NOISE PREDICTION MODELLING REPORT

KUDZ ZE KAYAH PROJECT

BMC-15-02-2226_022_Noise_Model_Report_Rev0_161209

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EXECUTIVE SUMMARY

Noise prediction modelling was conducted to assess potential Project related noise effects of the Kudz Ze Kayah Project (the Project). Although there are no applicable standards for noise in Yukon, predicted noise levels were compared with relevant standards and guidelines from other jurisdictions (i.e. the British Columbia Oil and Gas Commission (BC OGC) standards (2009), the Alberta Energy Resources Conservation Board (ERCB) Directive 038 (2007) and Environment Canada's Environmental Code of Practice for Metal Mines (2009) guidelines on maximum noise levels in residential areas adjacent to mine sites).

No baseline sound level data were collected at or in the vicinity of the Project. However, based on the isolated location of the Project, the existing acoustic ambient conditions are assumed to be similar to the average ambient sound level for rural areas as established by the Energy Resources Conservation Board (now Alberta Energy Regulator) (ERCB, 2007) and the BC OGC (2009).

Noise modelling was conducted using SoundPLAN Essential, a widely used and well recognized acoustic modelling software, using international standards (International Organization for Standardization (ISO 9613). The main noise sources were identified for each of the Project phases: construction, operation, and closure. For traffic related noise, emissions were calculated from estimated traffic volume, road surface and vehicle speed, according to the United States (US) Federal Highway Administration (FHWA) Traffic Noise Model (TNM) standard. For each of the Project phases, the worst-case scenario was modeled, where for example, all equipment expected to be in operation on an as needed or non-continuous basis was assumed to operate at the same time. Design mitigations (shielding and enclosures) were incorporated into the model. Noise levels were predicted for the sensitive receptor (off-shift workers at the camp) and were provided for the entire modelling domain as a grid noise map.

The noise prediction scenarios modelled for each Project phase indicate that standards exceedances (BC OGC / ERCB) are not expected to occur at the camp receptor. Results also indicate that enclosures are effective in reducing ambient outdoor noise levels.

Higher noise levels could occur in the immediate vicinity of the noise sources during all Project phases. Note that only design mitigations were incorporated in the model. Additional mitigations for noise control are discussed in the conceptual Noise Management Plan in the Project Proposal, and could contribute to further reduce ambient noise levels.

Under the loudest scenarios, daytime and night-time noise levels differ from baseline by more than 1 dBA over a maximum extent of approximately 4 km in the east-west direction and 8 km in the north-south direction centered around the Project footprint. The typical threshold for an increase in sound level that is considered to be "barely perceptible" by the human ear ranges from 1 to 5 dBA (Health Canada, 2011). A similar threshold is assumed for animals.

In terms of evaluating potential effects on indoor activities (i.e. off-shift workers sleeping), a building attenuation factor is applied to predicted outdoor noise levels. For all Project phases, the predicted night-time noise levels (with design mitigations), when adjusted to indoor levels using the value of 15 dBA (for windows partially open), fall below the recommended threshold of 30 dBA for sleep disturbance.

LIST OF ACRONYMS

BC OGC	British Columbia Oil and Gas Commission
CONCAWE	Conservation of Clean Air and Water in Europe
dB	Decibel
dBA	A-weighed decibel
DGM	Digital Ground Model
EC	Environment Canada
ERCB	Energy Resources Conservation Board (Alberta)
FHWA	Federal Highway Administration (US)
hPa	hectopascal
ISO	International Organization for Standardization
kPa	kilopascal
KZK	Kudz Ze Kayah
Leq	Equivalent Continuous Level
masl	meters above sea level
MoE	Ministry of the Environment
MMU	Mobile Manufacturing Unit
NPC	Noise Pollution Control
OHS	Occupational Health and Safety
P	Peak Overpressure
PPE	Personal Protective Equipment
SPL	Sound Pressure Level
t	tonnes
TNM	Traffic Noise Model
TNT	Trinitrotoluene
US	United States
VMS	Volcanic Massive Sulphide
WSF	Waste Storage Facility

GLOSSARY

A-weighed Decibel: a measurement of noise level based on the sensitivity of human hearing at moderate levels.

Decibel: a noise level measured on a logarithmic scale.

Hectopascal: a metric measurement unit of pressure commonly used to measure atmospheric pressure. (1 hPa = 0.1 kPa)

Kilopascal: a metric measurement unit of pressure commonly used to measure atmospheric pressure. (1 kPa = 10 hPa)

Equivalent Continuous Level: a common method of describing sound levels that vary over time, resulting in a single decibel value which takes into account the total sound energy over the period of time of interest.

Peak Overpressure: the peak pressure caused by a shock wave over and above normal atmospheric pressure.

SoundPLAN Essential: a standard based software for predicting noise from roads, railroads, parking lots and industrial point, line and area sources.

Sound Pressure Level: a measurement of sound level. A ratio of the absolute sound pressure and a reference level, usually the lowest intensity sound that can be heard by most people.

Trinitrotoluene: an explosive material commonly referred to as “TNT”.

Volcanic Massive Sulphide: a type of metal ore deposit, mainly copper-zinc, associated with and created by volcanic-associated hydrothermal events in submarine environments.

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1 INTRODUCTION

Noise prediction modelling was conducted to assess potential project related noise effects of the Kudz Ze Kayah (KZK) Project (the Project). Noise was selected as a Valued Component because of its importance to both humans and wildlife. Elevated noise levels may lead to annoyance, stress, sleep disruption, decreased ability to concentrate, lowered learning performance, and other negative health effects in humans (enHealth Council, 2004). For wildlife, noise may lead to habitat avoidance, as well as unfavourable physiological and behavioral responses (National Park Service, 2011).

1.1 PROJECT OVERVIEW

The Project is located approximately 260 km northwest of Watson Lake and 115 km southeast of Ross River. Access to the Project is via a 24 km long, all weather, single lane gravel tote road that connects the Project to the Robert Campbell Highway. The Project site is within the northern foothills of the Pelly Mountains of the Yukon Plateau and in the Finlayson Creek watershed.

The Project comprises the ABM Deposit, of which there are two zones, the ABM Zone and the Krakatoa Zone. The ABM Deposit, is a polymetallic volcanogenic massive sulphide (VMS) deposit containing economic concentrations of copper, lead, zinc, gold and silver. Mining is planned to be conducted via both open pit and underground mining methods, with ore processed into separate copper, lead and zinc concentrates via sequential flotation through a 5,500 tonne per day processing plant. Tailings will be deposited in a dry stack tailings facility on the western slope of the Geona Creek valley, while waste rock will be stored according to acid generation and metal leaching potential. Strongly acid generating material will be co-disposed with the tailings or alternatively stored as paste backfill in the mined out underground workings. Other waste rock material will be placed on the surface.

The mine is planned to operate for ten years. Concentrate will be transported to the port of Stewart in British Columbia for sale to market.

There are no permanent or temporary residences in the vicinity of the Project. The only people that will be in the Project area during construction, operations and closure are BMC employees and contractors.

2 NOISE STANDARDS

Noise levels are measured on a logarithmic scale, of which the unit is the decibel (dB). The A-weighing scale (dBA) is based on the sensitivity of human hearing at moderate levels. Equivalent continuous level (Leq) is a common method of describing sound levels that vary over time, resulting in a single decibel value which takes into account the total sound energy over the period of time of interest. Noise standards are generally expressed in dBA Leq.

Although there are no applicable standards for noise in Yukon, predicted noise levels can be compared with relevant standards from other jurisdictions, such as the British Columbia Oil and Gas Commission standards (BC OGC, 2009) or the Alberta Energy Resources Conservation Board (ERCB) Directive 038 (ERCB, 2007). Environment Canada's Environmental Code of Practice for Metal Mines (Environment Canada, 2009) also provides guidance on maximum noise levels in residential areas adjacent to mine sites, and specifies that since ambient noise can also affect wildlife, sites in remote locations should also work to meet these objectives for off-site ambient noise levels. Table 2-1 summarizes relevant outdoor noise standards.

