg.

Regardless of whether the bulk explosive trucks are moved to an isolated area of the pit or remain in the blast area during an electrical storm, one would need to know what the minimum safe distance is for people to be away from a parked truck, and the minimum distance separation between two or more parked explosive bulk trucks.

Table 11.31 lists the safe minimum distances for people to evacuate to, depending on the quantity of explosives on a bulk truck. These were obtained from the American Table of Distances, published in June, 1991. For example, people would have to evacuate to a minimum distance of 610 m (2,000 ft.) from a parked bulk explosive truck containing 17,000 kg of explosive.

Table 11.31 – Minimum Safe Distances for People from Parked Bulk Explosive Trucks

Quantity of Explosives (Lbs)	Quantity of Explosives (Kg)	Minimum Safe Distance for People (m)	Minimum Safe Distance for People (ft)
400 - 500	182 – 227	145	476
1,001 – 1,200	454 – 544	194	636
2,501 – 3,000	1,134 – 1,361	263	864
5,001 – 6,000	2,268 – 2,722	333	1,092
6,001 – 7,000	2,723 – 3,175	349	1,146
9,001 – 10,000	4,083 – 4,536	393	1,290
10,001 – 20,000	4,537 – 5,443	419	1,374
18,001 – 20,000	8,165 – 9,072	569	1,866
30,001 – 35,000	13,608 – 15,876	610	2,000
35,001 – 40,000	15,876 – 18,144	610	2,000
45,001 – 50,000	20,412 – 22,680	610	2,000
70,001 – 75,000	31,752 – 34,019	610	2,000
95,000 – 100,000	43,092 – 45,359	610	2,000

Table 11.32 – Minimum Safe Distance Required Between Parked Explosive Trucks

Quantity of Explosives (Lbs)	Quantity of Explosives (Kg)	Min. Safe Dist. Between Explosive Trucks (m)	Min. Safe Dist. Between Explosive Trucks (ft.)
400 - 500	182 – 227	18	58
1,001 – 1,200	454 – 544	24	78
2,501 – 3,000	1,134 – 1,361	32	104
5,001 – 6,000	2,268 – 2,722	40	130
6,001 – 7,000	2,723 – 3,175	45	136
9,001 – 10,000	4,083 – 4,536	48	156
18,001 – 20,000	8,165 – 9,072	60	196
25,001 - 30,000	11,340 – 13,607	68	224
30,001 – 35,000	13,608 – 15,876	73	238
35,001 – 40,000	15,876 – 18,144	76	248
45,001 – 50,000	20,412 – 22,680	82	270
70,001 – 75,000	31,752 – 34,019	98	320
95,000 – 100,000	43,092 – 45,359	113	370

Table 11.32 lists the minimum safe distances bulk explosive trucks need to be separated from each other if left in the pit during an electrical storm. For example, two bulk trucks with at least one of the trucks containing 17,000 kg would need to be separated on-site by at least 76 m, to reduce the risk of detonation of both trucks if one was struck by lightning. The safe separation distance between parked trucks is always calculated based on the truck having the most explosives remaining on board. The separation distances listed in Table 11.32 also apply to bulk trucks when travelling along mine roads during an electrical storm.

11.4 Lightning Detection Systems and BAI Recommendations

The three basic types of lightning detection systems are permanent ground based, portable mobile briefcase units and hand-held units.

Permanent Ground Based Systems are the most reliable and accurate in calculating the distance, direction and severity of lightning strikes over large distances (100's of Km) in real time. One system could cover the entire mine's active pit areas with multiple antenna stations. They use radio detection techniques or satellites to triangulate distance from multiple station locations. The minimum number of antennas is three, although it is always better to have more for increased reliability/redundancy for continuous coverage, if one of the antennas malfunctions. Refer to Figure 11.41.



Figure 11.41 – Example of a Boltek, Inc. ground based antenna.

Another good thing about permanent ground based systems is that most of them can detect IC (Intra-Cloud) and CG (Cloud-to-Ground) lightning discharges. Although the IC lightning does not pose a danger to the blasters, systems which can monitor the IC lightning provide much better early detection, because IC lightning always precedes the CG lightning.

A few major suppliers of these systems are:

- Vaisala, Inc.
- TOA Systems, Inc.
- Sky Scan, Inc.
- Boltek, Inc.
- U.S. Precision Lightning Network, Inc.
- Thorguard, Inc.
- EarthNetworks, Inc.

Mobile portable units are generally no larger than the size of a brief case, which can detect only CG lightning up to 65 Km away. Distance calculations are a function of the signal frequency and the attenuation. The original lightning signal is analyzed and processed, as the exponential decrease in strength, as it passes through the detector's signal strength electronics.

Mobile portable units are very popular with blast crews because they can be brought onto the blast site, can be set up very quickly and are very simple to use. Refer to Figure 11.42. Some systems provide both an audible and flashing light warning at the desired warning distance set by the blaster.



Figure 11.42 – Example of a portable lightning detection mobile unit.

Two suppliers for mobile lightning detection systems are:

- Ideal Supply at www.idealsupplyinc.com
- Blaster's Tool and Supply at www.blasterstool.com

Hand-held personal units operate by picking up the electromagnetic pulse (EMF), which is created by a lightning strike. Distance is estimated by gauging the strength of the EM pulse. These units can generally detect localized lightning up to approximately 40 Km away. As with the mobile units, hand-held systems can only measure CG lightning. Refer to Figure 11.43.

Most lightning detection suppliers for the ground based and mobile units also carry the hand-held units.



Figure 11.43 – Example of a hand-held lightning detection unit.

11.5 BAI Recommendations for Lightning Detection Systems

BAI recommends installing a good permanent ground based lightning detection system to cover all active mine areas, and to supply each blast crew with a portable mobile unit, which will serve as an on-site backup. Reliable lightning detection systems are required, because if a lightning strike occurs on or near a loaded blast, it will generally result in premature detonation that can cause a catastrophic event for mine employees.

Many of the ground based systems have similar features, but they also offer different degrees of sophistication at varying costs, so it's advisable to not rush into a quick decision without evaluating all of the options. A few important things to consider for a ground based system are:

- Minimum range 100 Km
- Capable of monitoring both IC (Intra-Cloud) and CG (Cloud-to-Ground) lightning.
- Real time monitoring.
- Base station in office must provide automatic warnings at your preset settings, without having to rely on a PC.
- Real time tracking software and analysis.
- Must provide lightning distance, movement direction of storm and lightning intensity.
- Operates in metric units.
- Antennas can withstand the winter temperatures and high winds at the mine site.
- If system is satellite based, check that it covers British Columbia in real time.

The ground based system should serve not only the blast crews, but anyone working on the mine property. Contractors, utility workers, pipeline workers, tradesmen and visitors, etc. all have a need to be informed of an approaching electrical storm, so they could also take appropriate actions.

The controller manning the office base station should start informing everyone of an approaching storm at least one hour away on the lightning location, storm direction, and storm speed. These announcements should become more frequent (i.e. minutes apart) as the storm approaches the recommended evacuation distance of 20 - 25 km. The continual announcements will be very comforting to the blasters and the other groups, because they know someone is closely monitoring the storm. Once the evacuation command is given, everyone must stop whatever they are doing and focus only on the evacuation. It does not mean, stemming one last hole!

APPENDIX A

Detailed Fragmentation Runs for Ore and Mine Rock

Fragmentation is highly dependent on the rock properties, structural geology, powder factor and the blast design. Numerical fragmentation predictions are based on the Kuz-Ram model. This was a combination of the derivative works done by Kutznetsov (1973), Cunningham (1987), Lily (1986), and Rosin & Rambler (1933).

Blastability Index – This is dependent on the specific gravity of the rock/ore, Young's Modulus, compressive strength, rock mass description (RMD), joint spacing and orientation, and the hardness factor. The only information lacking was the jointing information, so averages were used in all of the fragmentation runs to be consistent. The blastability index generally varies between 7 (for soft, low/medium strength rocks) to 14 (for very hard, massive, competent rocks).