Table 2-1: Noise Standards (Leq)

Standard	Daytime (7:00 – 22:00)	Night-time (22:00 – 7:00)
EC (2009)	55 dBA	45 dBA
BC OGC (2009) *	50 dBA	40 dBA
ERCB (2007) Directive 38 *	50 dBA	40 dBA

* Standards presented for Category 1 dwellings (more than 500 m from heavily travelled roads, rail line and not subject to frequent aircraft flyover), with 0 Class A adjustment (for seasonal or ambient monitoring) and 0 Class B adjustment (for short duration).

In addition to the standards above, Project noise from blasting can be evaluated against Ontario Ministry of the Environment (MoE) (Ontario MoE, 1978) Noise Pollution Control (NPC) NPC-119 Blasting, which specifies a cautionary limit of 120 dB. Environment Canada's Environmental Code of Practice for Metal Mines (2009) suggests that mines should design their blasts so that concussion noise of a maximum of 128 dB is not exceeded at or beyond the boundaries of the mine property.

3 EXSITING CONDITIONS

The Project is located in a remote area in central Yukon, where noise levels are low and dominated by natural sounds (wind, wildlife, and creeks). As such, no baseline sound level data were collected at or in the vicinity of the Project. However, based on the isolated location of the Project, the existing acoustic ambient conditions are expected to be similar to the average ambient sound level for rural areas as established by the Energy Resources Conservation Board (now Alberta Energy Regulator) (ERCB, 2007) and the BC Oil & Gas Commission (BC OGC, 2009).

The baseline night-time (22:00 to 7:00) ambient sound level for rural areas was established at 35 dBA Leq by both the ERCB and the BC OGC: where "Daytime adjustment recognizes that daytime ambient sound levels are commonly 10 dBA Leq higher than night-time levels and that night-time noise disturbances are generally considered less acceptable" (ERCB, 2007). In the case of a rural area, the average daytime (7:00 to 22:00) ambient sound level would therefore be 45 dBA Leq, according to both the ERCB and the BC OGC.

No similar daytime or night-time average ambient sound levels exist for Yukon; however, comparisons can be made with baseline noise data collected for other Yukon projects located in a remote setting comparable to the Project. Noise monitoring carried out in August 2011 for the Casino Project found an average daytime Leq of 40.3 dBA and an average night-time Leq of 33.9 dBA (RWDI, 2012). Although noise levels were variable and hourly values ranged between 30.3 dBA to 43.4 dBA during the course of the 22-hour study (RWDI, 2012); the average ambient sounds levels were found to be below the values of 45 dBA and 35 dBA established by the ERCB and the BC OGC for daytime and night-time respectively. The use of the BC OGC / ERCB recommended values as baseline sound levels was therefore deemed an appropriate approach.

4 NOISE MODELLING

Noise modelling was conducted using SoundPLAN Essential, a standard software for predicting noise from roads, railroads, parking lots and industrial point, line and area sources. SoundPLAN Essential can integrate noise protection walls and berms, and simulates the noise on top of continuously triangulated digital ground model (DGM). The sound level at a receptor is calculated from the sound power and the propagation, which itself is derived from spreading, air absorption, screening, ground effect and reflection coefficients. SoundPLAN processes the hourly Leqs and then rates them according to the required descriptors (if different than Leq).

SoundPLAN is a widely used and well recognized acoustic modelling software, using international standards (International Organization for Standardization (ISO) 9613). While Alberta ERCB and the BC OGC do not endorse any specific noise model, the ERCB does require that models use international standards from Conservation of Clean Air and Water in Europe (CONCAWE) or ISO 9613.

4.1 INPUT DATA

4.1.1 METEOROLOGICAL DATA

SoundPLAN Essential doesn't require the input of meteorological parameters other than average temperature, relative humidity, and pressure, as the ISO 9613 Standard method aims at determining the average sound level under meteorological conditions favorable to stable propagation (moderate downwind propagation, or equivalently, propagation under a well-developed, but moderate, ground-based temperature inversion, such as that which commonly occurs at night). The model only requires the input of average climatic conditions at the Project site, which were obtained from the local meteorological station for the period September 1, 2015 to August 31, 2016. Average annual temperature was 0°C, average relative humidity was 70%, and average station pressure was 835 hPa.

4.1.2 TERRAIN DATA

The Project area is mountainous and elevation ranges from about 1,300 to 2,000 m above sea level (masl). A DGM was created for the modelling area from 20 m elevation contours.

4.1.3 NOISE SOURCES

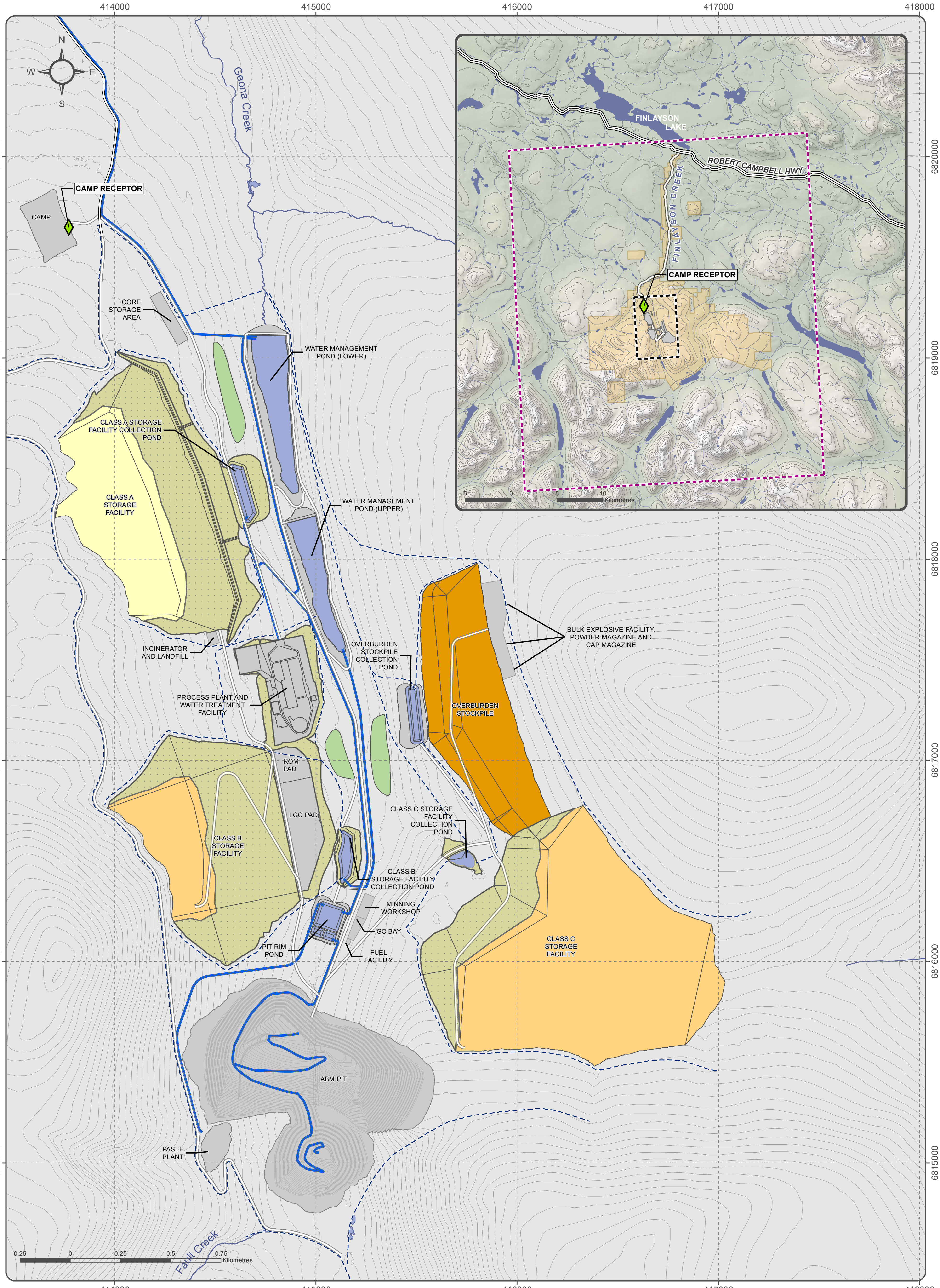
The main noise sources were identified for each of the Project phases according to the following schedule:

- Construction Phase: Year -2 to 0;
- Operation Phase: Year 1 to 10; and
- Closure Phase: Year 11 to 13.

Noise levels for each source were obtained from the built-in library of the noise modelling software, either as mean noise levels or as emission spectra. Where more than one sound pressure value was available for a given source, the most similar equipment specifications were selected or if specifications were not available, the loudest value was selected to ensure a conservative approach. Figure 4-1 shows the proposed location of the various Project features.

For traffic related noise, emissions were calculated from estimated traffic volume, road surface, and vehicle speed, according to the United States (US) Federal Highway Administration (FHWA) Traffic Noise Model (TNM) standard.

For each of the Project phases, the worst-case scenario was modeled, where for example, all equipment expected to be in operation on an as needed or non-continuous basis was assumed to operate at the same time. Design mitigations (e.g., shielding and enclosures) were incorporated into the model.



Noise Receptor
Pipeline
Diversion Ditch
Class A Storage Facility
Class B and C Storage Facility
Overburden Stockpile
Topsoil Stockpile
Progressive Reclamation, Footprint
Pond/Water
Footprints
Access Road Noise Modeling Domain
Project Site Noise Modeling Domain
Tote Road/Proposed Access Road
Proposed Project Site Road
Contours (10 m)

Datum: NAD 83; Projection: UTM Zone 9N

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KUDZ ZE KAYAH PROJECT

FIGURE 4 -1
PROJECT LAYOUT

NOVEMBER 2016

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(*Last edited by: amatlashevska;11/23/2016/11:05 AM*)

4.1.3.1 Construction Phase

Table 4-1 below presents the daytime and night-time noise sources included in the model for the construction phase.

Table 4-1: Noise Sources Construction Phase

Source	Location	Total Sound Pressure (dBA)	Usage
Diesel Generator	Camp	102.0	12h/day
Diesel Genset	Process Plant Facility	111.0	14h/day
Pump	Open pit – overburden sump	65.1	24h/day
Pump	Open pit well 1	61..5	24h/day
Pump	Open pit well 2	61.5	24h/day
Pump	Open pit well 3	61.5	24h/day
Pump	Class A Collection Pond	65.1	As required
Pump	Class B Collection Pond	65.1	As required
Pump	Lower Water Management Pond	65.1	As required
Drill 1	Open pit	86.8	24h/day
Drill 2`	Open pit	86.8	24h/day
Welding plant (x6)	Process Plant Facility	75.9	14h/day
Bulldozer	Open pit	89.0	4h/day
Excavator	Open pit	95.5	14h/day
Crane (x6)	Process Plant Facility	105.0	2 to 4h/day
Excavator	Process Plant Facility	95.5	12h/day
Elevated Work Platform (x6)	Process Plant Facility	80.4	8h/day
Bulldozer	Class A Storage Facility	89.0	6h/day
Grader	Class A Storage Facility	92.4	1h/day
Bulldozer	Class B Storage Facility	89.0	6h/day
Grader	Class B Storage Facility	92.4	1h/day
Bulldozer	Class C Storage Facility	89.0	10h/day
Grader	Class C Storage Facility	92.4	1h/day
Bulldozer	Overburden Stockpile	89.0	12h/day
Grader	Overburden Stockpile	92.4	1h/day
Crane	Mine workshop	76.6	4h/day
Excavator	Explosive Facility	86.4	12h/day
Fuel and lube truck	Fuel farm to pit	49.9*	50 trips/ day
Explosives Truck (MMU)	Open pit to Explosives Facility	40.1 *	6 hours/day
Heavy Truck	Process Plant Facility to Waste Storage Facility (WSF)	49.22 *	40 trips/day
Bus	Highway to Site	30.9 *	1 trip/day
Heavy Truck (supplies)	Highway to Site	41.7 *	7 trips/day
Heavy Truck	Open pit to Class A WSF	45.7 *	18 trips/day

Source	Location	Total Sound Pressure (dBA)	Usage
Heavy Truck	Open pit to Class B WSF	50.5 *	55 trips/day
Heavy Truck	Open pit to Class C WSF	53.1 *	99 trips/day
Heavy Truck	Open pit to Overburden Stockpile	54.9 *	153 trips/day
Heavy Truck	Mine Workshop to WSF as required	49.2*	40 trips/day
Light Truck	Camp to Process Plant Facility	36.5*	8 trips/day
Light Truck	Open pit to Class A Storage Facility	32.3 *	3 trips/day
Light Truck	Open pit to Class B Storage Facility	32.3 *	3 trips/day
Light Truck	Open pit to Class C Storage Facility	32.3 *	3 trips/day
Light Truck	Open pit to Overburden Stockpile	32.3*	3 trips/day

** Calculated from TNM for average of all road surfaces, speed of 30 km/h on site and 50km/h on the mine access road, estimated traffic volume provided in Table, and road gradient obtained from DGM (only provided as an indication as model input is by road segment)*

Sound attenuating steel enclosures around the camp and process plant generators were incorporated in the model to evaluate potential noise reduction at the camp receptor resulting from these mitigations. A completely closed enclosure located close to the source has an estimated shielding factor of 10 dBA (US Department of Transportation, 2006).

4.1.3.2 Operation Phase

Table 4-2 below presents the daytime and night-time noise sources included in the model for the operation phase.

Table 4-2: Noise Sources Operation Phase

Source	Location	Total Sound Pressure (dBA)	Usage
Boiler	Camp	89.6	24h/day
Dual Fuel Genset	Process Plant Facility	111.0	24h/day
Crusher	Process Plant Facility	118.0	24h/day
Grinder	Process Plant Facility	105.4	24h/day
Material Handling and Transfer	Process Plant Facility	125.0	24h/day
Pump	Open pit – overburden sump	65.1	24h/day
Pump	Open pit well 1	61..5	24h/day
Pump	Open pit well 2	61.5	24h/day
Pump	Open pit well 3	61.5	24h/day
Pump	Pit Rim Pond	65.1	24h/day
Pump	Class A Collection Pond	65.1	As required
Pump	Class B Collection Pond	65.1	As required
Pump	Lower Water Management Pond	65.1	As required
Fan	20 m inside the HW portal	70.3	24h/day
Compressor	Main ramp portal (Year 3 and 4)	115.0	24h/day
Drill 1	Open pit	86.8	24h/day
Drill 2`	Open pit	86.8	24h/day