Powder Factor – This is defined as the amount of explosives used per cubic meter of rock or per tonne of rock/ore, but the amount of explosives in the subgrade is not used for the fragmentation predictions. However, the true powder factor does take into account the amount of explosives used in the subgrade.

Uniformity Index – This number represents how uniform the fragmentation distribution is. It generally varies between 0.80 and 1.50. If the uniformity index is > 1.0, the overall fragmentation distribution is more uniform. If the uniformity index is < 1.0, there is a much higher probability of generating a wider distribution between the fines and oversize.

Mean Fragment Size – This represents the rock size for the 50% cumulative passing or the P50. Standard cumulative percent passing sizes of interest for mines are usually the P100, P80, P50 and P20. The desired fragmentation distribution for the ore is listed in Table A1.

Table A1 – Desired Fragmentation Distribution for Blasted Ore and Mine rock

Desired Fragmentation Size				Cumulative Percent Passing
43.3 in	1.10 m	110 cm	1100 mm	100%
19.7 in	0.50 m	50 cm	500 mm	90%
12.2 in	0.31 m	31 cm	310 mm	80%
7.9 in	0.20 m	20 cm	200 mm	65%
2.0 in	0.05 m	5 cm	50 mm	18%

Ore Fragmentation Predictions With and Without a 64 Kg Stem Charge Placed 4 m Down Into a 6 m Top Stemming					
	R1	R2		R3	R4
	No Stem Charge	SC = Stem Charge = 64 Kg		No Stem Charge	SC = Stem charge = 64 Kg
	Top Stemming = 6 m	D = 4 m, SD =1.0		Top Stemming = 6 m	D = 4 m, SD = 1.0
Drill Pattern	8 m x 8 m	9 m x 9 m		7 m x 7 m	7 m x 7 m
Hole Diameter	311 mm	311 mm		311 mm	311 mm
Type of Material	Ore	Ore		Ore	Ore
Blast Design					
Borehole Diameter	311 mm	311 mm		311 mm	311 mm
Rock Density	2.84 g/cc	2.84 g/cc		2.84 g/cc	2.84 g/cc
Type of Explosive	E/A 70/30	E/A 70/30		E/A 70/30	E/A 70/30
Explosive Density	1.2 g/cc	1.2 g/cc		1.2 g/cc	1.2 g/cc
Bench Height	15 m	15 m		15 m	15 m
Subgrade	1.5 m	1.5 m		1.5 m	1.5 m
Top Stemming	6.0 m	6.0 m		6.0 m	6.0 m
Burden	8.0 m	9.0 m		7.0 m	7.0 m
Spacing	8.0 m	9.0 m		7.0 m	7.0 m
Powder Factor 1 (Kg/m^3)	0.996	0.839		1.300	1.388
Powder Factor 2 (Kg/tonne)	0.351	0.296		0.458	0.489
Powder Factor 3 (lbs/yd^3)	1.679	1.415		2.193	2.339
Fragmentation Constants					
Young's Modulus	75 GPa	75 GPa		75 GPa	75 GPa
UCS	91 MPa	91 MPa		91 MPa	91 MPa
Blastability Index	5.352	5.352		5.352	5.352
Uniformity Index	1.169	1.527		1.191	1.588
Mean Fragmentation Size	19.12 cm	19.24 cm		15.44 cm	12.87 cm
	E/A 8 x 8 - 311 - 6	E/A 9 x 9 - 311 - 6 + SC		E/A 7 x 7 - 311 - 6	E/A 7 x 7 - 311 - 6 + SC
Fragmentation (Standard)	Ore (cm)	Ore (cm)		Ore (cm)	Ore (cm)
P100% Passing (cm)	187.00	110.00		145.00	69.00
P80% Passing (cm)	39.40	33.50		31.40	21.90
P50% Passing (cm)	19.12	19.24		15.44	12.87
P20% Passing (cm)	7.25	9.20		5.96	6.31
Fragmentation (Detailed)	**Percent**	**Percent**		**Percent**	**Percent**
Desired Size & % Passing	**Passing**	**Passing**		**Passing**	**Passing**
1100 mm 100%	99.53	100.00		99.92	100.00
500 mm 90%	88.13	94.91		93.96	99.75
310 mm 80%	70.45	76.20		79.59	93.91
200 mm 65%	51.83	52.06		61.05	75.23
50 mm 18%	13.46	8.47		16.55	14.31
25 mm	6.23	3.03		7.62	5.01
20 mm	4.83	2.16		5.90	3.54
15 mm	3.48	1.40		4.22	2.26
10 mm	2.18	0.76		2.63	1.19
5 mm	0.98	0.26		1.16	0.40
1 mm	0.15	0.02		0.17	0.03

Ore Fragmentation Prediction - 6 m Top Stemming	
With a 64 Kg Stem Charge Placed 4 m Down.	
	R4a
	SC = Stem charge = 64 Kg
	D = 4 m, SD = 1.0
Drill Pattern	8.5 m x 8.5 m
Hole Diameter	311 mm
Type of Material	Ore
Blast Design	
Borehole Diameter	311 mm
Rock Density	2.84 g/cc
Type of Explosive	E/A 70/30
Explosive Density	1.2 g/cc
Bench Height	15 m
Subgrade	1.5 m
Top Stemming	6.0 m
Burden	8.5 m
Spacing	8.5 m
Powder Factor 1 (Kg/m^3)	0.941
Powder Factor 2 (Kg/tonne)	0.331
Powder Factor 3 (lbs/yd^3)	1.587
Fragmentation Constants	
Young's Modulus	75 GPa
UCS	91 MPa
Blastability Index	5.352
Uniformity Index	1.543
Mean Fragmentation Size	17.56 cm
	E/A 8.5 x 8.5 - 311 - 6 + SC
Fragmentation (Standard)	Ore (cm)
P100% Passing (cm)	99.00
P80% Passing (cm)	30.85
P50% Passing (cm)	17.56
P20% Passing (cm)	8.41
Fragmentation (Detailed)	**Percent**
Desired Size & % Passing	**Passing**
1100 mm 100%	100.00
500 mm 90%	96.93
310 mm 80%	81.10
200 mm 65%	57.14
50 mm 18%	9.50
25 mm	3.37
20 mm	2.40
15 mm	1.55
10 mm	0.83
5 mm	0.29
1 mm	0.02