Source	Location	Total Sound Pressure (dBA)	Usage
Bulldozer	Open pit	89.0	4h/day
Excavator	Open pit	95.5	20h/day
Truck	From underground into pit	91.9	20 trips/day
Loader	Process Plant Facility	77.1	24h/day
Forklift	Reagent Store and Warehouse	100.0	6h/day
Bulldozer	Class A Storage Facility	89.0	2h/day
Grader	Class A Storage Facility	92.4	1h/day
Bulldozer	Class B Storage Facility	89.0	8h/day
Grader	Class B Storage Facility	92.4	1h/day
Bulldozer	Class C Storage Facility	89.0	14h/day
Grader	Class C Storage Facility	92.4	2h/day
Bulldozer	Overburden Stockpile	89.0	2h/day
Grader	Overburden Stockpile	92.4	1h/day
Loader	Paste Fill Plant	77.1	5h/day
Explosives Truck (MMU)	Open pit to Explosives Facility	40.1 *	6 h/day
Heavy Truck	Tailings Filter Area to Class A WSF and Paste Fill Plant	53.4 *	106 trips/day
Bus	Highway to Site	30.9*	1 trip/day
Heavy Truck (supplies)	Highway to Site	41.7 *	7 trip/day
Concentrate Truck	Process Plant Facility to Highway	48.1 *	19 trips/day
Heavy Truck	Open pit to Class A WSF	46.6 *	21 trips/day
Heavy Truck	Tailings Filter Area to Class A WSF	52.1 *	79 trips/day
Heavy Truck	Open pit to Class B WSF	53.3 *	103 trips/day
Heavy Truck	Open pit to Class C WSF	56.8 *	236 trips/day
Heavy Truck	Open pit to Overburden Stockpile	48.6 *	35 trips/day
Heavy Truck	Tailings Filter Area to Paste Fill Plant	53.4 *	106 trips/day
Light Truck	Camp to Process Plant Facility	38.3*	12 trips/day
Light Truck	Around Mill and Paste Fill Plant	41.3 *	25 trips/day
Light Truck	Open pit to Class A Storage Facility	33.5 *	3 trips/day
Light Truck	Open pit to Class B Storage Facility	33.5 *	3 trips/day
Light Truck	Open pit to Class C Storage Facility	32.3 *	3 trips/day
Light Truck	Open pit to Overburden Stockpile	31.7 *	2 trips/day

** Calculated from TNM for average of all road surfaces, speed of 30 km/h on site and 50km/h on the mine access road, estimated traffic volume provided in Table, and road gradient obtained from DGM (only provided as an indication as model input is by road segment)*

The mitigations included for the operation phase consists of enclosures around the camp boiler, Process Plant Facility genset, and around the compressor outside the main ramp underground portal. In addition, the Process Plant Facility activities (crushing, grinding, conveyor transfers, tailings and concentrate loading, and use of the forklift) will occur inside the building, which adds an effective shielding value of 10 dBA.

4.1.3.3 Closure Phase

Table 4-3 below presents the daytime noise sources included in the model for the closure phase. Decommissioning and closure activities are anticipated to occur during dayshift only, therefore night-time noise levels were not modelled for the closure phase. Note that the closure scenario modelled assumes that all reclamation activities are occurring simultaneously (e.g., no progressive reclamation) and is therefore conservative.

Table 4-3: Noise Sources Closure Phase

Source	Location	Total Sound Pressure (dBA)	Usage
Diesel Generator	Camp	102.0	12h/day
Diesel Genset	Process Plant Facility	111.0	12h/day
Pump	Class A Collection Pond	65.1	As required
Pump	Class B Collection Pond	65.1	As required
Pump	Lower Water Management Pond	65.1	As required
Loader	Open pit spillway	114.0	2 weeks, 8h/day
Crane (x6)	Process Plant Facility	105.0	2 to 4h/day
Bulldozer	Process Plant Facility	89.0	6h/day
Elevated Work Platform (x6)	Process Plant Facility	80.4	8h/day
Bulldozer	Class A Storage Facility	89.0	4h/day
Grader	Class A Storage Facility	92.4	1h/day
Bulldozer	Class B Storage Facility	89.0	4h/day
Grader	Class B Storage Facility	92.4	1h/day
Bulldozer	Class C Storage Facility	89.0	3h/day
Grader	Class C Storage Facility	92.4	1h/day
Loader	Overburden Stockpile	114.0	8h/day
Loader	Topsoil Stockpile	114.0	8h/day
Crane	Mine workshop	76.6	4h/day
Crane	Explosive Facility	76.6	4h/day
Crane	Paste Fill Plant	76.6	4h/day
Bulldozer	Mine workshop	89.9	6h/day
Bulldozer	Explosive Facility	89.0	6h/day
Bulldozer	Paste Fill Plant	89.0	6h/day
Loader	Fault Creek Diversion, Water Diversion Ditches, Water Management Ponds	114.0	8h/day
Crane	Process Plant Facility to Laydown area (WSF)	76.6	4h/day
Heavy Truck	Process Plant Facility to Laydown area (WSF)	42.1 *	8 trips/day
Bus	Highway to Site	30.9 *	1 trip/day
Heavy Truck (supplies)	Highway to Site	41.7 *	7 trip/day
Heavy Truck	Overburden Stockpile to Class A WSF, Topsoil Stockpile to Class A WSF	47.25 *	26 trips/day
Heavy Truck	Overburden Stockpile to Class B WSF, Topsoil Stockpile to Class B WSF	48.3 *	33 trips/day

Source	Location	Total Sound Pressure (dBA)	Usage
Heavy Truck	Overburden Stockpile to Class C WSF, Topsoil Stockpile to Class C WSF	46.3 *	21 trips/day
Heavy Truck	Explosives facility, Mine Workshop facility, Paste Fill Plant to laydown	35.9 *	2 trips/day
Light Truck	Camp to Open Pit	36.6 *	6 trips/day
Light Truck	Camp to Process Plant Facility	39.6 *	12 trips/day
Light Truck	Open pit to Class A Storage Facility	36.6 *	6 trips/day
Light Truck	Open pit to Class B Storage Facility	36.6 *	6 trips/day
Light Truck	Open pit to Class C Storage Facility	35.3 *	6 trips/day
Light Truck	Open pit to Overburden Stockpile	35.3 *	6 trips/day
Light Truck	Open pit to Topsoil Stockpile	35.3 *	6 trips/day

** Calculated from TNM for average of all road surfaces, speed of 30 km/h on site and 50km/h on the mine access road, estimated traffic volume provided in Table, and road gradient obtained from DGM (only provided as an indication as model input is by road segment)*

Design mitigations included in the closure scenario consist of sound attenuating steel enclosures around the camp and mill generators.

4.1.3.4 Blasting

For blasting noise, a reasonable worst-case scenario was considered with the peak blasting activity in the open pit expected to occur during the operation phase. The average explosive consumption is expected to be 9.0 tonnes per day, with an average of four blasts per week over areas of 2,500 m^2 (10 m benches). Blasting is only to occur during dayshift.

4.1.4 DOMAIN AND RECEPTOR

The modelling domain for all Project phases was chosen to include areas where measurable changes in sound level might be caused by the Project, and consists of an approximately 4.6 km by 6.0 km area centered on the mine footprint (see Figure 4-1). Camp was selected as a receptor of interest as it will be representative of off-shift workers' long term exposure. In addition to the sensitive receptor, noise predictions are provided for the entire modelling domain as a grid noise map, with grid cells size of 100 m by 100 m.

An additional run was modelled over a larger domain including the entire Project access road (to the Robert Campbell Highway: 32 km by 36 km), to evaluate the potential effects of increased traffic on the Project access road, and the extent of predicted changes in baseline noise levels associated with the Project activities. It is expected that the maximum level of traffic on the mine access road will occur at daytime during the operation phase (1 bus, 7 supplies truck and 19 concentrate trucks per day; see Table 4-2), as such, this is the scenario that was chosen to be modelled over this larger domain in order to assess the worst case conditions. For this model run, grid cell size was set to 500 m by 500 m.

4.2 MODELLING RESULTS

Modelling results for daytime and night-time for each of the three phases are presented in Figure 4-2 to Figure 4-5. Results are further discussed in the following sections. Results in this section represent outdoor noise levels, which can be used to evaluate potential effects such as annoyance level and speech comprehension. For effects assessment on sleep disturbance or indoor activities, a building attenuation factor is applied.

4.2.1 CONSTRUCTION PHASE

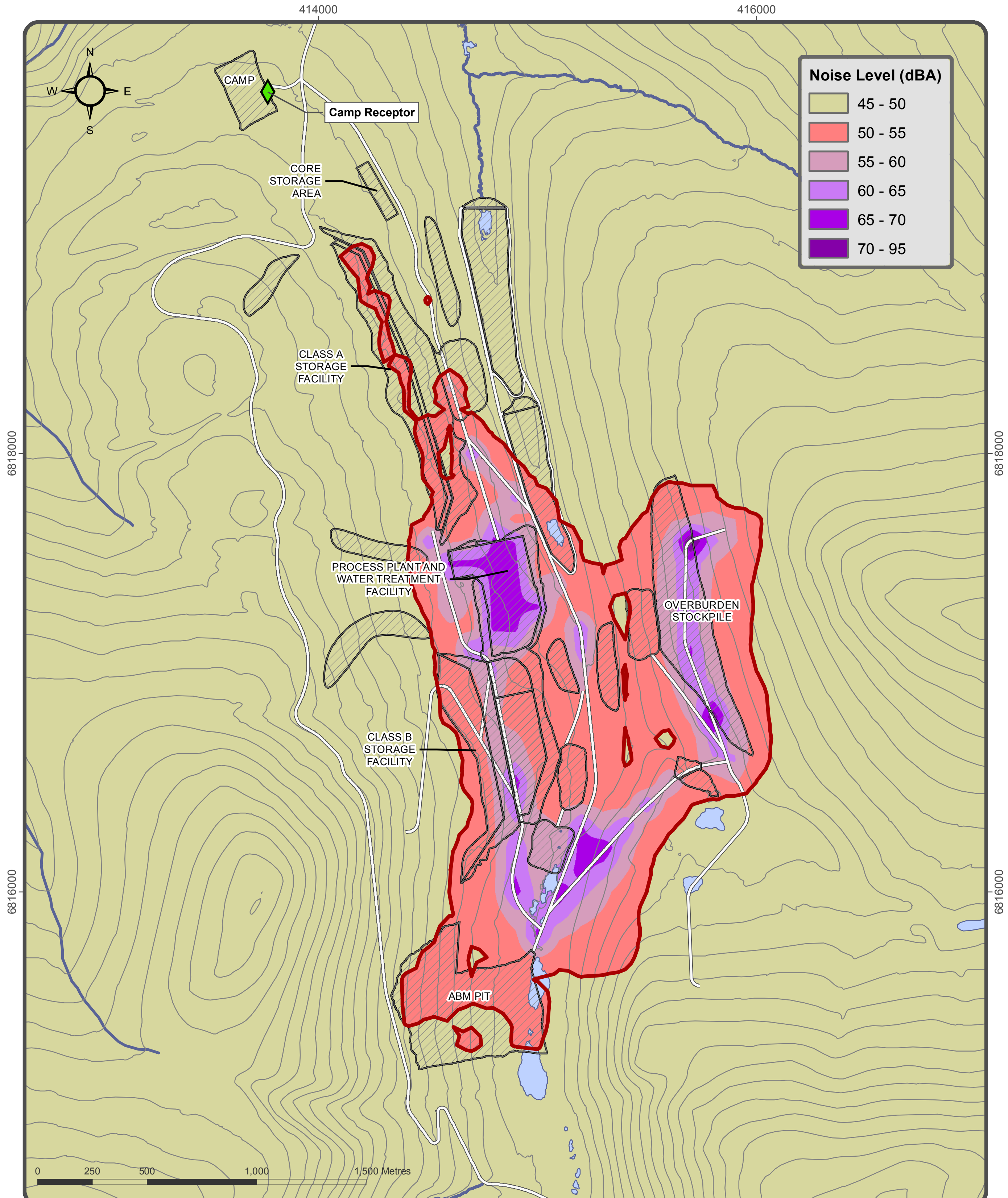
Predicted Project related outdoor noise levels in camp resulting from all the sources listed in Table 4-1 is 34.4 dBA during daytime and 33.9 dBA during night-time.

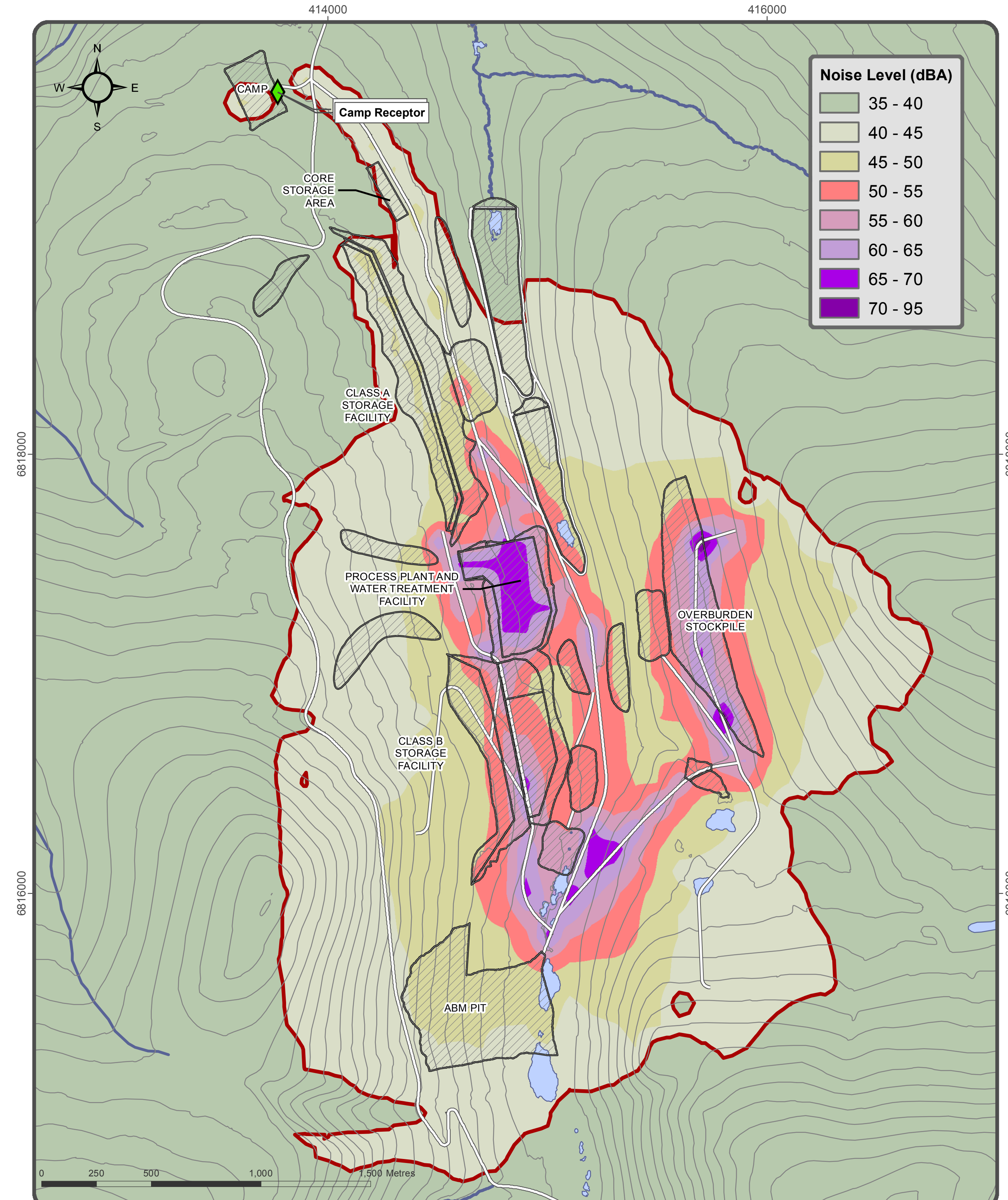
The model results were then added to the baseline levels of 45 dBA during daytime and 35 dBA during night-time to estimate the cumulative noise perceived at the receptor. Because decibels are logarithmic, they were added using the following equation:

$$L = 10\ Log_{10}\left(\sum_{i=1}^{n} 10^{(L_i/10)}\right)$$

Resulting predicted noise at camp (project noise plus baseline) is modelled at 45.4 dBA during daytime and 37.5 dBA during night-time during construction. Both the daytime and night-time predicted noise levels are below their respective BC OGC / ERCB standard, and below Environment Canada's Environmental Code of Practice for Metal Mines (2009) guideline for maximum noise levels in residential areas adjacent to mine sites (45.0 dBA).