Fragmentation Predictions With and Without a 64 Kg Stem Charge Placed 4 m Down Into a 6 m Top Stemming					
	R5	R6		R7	R8
	No Stem Charge	SC = Stem Charge = 64 Kg		No Stem Charge	SC = Stem Charge = 64 Kg
	Top Stemming = 6 m	D = 4 m, SD =1.0		Top Stemming = 6 m	D = 4 m, SD = 1.0
	Two Explosive Decks	Two Explosive Decks		Two Explosive Decks	Two Explosive Decks
Drill Pattern	8 m x 8 m	8 m x 8 m		7 m x 7 m	7 m x 7 m
Hole Diameter	311 mm	311 mm		311 mm	311 mm
Type of Material	Ore	Ore		Ore	Ore
Blast Design					
Borehole Diameter	311 mm	311 mm		311 mm	311 mm
Rock Density	2.84 g/cc	2.84 g/cc		2.84 g/cc	2.84 g/cc
Type of Explosive	E/A 70/30	E/A 70/30		E/A 70/30	E/A 70/30
Explosive Density	1.2 g/cc	1.2 g/cc		1.2 g/cc	1.2 g/cc
Bench Height	15 m	15 m		15 m	15 m
Subgrade	1.5 m	1.5 m		1.5 m	1.5 m
Top Stemming	6.0 m	6.0 m		6.0 m	6.0 m
Burden	8.0 m	8.0 m		7.0 m	7.0 m
Spacing	8.0 m	8.0 m		7.0 m	7.0 m
Powder Factor 1 (Kg/m^3)	0.683	0.749		0.892	0.979
Powder Factor 2 (Kg/tonne)	0.240	0.264		0.314	0.345
Powder Factor 3 (lbs/yd^3)	1.151	1.263		1.503	1.650
Fragmentation Constants					
Young's Modulus	75 GPa	75 GPa		75 GPa	75 GPa
UCS	91 MPa	91 MPa		91 MPa	91 MPa
Blastability Index	5.352	5.352		5.352	5.352
Uniformity Index	1.121	1.495		1.149	1.532
Mean Fragmentation Size	24.28 cm	20.24 cm		19.61 cm	16.35 cm
	E/A 8 x 8 - 311 -2D - 6	E/A 8 x 8 - 311 -2D - 6 + SC		E/A 7 x 7 - 311 - 2D - 6	E/A 7 x 7 - 311 - 2D - 6 + SC
Fragmentation (Standard)	Ore (cm)	Ore (cm)		Ore (cm)	Ore (cm)
P100% Passing (cm)	261.00	120.00		199.00	93.00
P80% Passing (cm)	51.50	35.55		40.90	28.35
P50% Passing (cm)	24.28	20.24		19.61	16.35
P20% Passing (cm)	8.85	9.48		7.32	7.80
Fragmentation (Detailed)	**Percent**	**Percent**		**Percent**	**Percent**
Desired Size & % Passing	**Passing**	**Passing**		**Passing**	**Passing**
1100 mm 100%	97.70	99.98		99.35	100.00
500 mm 90%	78.93	93.14		86.89	97.86
310 mm 80%	59.80	73.04		69.05	84.24
200 mm 65%	42.73	49.38		50.78	61.10
50 mm 18%	11.11	8.21		13.42	10.67
25 mm	5.27	2.99		6.29	3.82
20 mm	4.13	2.15		4.90	2.73
15 mm	3.01	1.41		3.55	1.77
10 mm	1.92	0.77		2.24	0.95
5 mm	0.89	0.27		1.02	0.33
1 mm	0.15	0.02		0.16	0.03

Waste Fragmentation - 6 m Top Stemming	
No stem Charge	
	R9a
	No Stem Charge
	Top Stemming = 6 m
Drill Pattern	8.0 m x 8.0 m
Hole Diameter	311 mm
Type of Material	Waste
Blast Design	
Borehole Diameter	311 mm
Rock Density	3.10 g/cc
Type of Explosive	E/A 70/30
Explosive Density	1.2 g/cc
Bench Height	15 m
Subgrade	1.5 m
Top Stemming	6.0 m
Burden	8.0 m
Spacing	8.0 m
Powder Factor 1 (Kg/m^3)	0.996
Powder Factor 2 (Kg/tonne)	0.321
Powder Factor 3 (lbs/yd^3)	1.679
Fragmentation Constants	
Young's Modulus	94 GPa
UCS	86 MPa
Blastability Index	5.682
Uniformity Index	1.169
Mean Fragmentation Size	20.31 cm
	E/A 8.0 x 8.0 - 311 - 6
Fragmentation (Standard)	Waste (cm)
P100% Passing (cm)	198.00
P80% Passing (cm)	41.80
P50% Passing (cm)	20.30
P20% Passing (cm)	7.70
Fragmentation (Detailed)	**Percent**
Desired Size & % Passing	**Passing**
1100 mm 100%	99.32
500 mm 90%	86.30
310 mm 80%	67.91
200 mm 65%	49.39
50 mm 18%	12.61
25 mm	5.82
20 mm	4.51
15 mm	3.25
10 mm	2.03
5 mm	0.91
1 mm	0.14

Waste Fragmentation With and Without a Stem Charge Placed 4m down into a 6m Top Stemming					
	R9	R10		R11	R12
	No Stem Charge	SC = Stem charge = 64 Kg		No Stem Charge	SC = Stem charge = 64 Kg
	Top Stemming = 6 m	D = 4 m, SD =1.0		Top Stemming = 6 m	D = 4 m, SD =1.0
				Two Explosive Decks	Two Explosive Decks
Drill Pattern	8.5 m x 8.5 m	8.5 m x 8.5 m		7.0 m x 7.0 m	7.5 m x 7.5 m
Hole Diameter	311 mm	311 mm		311 mm	311 mm
Type of Material	Waste	Waste		Waste	Waste
Blast Design					
Borehole Diameter	311 mm	311 mm		311 mm	311 mm
Rock Density	3.10 g/cc	3.10 g/cc		3.10 g/cc	3.10 g/cc
Type of Explosive	E/A 70/30	E/A 70/30		E/A 70/30	E/A 70/30
Explosive Density	1.2 g/cc	1.2 g/cc		1.2 g/cc	1.2 g/cc
Bench Height	15 m	15 m		15 m	15 m
Subgrade	1.5 m	1.5 m		1.5 m	1.5 m
Top Stemming	6.0 m	6.0 m		6.0 m	6.0 m
Burden	8.5 m	8.5 m		7.0 m	7.5 m
Spacing	8.5 m	8.5 m		7.0 m	7.5 m
Powder Factor 1 (Kg/m^3)	0.882	0.941		0.892	0.852
Powder Factor 2 (Kg/tonne)	0.285	0.304		0.288	0.275
Powder Factor 3 (lbs/yd^3)	1.487	1.587		1.503	1.437
Fragmentation Constants					
Young's Modulus	94 GPa	94 GPa		94 GPa	94 GPa
UCS	86 MPa	86 MPa		86 MPa	86 MPa
Blastability Index	5.682	5.682		5.682	5.682
Uniformity Index	1.157	1.543		1.149	1.514
Mean Fragmentation Size	22.37 cm	18.64 cm		20.82 cm	19.38 cm
	E/A 8.5 x 8.5 - 311 - 6	E/A 8.5 x 8.5 - 311 - 6 + SC		E/A 7.0 x 7.0 - 311 - 2D 6	E/A 7.5 x 7.5 - 311 - 2D 6 + SC
Fragmentation (Standard)	Ore (cm)	Ore (cm)		Ore (cm)	Ore (cm)
P100% Passing (cm)	223.00	105.00		211.00	113.00
P80% Passing (cm)	46.40	32.20		43.35	33.80
P50% Passing (cm)	22.37	18.64		20.82	19.38
P20% Passing (cm)	8.40	8.95		7.77	9.20
Fragmentation (Detailed)	**Percent**	**Percent**		**Percent**	**Percent**
Desired Size & % Passing	**Passing**	**Passing**		**Passing**	**Passing**
1100 mm 100%	98.74	100.00		99.09	99.99
500 mm 90%	82.76	95.82		84.99	94.56
310 mm 80%	63.62	78.11		66.54	75.62
200 mm 65%	45.61	53.81		48.40	51.66
50 mm 18%	11.52	8.70		12.58	8.53
25 mm	5.34	3.07		5.88	3.07
20 mm	4.15	2.19		4.58	2.20
15 mm	2.99	1.41		3.31	1.43
10 mm	1.88	0.76		2.09	0.78
5 mm	0.85	0.26		0.95	0.27
1 mm	0.13	0.02		0.15	0.02

Ore and Waste Fragmentation Predictions With and Without a 64 Kg Stem Charge Placed 4 m Down Into a 6 m Top Stemming					
	R13	R14		R15	R16
	No Stem Charge	No Stem Charge		No Stem Charge	No Stem Charge
	Top Stemming = 2.8 m	Top Stemming = 2.8 m		Top Stemming = 2.8 m	Top Stemming = 2.8 m
	Two Explosive Decks	Two Explosive Decks		Three Explosive Decks	Three Explosive Decks
	Wet Holes	Wet Holes		Wet Holes	Wet Holes
Drill Pattern	4 m x 4 m	4.6 m x 4.6 m		3.7 m x 3.7 m	4.2 m x 4.2 m
Hole Diameter	152 mm	152 mm		152 mm	152 mm
Type of Material	Ore	Waste		Ore	Waste
Blast Design					
Borehole Diameter	152 mm	152 mm		152 mm	152 mm
Rock Density	2.84 g/cc	3.10 g/cc		2.84 g/cc	3.10 g/cc
Type of Explosive	E/A 70/30	E/A 70/30		E/A 70/30	E/A 70/30
Explosive Density	1.2 g/cc	1.2 g/cc		1.2 g/cc	1.2 g/cc
Bench Height	15 m	15 m		15 m	15 m
Subgrade	1.5 m	1.5 m		1.5 m	1.5 m
Top Stemming	2.8 m	2.8 m		2.8 m	2.8 m
Burden	4.0 m	4.6 m		3.7 m	4.2 m
Spacing	4.0 m	4.6 m		3.7 m	4.2 m
Powder Factor 1 (Kg/m^3)	1.064	0.804		0.993	0.770
Powder Factor 2 (Kg/tonne)	0.375	0.259		0.350	0.248
Powder Factor 3 (lbs/yd^3)	1.794	1.356		1.674	1.299
Fragmentation Constants					
Young's Modulus	75 GPa	94 GPa		75 GPa	94 GPa
UCS	91 MPa	86 MPa		91 MPa	86 MPa
Blastability Index	5.352	5.682		5.352	5.682
Uniformity Index	1.491	1.457		1.47	1.439
Mean Fragmentation Size	18.16 cm	18.86 cm		14.46 cm	18.80 cm
	E/A 4 x 4 - 152 -2D - 2.8	E/A 4.6 x 4.6 - 152 -2D - 2.8		E/A 3.7 x 3.7 - 152 -3D - 2.8	E/A 4.2 x 4.2 - 152 -3D - 2.8
Fragmentation (Standard)	Ore (cm)	Ore (cm)		Ore (cm)	Ore (cm)
P100% Passing (cm)	113.00	117.00		89.00	120.00
P80% Passing (cm)	25.00	33.60		25.65	33.76
P50% Passing (cm)	24.20	18.86		14.46	18.80
P20% Passing (cm)	6.65	8.66		6.70	8.56
Fragmentation (Detailed)	**Percent**	**Percent**		**Percent**	**Percent**
Desired Size & % Passing	**Passing**	**Passing**		**Passing**	**Passing**
1100 mm 100%	100.00	99.99		100.00	99.99
500 mm 90%	98.92	94.33		98.63	94.11
310 mm 80%	89.14	76.07		88.07	75.90
200 mm 65%	68.49	53.00		67.25	53.11
50 mm 18%	13.59	9.53		13.54	9.79
25 mm	5.06	3.58		5.12	3.73
20 mm	3.66	2.60		3.71	2.72
15 mm	2.40	1.72		2.45	1.80
10 mm	1.32	0.96		1.36	1.01
5 mm	0.47	0.35		0.49	0.37
1 mm	0.04	0.03		0.05	0.04

APPENDIX B

Additional Fragmentation Runs for Mine rock

Waste Fragmentation - One Explosive Deck - 64 Kg Stem charge - 6 m Top Stemming - 311 mm					
	R10	R10a		R10b	R10c
	SC = Stem charge = 64 Kg	SC = Stem charge = 64 Kg		No Stem Charge	SC = Stem charge = 64 Kg
	D = 4 m, SD =1.0	D = 4 m, SD =1.0		Top Stemming = 6 m	D = 4 m, SD =1.0
	One Explosive Deck	One Explosive Deck		One Explosive Deck	One Explosive Deck
Drill Pattern	8.5 m x 8.5 m	9.0 m x 9.0 m		9.5 m x 9.5 m	10 m x 10 m
Hole Diameter	311 mm	311 mm		311 mm	311 mm
Type of Material	Waste	Waste		Waste	Waste
Blast Design					
Borehole Diameter	311 mm	311 mm		311 mm	311 mm
Rock Density	3.10 g/cc	3.10 g/cc		3.10 g/cc	3.10 g/cc
Type of Explosive	E/A 70/30	E/A 70/30		E/A 70/30	E/A 70/30
Explosive Density	1.2 g/cc	1.2 g/cc		1.2 g/cc	1.2 g/cc
Bench Height	15 m	15 m		15 m	15 m
Subgrade	1.5 m	1.5 m		1.5 m	1.5 m
Top Stemming	6.0 m	6.0 m		6.0 m	6.0 m
Burden	8.5 m	9.0 m		9.5 m	10 m
Spacing	8.5 m	9.0 m		9.5 m	10 m
Powder Factor 1 (Kg/m^3)	0.941	0.839		0.753	0.680
Powder Factor 2 (Kg/tonne)	0.304	0.271		0.243	0.219
Powder Factor 3 (lbs/yd^3)	1.587	1.415		1.270	1.146
Fragmentation Constants					
Young's Modulus	94 GPa	94 GPa		94 GPa	94 GPa
UCS	86 MPa	86 MPa		86 MPa	86 MPa
Blastability Index	5.682	5.682		5.682	5.682
Uniformity Index	1.543	1.145		1.133	1.11
Mean Fragmentation Size	18.64 cm	25.41 cm		26.72 cm	29.01 cm
	E/A 8.5 x 8.5 - 311 - 1D + SC 6m	E/A 9.0 x 9.0 - 311 - 1D + SC 6m		E/A 9.5 x 9.5 - 311 - 2D +SC 6m	E/A 10 x 10 - 311 - 1D + SC 6m
Fragmentation (Standard)	Waste (cm)	Waste (cm)		Waste (cm)	Waste (cm)
P100% Passing (cm)	105.00	251.00		280.00	312.00
P80% Passing (cm)	32.20	51.20		56.20	61.60
P50% Passing (cm)	18.64	19.12		26.72	29.01
P20% Passing (cm)	8.95	9.11		9.83	10.55
Fragmentation (Detailed)	**Percent**	**Percent**		**Percent**	**Percent**
Desired Size & % Passing	**Passing**	**Passing**		**Passing**	**Passing**
1100 mm 100%	100.00	97.91		96.80	95.43
500 mm 90%	95.82	79.15		75.57	72.07
310 mm 80%	78.11	59.63		55.95	52.60
200 mm 65%	53.81	42.25		39.29	36.68
50 mm 18%	8.70	10.62		9.86	9.22
25 mm	3.07	4.95		4.62	4.35
20 mm	2.19	3.85		3.61	3.40
15 mm	1.41	2.79		2.62	2.48
10 mm	0.76	1.76		1.66	1.58
5 mm	0.26	0.80		0.76	0.73
1 mm	0.02	0.13		0.12	0.12

Waste Fragmentation With a Stem Charge Placed 4m Down into a 6m Top Stemming		
	R10	R10d
	SC = Stem charge = 64 Kg	SC = Stem charge = 64 Kg
	D = 4 m, SD =1.0	D = 4 m, SD =1.0
Drill Pattern	8.5 m x 8.5 m	8.7 m x 8.7 m
Hole Diameter	311 mm	311 mm
Type of Material	Waste	Waste
Blast Design		
Borehole Diameter	311 mm	311 mm
Rock Density	3.10 g/cc	3.10 g/cc
Type of Explosive	E/A 70/30	E/A 70/30
Explosive Density	1.2 g/cc	1.2 g/cc
Bench Height	15 m	15 m
Subgrade	1.5 m	1.5 m
Top Stemming	6.0 m	6.0 m
Burden	8.5 m	8.7 m
Spacing	8.5 m	8.7 m
Powder Factor 1 (Kg/m^3)	0.941	0.898
Powder Factor 2 (Kg/tonne)	0.304	0.290
Powder Factor 3 (lbs/yd^3)	1.587	1.514
Fragmentation Constants		
Young's Modulus	94 GPa	94 GPa
UCS	86 MPa	86 MPa
Blastability Index	5.682	5.682
Uniformity Index	1.543	1.536
Mean Fragmentation Size	18.64 cm	19.35 cm
	E/A 8.5 x 8.5 - 311 - 6 + SC	E/A 8.7 x 8.7 - 311 - 6 + SC
Fragmentation (Standard)	Ore (cm)	Ore (cm)
P100% Passing (cm)	105.00	110.00
P80% Passing (cm)	32.20	33.50
P50% Passing (cm)	18.64	19.35
P20% Passing (cm)	8.95	9.25
Fragmentation (Detailed)	**Percent**	**Percent**
Desired Size & % Passing	**Passing**	**Passing**
1100 mm 100%	100.00	100.00
500 mm 90%	95.82	94.92
310 mm 80%	78.11	76.07
200 mm 65%	53.81	51.77
50 mm 18%	8.70	8.30
25 mm	3.07	2.94
20 mm	2.19	2.10
15 mm	1.41	1.35
10 mm	0.76	0.73
5 mm	0.26	0.25
1 mm	0.02	0.02