Figure 4-2 shows that noise levels could be higher in the immediate area around the process plant facility, however, these noise levels are not comparable to the BC OGC or ERBC standards as they occur in an industrial area. Workers will be equipped with adequate PPE, where required.





Noise Levels Predictions shown on this map were produced with SoundPLAN Essential 3.0

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

AEG

- Noise Receptor
- Standard Noise Level Boundary
- Location of Proposed Mine Footprint (Year One)
- Tote Road/Proposed Access Road and Project Site Roads
- Contour (20 m)
- Watercourse
- Waterbody

Standard Noise Levels:
Daytime - 50 dBA; Night-Time - 40 dBA

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KUDZ ZE KAYAH PROJECT

FIGURE 4-2

CONSTRUCTION PHASE PREDICTED NOISE LEVELS (WITH DESIGN MITIGATIONS)

NOVEMBER 2016

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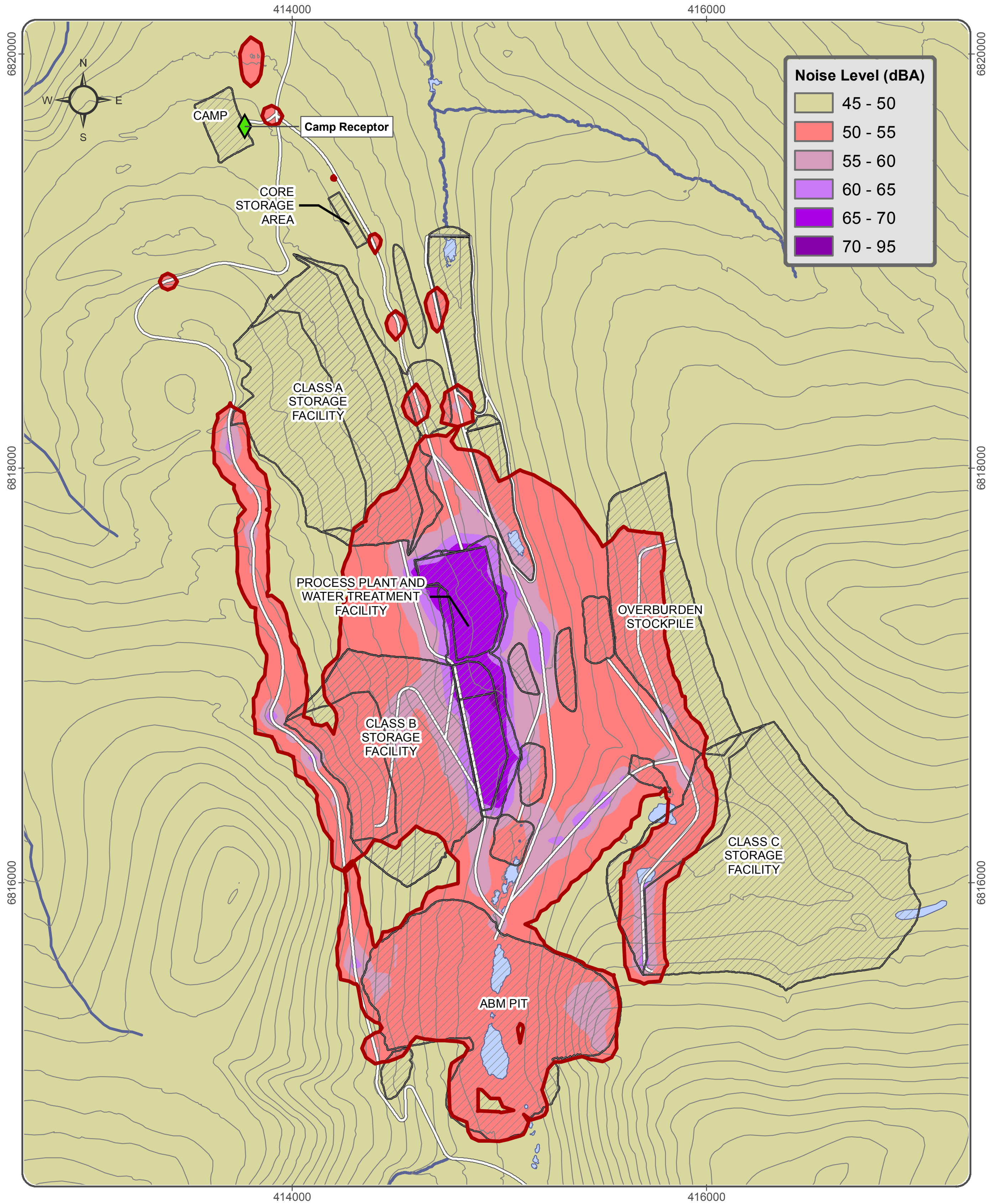
4.2.2 OPERATION PHASE

Predicted Project related noise levels in camp resulting from all the sources listed in Table 4-2 are 37.0 dBA during daytime and 34.2 dBA during night-time. When added to baseline noise levels (of 45 dBA during daytime and 35 dBA during night-time), cumulative noise predicted at the camp receptor is 47.8 dBA during daytime and 42.8 dBA during night-time. The predicted noise level in camp is below the BC OGC / ERCB standard of 50 dBA during daytime and 40 dBA during night-time. Predicted noise levels in camp remain below Environment Canada's Environmental Code of Practice for Metal Mines (2009) guidelines for maximum noise levels in residential areas adjacent to mine sites during both daytime and night-time.

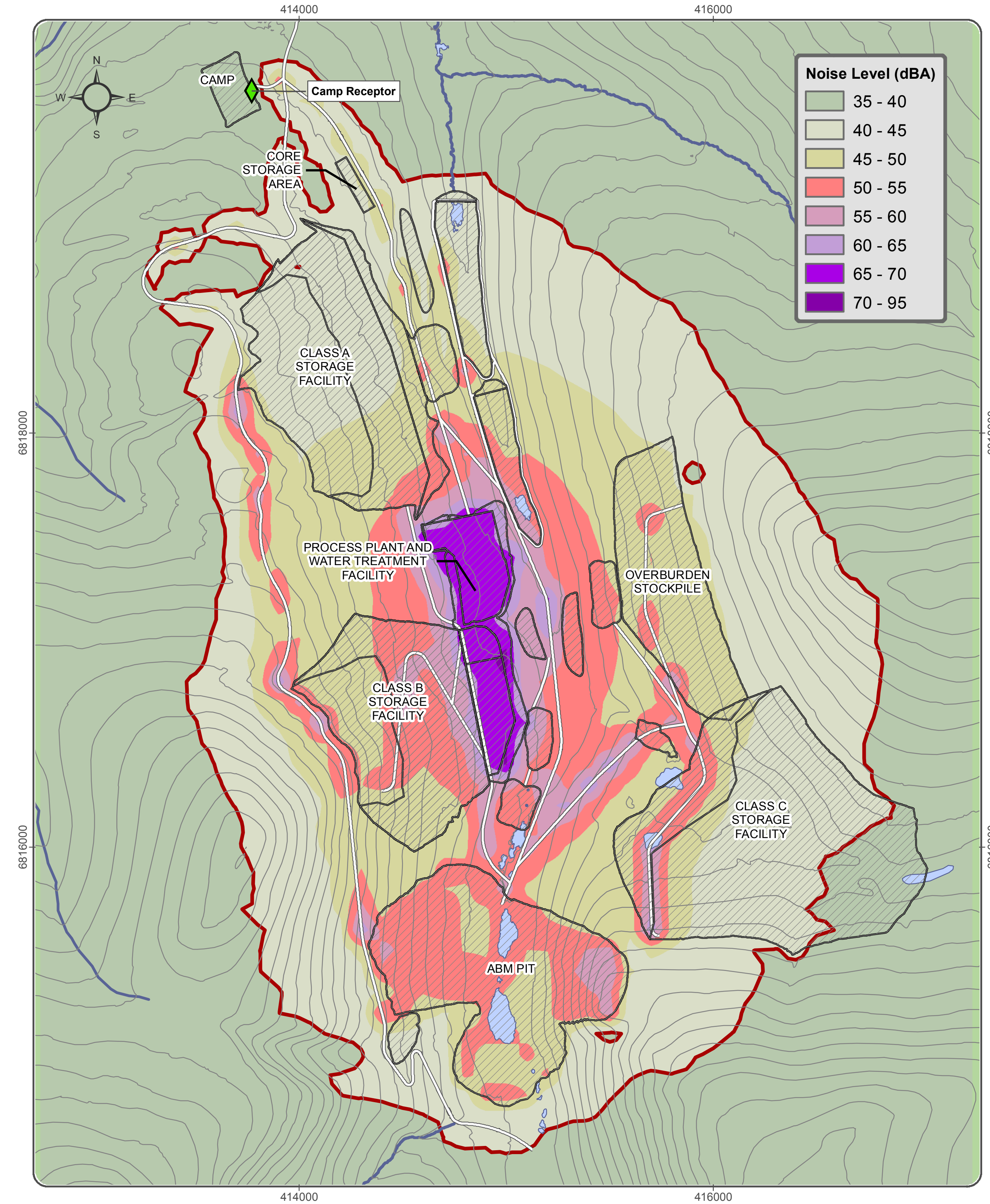
Figure 4-3 shows that noise levels in the immediate area around the process plant facility could be more elevated, however, these noise levels are not comparable to the BC OGC or ERBC standards as they occur in an industrial area. Workers will be equipped with adequate PPE, where required.