Waste Fragmentation - Two Exposive Decks - 64 Kg Stem Charge - 6 m Top Stemming - 311 mm					
	R12	R12a		R12b	R12c
	SC = Stem charge = 64 Kg	SC = Stem charge = 64 Kg		SC = Stem charge = 64 Kg	SC = Stem charge = 64 Kg
	D = 4 m, SD =1.0	D = 4 m, SD =1.0		D = 4 m, SD =1.0	D = 4 m, SD =1.0
	Two Explosive Decks	Two Explosive Decks		Two Explosive Decks	Two Explosive Decks
Drill Pattern	7.5 m x 7.5 m	8.0 m x 8.0 m		8.5 m x 8.5 m	9 m x 9 m
Hole Diameter	311 mm	311 mm		311 mm	311 mm
Type of Material	Waste	Waste		Waste	Waste
Blast Design					
Borehole Diameter	311 mm	311 mm		311 mm	311 mm
Rock Density	3.10 g/cc	3.10 g/cc		3.10 g/cc	3.10 g/cc
Type of Explosive	E/A 70/30	E/A 70/30		E/A 70/30	E/A 70/30
Explosive Density	1.2 g/cc	1.2 g/cc		1.2 g/cc	1.2 g/cc
Bench Height	15 m	15 m		15 m	15 m
Subgrade	1.5 m	1.5 m		1.5 m	1.5 m
Top Stemming	6.0 m	6.0 m		6.0 m	6.0 m
Burden	7.5 m	8.0 m		8.5 m	9.0 m
Spacing	7.5 m	8.0 m		8.5 m	9.0 m
Powder Factor 1 (Kg/m^3)	0.852	0.749		0.664	0.592
Powder Factor 2 (Kg/tonne)	0.275	0.242		0.214	0.191
Powder Factor 3 (lbs/yd^3)	1.437	1.263		1.119	0.998
Fragmentation Constants					
Young's Modulus	94 GPa	94 GPa		94 GPa	94 GPa
UCS	86 MPa	86 MPa		86 MPa	86 MPa
Blastability Index	5.682	5.682		5.682	5.682
Uniformity Index	1.514	1.495		1.475	1.455
Mean Fragmentation Size	19.38 cm	21.49 cm		23.68 cm	25.94 cm
	E/A 7.5 x 7.5 - 311 - 2D + SC 6m	E/A 8.0 x 8.0 - 311 - 2D + SC 6m		E/A 8.5 x 8.5 - 311 - 2D + SC 6m	E/A 9.0 x 9.0 - 311 - 2D + SC 6m
Fragmentation (Standard)	Waste (cm)	Waste (cm)		Waste (cm)	Waste (cm)
P100% Passing (cm)	113.00	128.00		144.00	162.00
P80% Passing (cm)	33.80	37.75		41.90	46.30
P50% Passing (cm)	19.38	21.49		23.58	25.94
P20% Passing (cm)	9.20	10.07		11.00	11.90
Fragmentation (Detailed)	**Percent**	**Percent**		**Percent**	**Percent**
Desired Size & % Passing	**Passing**	**Passing**		**Passing**	**Passing**
1100 mm 100%	99.99	99.97		99.87	99.66
500 mm 90%	94.56	91.37		87.61	83.48
310 mm 80%	75.62	69.84		64.35	59.26
200 mm 65%	51.66	46.34		41.74	37.79
50 mm 18%	8.53	7.54		6.75	6.12
25 mm	3.07	2.74		2.48	2.28
20 mm	2.20	1.97		1.79	1.65
15 mm	1.43	1.29		1.18	1.09
10 mm	0.78	0.70		0.65	0.60
5 mm	0.27	0.25		0.23	0.22
1 mm	0.02	0.02		0.02	0.02

Waste Fragmentation - Two Exposive Decks - 64 Kg Stem Charge - 6 m Top Stemming - 311 mm		
	R12d	R12e
	SC = Stem charge = 64 Kg	SC = Stem charge = 64 Kg
	D = 4 m, SD =1.0	D = 4 m, SD =1.0
	Two Explosive Decks	Two Explosive Decks
Drill Pattern	9.5 m x 9.5 m	10 m x 10 m
Hole Diameter	311 mm	311 mm
Type of Material	Waste	Waste
Blast Design		
Borehole Diameter	311 mm	311 mm
Rock Density	3.10 g/cc	3.10 g/cc
Type of Explosive	E/A 70/30	E/A 70/30
Explosive Density	1.2 g/cc	1.2 g/cc
Bench Height	15 m	15 m
Subgrade	1.5 m	1.5 m
Top Stemming	6.0 m	6.0 m
Burden	9.5 m	10.0 m
Spacing	9.5 m	10.0 m
Powder Factor 1 (Kg/m^3)	0.531	0.480
Powder Factor 2 (Kg/tonne)	0.171	0.155
Powder Factor 3 (lbs/yd^3)	0.896	0.808
Fragmentation Constants		
Young's Modulus	94 GPa	94 GPa
UCS	86 MPa	86 MPa
Blastability Index	5.682	5.682
Uniformity Index	1.435	1.414
Mean Fragmentation Size	28.29 cm	30.71 cm
	E/A 9.5 x 9.5 - 311 - 2D + SC 6m	E/A 10 x 10 - 311 - 2D + SC 6m
Fragmentation (Standard)	Waste (cm)	Waste (cm)
P100% Passing (cm)	181.00	202.00
P80% Passing (cm)	50.90	55.70
P50% Passing (cm)	28.29	30.71
P20% Passing (cm)	12.85	13.80
Fragmentation (Detailed)	**Percent**	**Percent**
Desired Size & % Passing	**Passing**	**Passing**
1100 mm 100%	99.23	98.51
500 mm 90%	79.18	74.86
310 mm 80%	54.63	50.46
200 mm 65%	34.39	31.48
50 mm 18%	5.60	5.19
25 mm	2.11	1.98
20 mm	1.54	1.45
15 mm	1.02	0.97
10 mm	0.57	0.55
5 mm	0.21	0.21
1 mm	0.02	0.02

Ore Fragmentation - Two Exposive Decks - 2.8 m Top Stemming - 152 mm		
	R13	R13a
	No Stem Charge	No Stem Charge
	Top Stemming = 2.8 m	Top Stemming = 2.8 m
	Two Explosive Decks	Two Explosive Decks
	Wet Holes	Wet Holes
Drill Pattern	4 m x 4 m	4.6 m x 4.6 m
Hole Diameter	152 mm	152 mm
Type of Material	Ore	Ore
Blast Design		
Borehole Diameter	152 mm	152 mm
Rock Density	2.84 g/cc	2.84 g/cc
Type of Explosive	E/A 70/30	E/A 70/30
Explosive Density	1.2 g/cc	1.2 g/cc
Bench Height	15 m	15 m
Subgrade	1.5 m	1.5 m
Top Stemming	2.8 m	2.8 m
Burden	4.0 m	4.2 m
Spacing	4.0 m	4.2 m
Powder Factor 1 (Kg/m^3)	1.064	0.804
Powder Factor 2 (Kg/tonne)	0.375	0.283
Powder Factor 3 (lbs/yd^3)	1.794	1.356
Fragmentation Constants		
Young's Modulus	75 GPa	75 GPa
UCS	91 MPa	91 MPa
Blastability Index	5.352	5.352
Uniformity Index	1.491	1.457
Mean Fragmentation Size	14.20 cm	17.76 cm
	E/A 4 x 4 - 152 -2D - 2.8	E/A 4.6 x 4.6 - 152 -2D - 2.8
Fragmentation (Standard)	Ore (cm)	Ore (cm)
P100% Passing (cm)	85.00	111.00
P80% Passing (cm)	25.00	31.70
P50% Passing (cm)	14.20	15.36
P20% Passing (cm)	6.65	8.16
Fragmentation (Detailed)	**Percent**	**Percent**
Desired Size & % Passing	**Passing**	**Passing**
1100 mm 100%	100.00	99.99
500 mm 90%	98.92	95.63
310 mm 80%	89.13	78.99
200 mm 65%	68.48	56.12
50 mm 18%	13.59	10.35
25 mm	5.06	3.90
20 mm	3.66	2.83
15 mm	2.40	1.87
10 mm	1.32	1.04
5 mm	0.47	0.38
1 mm	0.04	0.04

Waste Fragmentation - Two Exposive Decks - No Stem Charge - 2.8 m Top Stemming - 152 mm					
	R14	R14a		R14b	R14c
	No Stem Charge	No Stem Charge		No Stem Charge	No Stem Charge
	Top Stemming = 2.8 m	Top Stemming = 2.8 m		Top Stemming = 2.8 m	Top Stemming = 2.8 m
	Two Explosive Decks	Two Explosive Decks		Two Explosive Decks	Two Explosive Decks
Drill Pattern	4.6 m x 4.6 m	4.8 m x 4.8 m		5.0 m x 5.0 m	5.2 m x 5.2 m
Hole Diameter	152 mm	152 mm		152 mm	152 mm
Type of Material	Waste	Waste		Waste	Waste
Blast Design					
Borehole Diameter	152 mm	152 mm		152 mm	152 mm
Rock Density	3.10 g/cc	3.10 g/cc		3.10 g/cc	3.10 g/cc
Type of Explosive	E/A 70/30	E/A 70/30		E/A 70/30	E/A 70/30
Explosive Density	1.2 g/cc	1.2 g/cc		1.2 g/cc	1.2 g/cc
Bench Height	15 m	15 m		15 m	15 m
Subgrade	1.5 m	1.5 m		1.5 m	1.5 m
Top Stemming	2.8 m	2.8 m		2.8 m	2.8 m
Burden	4.6 m	4.8 m		5.0 m	5.2 m
Spacing	4.6 m	4.8 m		5.0 m	5.2 m
Powder Factor 1 (Kg/m^3)	0.804	0.739		0.681	0.630
Powder Factor 2 (Kg/tonne)	0.259	0.238		0.220	0.203
Powder Factor 3 (lbs/yd^3)	1.356	1.246		1.148	1.061
Fragmentation Constants					
Young's Modulus	94 GPa	94 GPa		94 GPa	94 GPa
UCS	86 MPa	86 MPa		86 MPa	86 MPa
Blastability Index	5.682	5.682		5.682	5.682
Uniformity Index	1.457	1.445		1.432	1.419
Mean Fragmentation Size	18.86 cm	20.18 cm		21.55 cm	22.94 cm
	E/A 4.6 x 4.6 - 152 -2D - 2.8m	E/A 4.8 x 4.8 - 152 - 2D + 2.8m		E/A 5.0 x 5.0 - 152 - 2D + 2.8m	E/A 5.2 x 5.2 - 152 - 2D + 2.8m
Fragmentation (Standard)	Waste (cm)	Waste (cm)		Waste (cm)	Waste (cm)
P100% Passing (cm)	117.00	128.00		139.00	162.00
P80% Passing (cm)	33.60	36.20		38.80	46.30
P50% Passing (cm)	18.86	20.18		21.55	25.94
P20% Passing (cm)	8.66	9.23		9.77	11.90
Fragmentation (Detailed)	**Percent**	**Percent**		**Percent**	**Percent**
Desired Size & % Passing	Passing	**Passing**		**Passing**	**Passing**
1100 mm 100%	99.99	99.97		99.92	99.66
500 mm 90%	94.33	92.34		90.11	83.48
310 mm 80%	76.07	72.42		68.86	59.26
200 mm 65%	53.00	49.53		46.36	37.79
50 mm 18%	9.53	8.82		8.20	6.12
25 mm	3.58	3.33		3.12	2.28
20 mm	2.60	2.43		2.28	1.65
15 mm	1.72	1.61		1.51	1.09
10 mm	0.96	0.90		0.85	0.60
5 mm	0.35	0.33		0.32	0.22
1 mm	0.03	0.03		0.03	0.02

Ore Fragmentation - Thee Explosive Decks		
No Stem Charge - 2.8 m top stemming - 152 mm		
	R15	R15a
	No Stem Charge	No Stem Charge
	Top Stemming = 2.8 m	Top Stemming = 2.8 m
	Three Explosive Decks	Three Explosive Decks
Drill Pattern	3.7 m x 3.7 m	4.2 m x 4.2 m
Hole Diameter	152 mm	152 mm
Type of Material	Ore	Ore
Blast Design		
Borehole Diameter	152 mm	152 mm
Rock Density	2.84 g/cc	2.84 g/cc
Type of Explosive	E/A 70/30	E/A 70/30
Explosive Density	1.2 g/cc	1.2 g/cc
Bench Height	15 m	15 m
Subgrade	1.5 m	1.5 m
Top Stemming	2.8 m	2.8 m
Burden	3.7 m	4.2 m
Spacing	3.7 m	4.2 m
Powder Factor 1 (Kg/m^3)	0.993	0.770
Powder Factor 2 (Kg/tonne)	0.350	0.271
Powder Factor 3 (lbs/yd^3)	1.674	1.299
Fragmentation Constants		
Young's Modulus	75 GPa	75 GPa
UCS	91 MPa	91 MPa
Blastability Index	5.352	5.352
Uniformity Index	1.47	1.439
Mean Fragmentation Size	14.46 cm	17.71 cm
	E/A 3.7 x 3.7 - 152 -3D - 2.8	E/A 4.2 x 4.2 - 152 -3D - 2.8
Fragmentation (Standard)	Ore (cm)	Ore (cm)
P100% Passing (cm)	89.00	113.00
P80% Passing (cm)	25.65	31.80
P50% Passing (cm)	14.46	17.71
P20% Passing (cm)	6.70	8.06
Fragmentation (Detailed)	**Percent**	**Percent**
Desired Size & % Passing	**Passing**	**Passing**
1100 mm 100%	100.00	99.99
500 mm 90%	98.63	95.43
310 mm 80%	88.07	78.80
200 mm 65%	67.25	56.20
50 mm 18%	13.54	10.62
25 mm	5.12	4.06
20 mm	3.71	2.96
15 mm	2.45	1.97
10 mm	1.36	1.10
5 mm	0.49	0.41
1 mm	0.05	0.04