Figure 4-4 shows the modelling results over a larger domain, including the access road, and shows the extent of predicted changes in baseline noise levels associated with the Project activities.

DAYTIME



NIGHT-TIME



Noise Levels Predictions shown on this map were produced with SoundPLAN Essential 3.0

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

AEG

- Noise Receptor
- Standard Noise Level Boundary
- Location of Proposed Mine Footprint (Year Ten)
- Tote Road/Proposed Access Road and Project Site Roads
- Contour (20 m)
- Watercourse
- Waterbody

Standard Noise Levels:
Daytime - 50 dBA; Night-Time - 40 dBA

BMC MINERALS

KUDZ ZE KAYAH PROJECT

FIGURE 4-3
OPERATION PHASE PREDICTED NOISE LEVELS (WITH DESIGN MITIGATIONS)

NOVEMBER 2016

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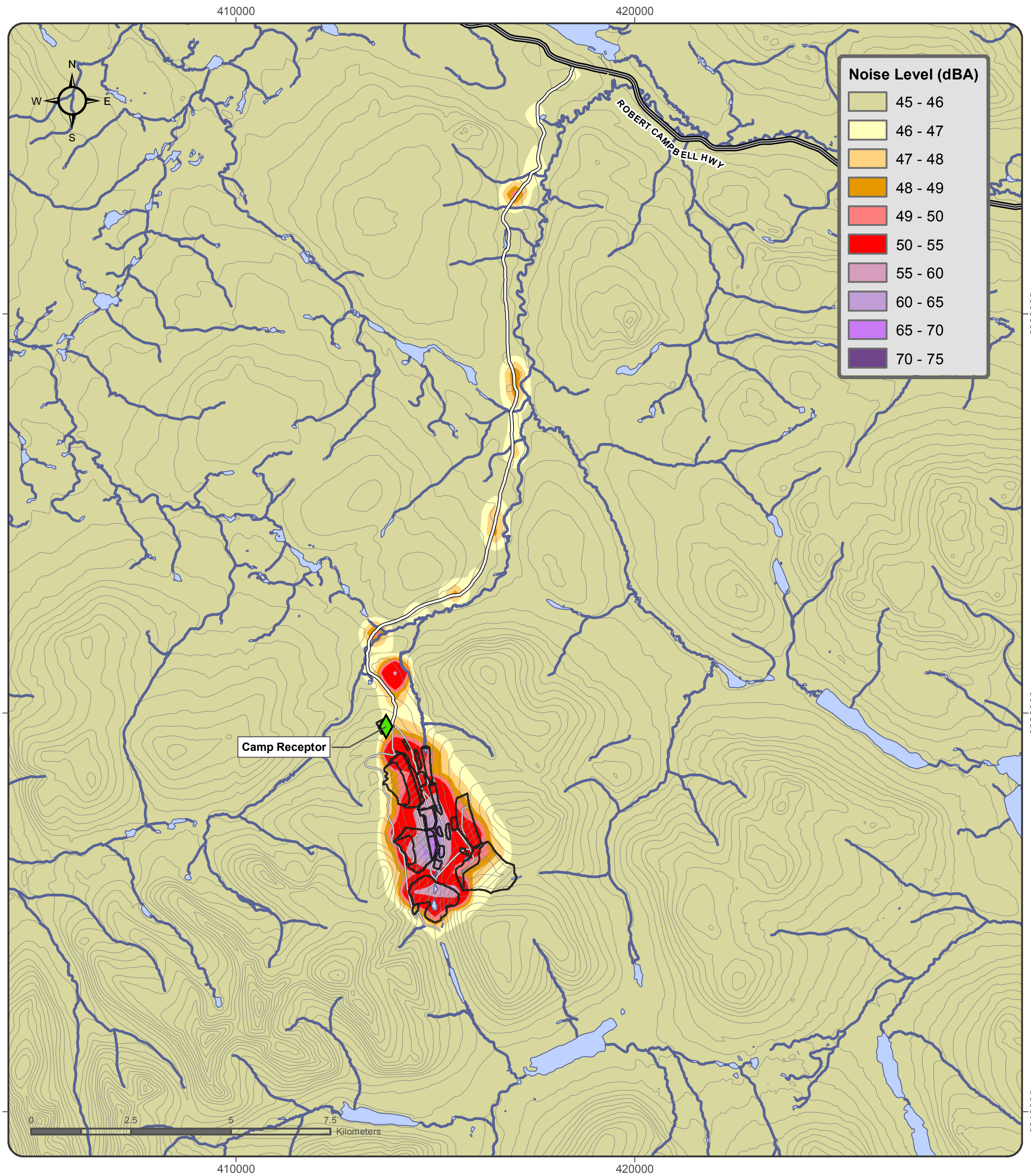

Noise Receptor

Location of Proposed Mine Footprint (Year 10)

Tote Road/Proposed Access Road

Project Site Roads

Contours (40 m)

Watercourse

Waterbody

Standard Noise Levels:
Daytime - 50 dBA

Noise Levels Predictions shown on this map were produced with SoundPLAN Essential 3.0