Waste Fragmentation - Three Exposive Decks - No Stem Charge - 2.8 m Top Stemming - 152 mm					
	R16	R16a		R16b	R16c
	No Stem Charge	No Stem Charge		No Stem Charge	No Stem Charge
	Top Stemming = 2.8 m	Top Stemming = 2.8 m		Top Stemming = 2.8 m	Top Stemming = 2.8 m
	Three Explosive Decks	Three Explosive Decks		Three Explosive Decks	Three Explosive Decks
Drill Pattern	4.2 m x 4.2 m	4.4 m x 4.4 m		4.6 m x 4.6 m	4.8 m x 4.8 m
Hole Diameter	152 mm	152 mm		152 mm	152 mm
Type of Material	Waste	Waste		Waste	Waste
Blast Design		152 mm		152 mm	152 mm
Borehole Diameter	152 mm	3.10 g/cc		3.10 g/cc	3.10 g/cc
Rock Density	3.10 g/cc	E/A 70/30		E/A 70/30	E/A 70/30
Type of Explosive	E/A 70/30	1.2 g/cc		1.2 g/cc	1.2 g/cc
Explosive Density	1.2 g/cc	15 m		15 m	15 m
Bench Height	15 m	1.5 m		1.5 m	1.5 m
Subgrade	1.5 m	2.8 m		2.8 m	2.8 m
Top Stemming	2.8 m	4.4 m		4.6 m	4.8 m
Burden	4.2 m	4.4 m		4.6 m	4.8 m
Spacing	4.2 m				
Powder Factor 1 (Kg/m^3)	0.770	0.702		0.642	0.590
Powder Factor 2 (Kg/tonne)	0.248	0.226		0.207	0.190
Powder Factor 3 (lbs/yd^3)	1.299	1.183		1.083	0.994
Fragmentation Constants					
Young's Modulus	94 GPa	94 GPa		94 GPa	94 GPa
UCS	86 MPa	86 MPa		86 MPa	86 MPa
Blastability Index	5.682	5.682		5.682	5.682
Uniformity Index	1.439	1.426		1.412	1.397
Mean Fragmentation Size	18.80 cm	20.26 cm		21.75 cm	23.28 cm
	E/A 4.2 x 4.2 - 152 -3D - 2.8	E/A 4.4 x 4.4 - 152 - 3D + 2.8m		E/A 4.6 x 4.6 - 152 - 2D + 2.8m	E/A 4.8 x 4.8 - 152 - 2D + 2.8m
Fragmentation (Standard)	Waste (cm)	Waste (cm)		Waste (cm)	Waste (cm)
P100% Passing (cm)	120.00	131.00		144.00	157.00
P80% Passing (cm)	33.76	36.60		39.50	41.60
P50% Passing (cm)	18.8	20.26		21.75	23.28
P20% Passing (cm)	**8.56**	9.15		9.75	10.35
Fragmentation (Detailed)	Percent	**Percent**		**Percent**	**Percent**
Desired Size & % Passing	Passing	**Passing**		**Passing**	**Passing**
1100 mm 100%	99.99	99.96		99.89	99.77
500 mm 90%	94.11	91.90		89.40	86.68
310 mm 80%	75.90	71.95		68.11	64.44
200 mm 65%	53.11	49.37		45.97	42.91
50 mm 18%	9.79	9.00		8.33	7.76
25 mm	3.73	3.45		3.22	3.02
20 mm	2.72	2.52		2.36	2.22
15 mm	1.80	1.68		1.58	1.49
10 mm	1.01	0.95		0.89	0.85
5 mm	0.37	0.35		0.34	0.32
1 mm	0.04	0.04		0.03	0.03

Appendix E COMMONLY USED NOISE TERMINOLOGY

Airborne Sound: Sound that reaches the point of interest by propagation through air.

Ambient Noise: All noises that exist in an area and are not related to a facility. Ambient noise includes sound from other industrial noise, transportation sources, animals, and nature. Ambient noise is the same as background sound level.

Ambient Sound Level (ASL): The ASL consists of all noise in the area that is not related to regulated facilities. This noise includes sound from other non-regulated industrial facilities, transportation sources, animals and nature. The ASL does not include any energy-related industrial component and must be measured without it. The ASL can be measured when the sound level in an area is not felt to be represented by the BSL. The ASL must be measured under representative conditions. As with comprehensive sound levels, representative conditions do not constitute the quietest or the noisiest day but conditions that portray typical conditions for the area. In some cases, the ASL can be considered as the Baseline Sound Level.

Attenuation: The reduction of sound intensity by various means (e.g., air, barrier, porous materials, silencers, enclosures, etc.).

Background Sound Level (i.e., Baseline): includes noise from all sources other than the sound of interest (i.e. sound other than that being measured, for example, sound from other industrial noise not being measured, transportation sources, animals, and nature sound).

Bands (octave, 1/3 octave): A series of electronic filters separate sound into discrete frequency bands, making it possible to know how sound energy is distributed as a function of frequency. Each octave band has a center frequency that is double the center frequency of the octave band preceding it.

Basic Sound Level (BSL): The A-weighted L_{eq} sound level commonly observed to occur in the designated land-use categories with industrial presence. The BSL is assumed to be 5 dBA above the ASL and is set out in Table 1 of AER Directive 038: Noise Control.

Calibration: The procedure used for the adjustment of a sound level meter using a reference source of a known sound pressure level and frequency. Calibration must take place before and after the sound level measurements.

Calibrator (Acoustical): A device which produces a known sound pressure on the microphone of a sound level measurement system, and is used to adjust the system to standard specifications.

Category: A classification of a dwelling unit in relation to transportation routes used to arrive at a BSL.

Class A Adjustment: Consists of the sum of adjustments that account for the adjustment seasonal nature of the noise source, absence of both tonal and impulse and impact components, and the actual ASL in an area. It cannot exceed +10 dBA. The Class A adjustment is added to the BSL, the daytime adjustment, and the Class B adjustment to arrive at a permissible sound level.

Class B Adjustment: An adjustment based on the duration of a noisy activity that recognizes that additional noise can be tolerated if it is known that the duration will be limited. An adjustment of B1, B2, B3, or B4 may be selected as applicable.

Comprehensive Sound Level (CSL): The sound level that is a composite of different airborne sounds from many sources far away from and near the point of measurement. The CSL does include industrial components and must be measured with them, but it should exclude abnormal noise events.

Daytime: Defined as the hours from 07:00 to 22:00.

Daytime Adjustment: An adjustment that allows a 10 dBA increase because daytime sound levels are generally about 10 dBA higher than nighttime values.

dB - Decibel: The logarithmic units associated with sound pressure level, sound power level, or acceleration level. See sound pressure level, for example.

dBA - Decibel, A-Weighted: The logarithmic units associated with a sound pressure level, where the sound pressure signal has been filtered using a frequency weighting that mimics the response of the human ear to quiet sound levels. The resultant sound pressure level is therefore representative of the subjective response of the human ear. A-weighted sound pressure levels are denoted by the suffix 'A' (i.e. dBA), and the term pressure is normally omitted from the description (i.e., sound level or noise level).

dBC - Decibel, C-Weighted: The logarithmic units associated with a sound pressure level, where the sound pressure signal has been filtered using a frequency weighting that mimics the response of the human ear to loud sound levels. C-weighted sound pressure levels are denoted by the suffix 'C' (i.e. dBC). C-weighted levels are often used in low-frequency noise analysis, as the filtering effect is nearly flat at lower frequencies.

Decibel Addition:

In acoustics, due to the logarithmic nature of the decibel scale, two or more sound pressure levels (denoted as SPL1, SPL2 … SPLn) are added as follows:

$$SPL1 + SPL2 + \ldots SPLn = 10 \log (10^{(SPL1/10)} + 10^{(SPL2/10)} + \ldots + 10^{(SPLn/10)})$$

As an example:

0 dB + 0 dB = 3 dB
50 dB + 50 dB = 53 dB
50 dB + 47 dB = 52 dB
50 dB + 40 dB = 50 dB

Directivity Factor (Q) (also, Directional or Directionality Factor): A factor mathematically related to Directivity Index, used in calculating propagated sound levels to account for the effect of reflecting surfaces near to the source. For example, for a source in free space where the sound is radiating spherically, Q = 1. For a source located on or very near to a surface (such as the ground, a wall, rooftop, etc.), where the sound is radiating hemispherically, Q = 2. This accounts for the additional sound energy reflecting off the surface, and translates into a +3 dB addition.

Dwelling Unit: Any permanently or seasonally occupied residence with the exception of an employee or worker residence, dormitory, or construction camp located within an industrial Project boundary. Trailer parks and campgrounds may qualify as dwelling units if it can be demonstrated that they are in regular and consistent use during the applicable season.

Dwelling Unit (most impacted): The nearest dwelling unit may not necessarily be the one most adversely affected because of factors such as topography and man-made features. For example, the nearest dwelling unit to a facility may be located behind an intervening ridge, while a more distant dwelling unit may be in direct line of sight with the facility. Care must be taken in determining the most impacted dwelling unit.

Emergency: An unplanned event requiring immediate action to prevent loss of life or property. Events occurring more than four times a year are not considered unplanned.

Energy Equivalent Sound Level (L_{eq}): An energy-average sound level taken over a specified period of time. It represents the average sound pressure encountered for the period. The time period is often added as a suffix to the label (e.g., L_{eq} (24) for the 24-hour equivalent sound level). L_{eq} is usually A-weighted. A L_{eq} value expressed in dBA is a good, single value descriptor of the annoyance of noise.

Far Field: Describes a region in free space where the sound pressure level from a source obeys the inverse-square law (the sound pressure level decreases 6 dB with each doubling of distance from the source). The far field is that area far enough away from the noise source that the noise emissions can be treated as if they come from a single point or line source and the individual components of the noise source are not apparent as separate sources. This is typically at a distance of at least three to five times the major dimensions of the noise sources.

Filter: A device separating the components of an incoming signal by its frequencies.

Free Sound Field (Free Field): A sound field in which the effects of obstacles or boundaries on sound propagated in that field are negligible.

Frequency: The number of times per second that the sine wave of sound or of a vibrating object repeats itself. Now expressed in hertz (Hz), formerly in cycles per second (cps).

Frequent Aircraft Flyovers: Used in the assessment of categories as part of a site specific analysis for dwellings that lie within a contour area with a noise exposure forecast (NEF) 25 or greater, as designated by Transport Canada. In the absence of any NEF contours for local airport, Transport Canada is to be contacted for current air traffic statistics. In this case, to qualify for the BSL adjustment, a dwelling must be within 5 km of an airport that has a minimum of nine aircraft takeoffs or landings over the nighttime period.

Heavily Travelled Road: Generally includes highways and any other road where the average traffic count is at least 10 vehicles per hour over the nighttime period. It is acknowledged that highways are sometimes lightly travelled during the nighttime period, which is usually the period of greatest concern.

Heavy Truck: Any truck having a gross vehicle weight of 12,000 kg or more and having three or more axles.

Hertz (Hz): Unit of measurement of frequency, numerically equal to cycles per second.

Human Perception of Sound: The human perception of noise impact is an important consideration in qualifying the noise effects caused by projects. The typical threshold for an increase in sound level that is considered to be "barely perceptible" by the human ear in a controlled laboratory setting varies from 1 to 5 dBA, depending on the sound pressure level and frequency of the sound.

Intensity: The sound energy flow through a unit area in a unit time.

Low Frequency Noise (LFN): Noise in the low frequency range, from infrasonic sounds (<20 Hz) up to 100 Hz. Where a clear tone is present below and including 250 HZ and the difference between the overall C-weighted sound level and the overall A-weighted sound level exceeds 20 dB.

Masking: a) The process by which the threshold of audibility for a sound is raised by the presence of another (masking) sound, or b) The amount by which the threshold of audibility of a sound is raised by the presence of another (masking) sound.

Near Field: The region or sound field very near to a source, where sound pressure does not obey the inverse-square law (i.e., 6 dBA loss per doubling of distance for a point source does not apply). Usually this region is located within a few wavelength of the source and is also controlled by the dimension of the source.

Nighttime: Defined as the hours from 22:00 to 07:00.

Noise: Generally associated with the unwanted portion of sound.

Noise Exposure Forecast (NEF): The NEF contours are site specific to each airport and take into account such factors as traffic levels, proximity to runways, flight paths, and aircraft type and size.

Noise Impact Assessment (NIA): An NIA identifies the expected sound level emanating from a facility as measured 15 m from the nearest or most impacted permanently or seasonally occupied dwelling. It also identifies what the permissible sound level is and how it was calculated.

Noise Level: Same as Sound Level, except applied to unwanted sounds.

Permanent Facility: Any existing or proposed facility that will be at a location longer than two months.

Permanently Occupied Dwelling: A fixed residence occupied on a full-time basis.

Permissible Sound Level (PSL): The maximum sound level that a facility should not exceed at a point 15 m from the nearest or most impacted dwelling unit. The PSL is the sum of the BSL, daytime adjustment, Class A adjustment, and Class B adjustment.

Pristine Area: A pure, natural area that might have a residence but no industrial presence, including energy, agricultural, forestry, manufacturing, recreational, or other industries that could make noise generation a consideration.

Representative Conditions: Those conditions typical for an area and/or the nature of a complaint. For ASLs, these are conditions that portray the typical activities for the area, not the quietest time. For CSLs, these do not constitute absolute worst-case conditions or the exact conditions the complainant has highlighted if those conditions are not easily duplicated. Sound levels must be taken only when representative conditions exist; this may necessitate a survey of extensive duration (two or more consecutive nights).

Seasonally Occupied Dwelling: A fixed residence that, while not being occupied on a full-time basis, is occupied on a regular basis. A regular basis does not imply a scheduled occupancy but implies use of six weeks per year or more. The residence must not be mobile and should have some sort of foundation or features of permanence (e.g., electrical power, domestic water supply, septic system) associated with it. Summer cottages or mobile homes are examples of seasonally occupied dwellings, while a holiday trailer simply pulled onto a site is not.

Sound: A dynamic (fluctuating) pressure.

Sound Level (SL): The A-weighted Sound Pressure Level expressed in dBA.

Sound Level Meter: An instrument comprised of a microphone, amplifier, output meter, and frequency-weighting networks which is used for the measurement of noise and sound levels.

Sound Pressure Level (SPL): The logarithmic ratio of the RMS sound pressure to the sound pressure at the threshold of hearing. The sound pressure level is defined by equation (1) where P is the RMS pressure due to a sound and P_0 is the reference pressure. P_0 is usually taken as 2.0×10^{-5} Pascal.

$$SPL\ (dB) = 20 \log (P_{RMS}/P_0)$$

Sound Power Level (PWL): The logarithmic ratio of the instantaneous sound power (energy) of a noise source to that of an international standard reference power. The sound power level is defined by equation (2) where W is the sound power of the source in watts, and W0 is the reference power of 10^{-12} watts.

$$PWL\ (dB) = 10 \log (W/W_0)$$

Inter-relationships between SPL and sound power PWL depend on the location and type of source.

Spectrum: The description of a sound wave's resolution into its components of frequency and amplitude.

Tonal Components: Most energy industrial facilities typically exhibit a tonal component. Examples of tonal components are transformer hum, sirens, and piping noise. The test for the presence of tonal components consists of two parts.

The first part must demonstrate that the sound pressure level of any one of the slow-response, A-weighted, 1/3-octave bands between 20 and 16 kHz is 10 dBA or more than the sound pressure level of at least one of the adjacent bands within two 1/3-octave bandwidths. In addition, there must be a minimum of a 5 dBA drop from the band containing the tone within 2 bandwidths on the opposite side. The second part is that the tonal component must be a pronounced peak clearly obvious within the spectrum

Transmission Loss: A measure of the reduction in sound energy resulting from incident sound waves striking a wall, partition or enclosure, and radiating through to the other side. Mathematically, the transmission coefficient t is the ratio of transmitted acoustic power to the incident acoustic power, and in decibels, the Transmission Loss (TL) of the wall is:

TL = 10 log (1 / t)

The TL of a wall varies by frequency. The associated noise reduction (NR) due to the TL of the wall is a function of the TL and the acoustical parameters of the receiving space.

Windscreen: A specialized piece of porous sponge that fits over the microphone in order to reduce the noise generated by the wind blowing around the microphone. Useful in moderately low wind speeds. Generally, outdoor measurements are not recommended when wind speeds exceed 15 km/hr, as the wind-induced noise on the microphone becomes of the same magnitude as the levels being measured.