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

AEG

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FIGURE 4-4

OPERATION PHASE PREDICTED DAYTIME NOISE LEVEL (WITH DESIGN MITIGATIONS) – EXTENDED DOMAIN

NOVEMBER 2016

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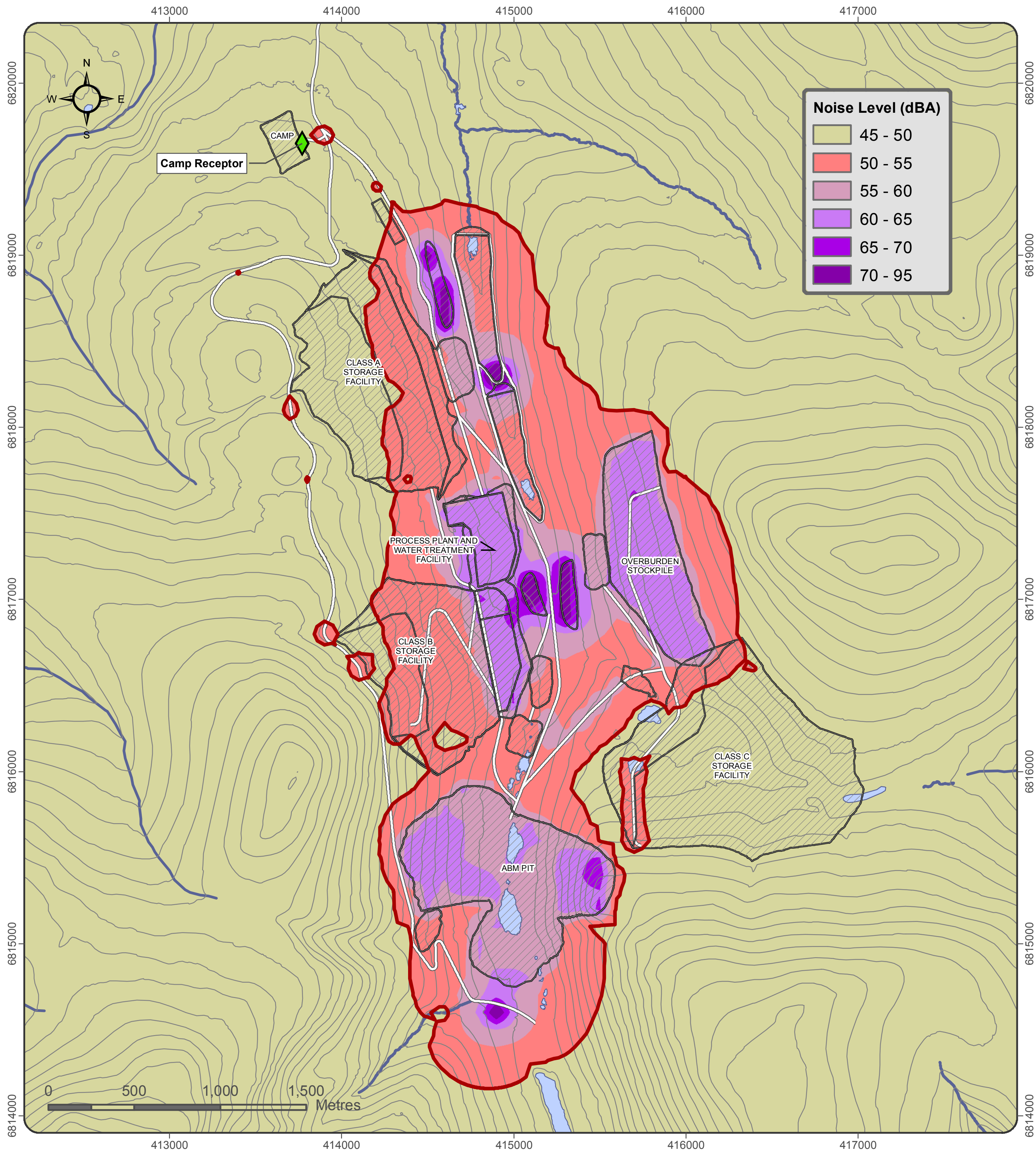
4.2.3 CLOSURE PHASE

The predicted outdoor noise level at camp resulting from all the sources listed in Table 4-3 is 40.2 dBA during daytime (no closure activities are anticipated to occur during night-time). When added to the daytime baseline noise level of 45 dBA, cumulative noise predicted at the camp receptor is 46.5 dBA, which is below the BC OGC / ERCB standard of 50 dBA and Environment Canada's Environmental Code of Practice for Metal Mines (2009) guidelines for maximum noise levels in residential areas adjacent to mine sites.

Figure 4-5 shows that the maximum noise levels are expected to occur in the immediate vicinity of the process plant facility, however, these noise levels are not comparable to the BC OGC or ERBC standards as they occur in an industrial area. Workers will be equipped with adequate PPE, where required.



Noise Receptor

Location of Proposed Mine Footprint (Year 10)

Standard Noise Level Boundary

Tote Road/Proposed Access Road and Project Site Roads

Contour (20 m)

Watercourse

Waterbody

Standard Noise Levels:
Daytime - 50 dBA

Noise Levels Predictions shown on this map were produced with SoundPLAN Essential 3.0

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

AEG

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KUDZ ZE KAYAH PROJECT

FIGURE 4-5

CLOSURE PHASE PREDICTED DAYTIME NOISE LEVELS (WITH DESIGN MITIGATIONS)

NOVEMBER 2016

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4.2.4 BLASTING

Unweighted peak noise levels from blasting were calculated from the empirical prediction formula derived by Linehan and Wiss (1980) for the US Bureau of Mines:

$$P = 6.31\, e^{-B} \left(\frac{D}{W^{1/3}}\right)^{-1.16}$$

where:
P = peak overpressure, in kPa
D = distance from blast to receiver, in m
W = maximum charge weight per delay, kg TNT equivalent
B = scaled depth of burial ($C/W^{1/3}$), in m/kg$^{1/3}$
C = depth to centre of gravity of charge, in m

The constants derived for the above equation vary somewhat between sites, so to obtain conservative predictions, those constants that result in the highest predicted noise levels were used. In addition, as the pit development progresses in a series of 10 m benches, the benches and rock face would act as a sound barrier and resulting noise outside the pit would be attenuated. The loudest stage would therefore occur during the initial pit development, when blasts are located close to the original ground elevation.

Assuming the use of ammonium nitrate (which is typical in mining practices), the average consumption of 9.0 tonnes per day (see Section 4.1.3.4), or 9,000 kg, is equivalent to about 3,780 kg of TNT, based on a relative effectiveness factor of 0.42 (US Army, 1992). Using this value and a charge depth of 10 m, peak overpressure was calculated for distances of up to 5,000 m from the open pit. Peak overpressure (P) can be converted to unweighted sound pressure level (SPL), according to the following equation (AMEC, 2011):

$$SPL = 20 \log P + 154$$

Results are presented in Table 4-4 below.

Table 4-4: Predicted Blasting Noise Levels

Distance (m)	50	100	250	500	1,000	2,000	3,000	4,000	5,000
SPL (dB)	153	146	136	129	122	116	111	109	106

Camp is located between 4,000 m to 5,000 m from the open pit, depending on the exact location of the blast within the pit. Noise from blasting experienced at camp is expected to be below the limit of 120 dB established by the Ontario MoE. This level is expected to be reached at a distance of about 1,280 m from the blast. The level of 128 dB that Environment Canada's Environmental Code of Practice for Metal Mines (2009) recommends not to exceed at or beyond the boundaries of the mine property, is expected to occur at a distance of about 575 m from the blast under the worst case conditions. Therefore, the 128 dB level will not be exceeded at or beyond the property limits.

5 DISCUSSION

To evaluate the effectiveness of the design mitigations incorporated into the model, noise levels were also predicted at the camp receptor assuming no enclosures or shielding, with all other model input kept the same. Table 5-1 below summarizes predicted cumulative (baseline plus the Project related) noise levels without and with these mitigations.

Table 5-1: Summary of Predicted Cumulative Noise Levels at the Camp Receptor (dBA)

Project Phase	Daytime		Night-time	
	No Mitigations	With Mitigations	No Mitigations	With Mitigations
BC OGC / ERCB Standards	50.0		40.0	
Construction	46.8	45.4	42.6	37.5
Operation	46.9	45.6	42.6	37.6
Closure	49.7	46.2	n/a	n/a

Notes: Results represent cumulative levels from Project activities and baseline levels (45.0 dBA for daytime and 35.0 dBA for night-time)
Results in red indicate exceedances of the applicable BC OCG / ERCB standard

These results indicate that enclosures are effective in reducing ambient outdoor noise levels. Prior to the implementation of any design mitigation measures, modelling results predict night-time exceedances of the BC OGC or ERCB standards in camp (sensitive receptor) during the construction and operation phases (but no exceedances of Environment Canada's Environmental Code of Practice for Metal Mines guidelines for maximum noise levels in residential areas adjacent to mine sites). Once mitigations are applied, no exceedances of the BC OGC / ERCB standards are predicted in camp.

In terms of potential effects of predicted noise levels on sleep disturbance, or indoor annoyance or speech comprehension, a building attenuation factor is applied to predicted outdoor noise levels.

> *The WHO's Guidelines for Community Noise (1999) report a threshold for sleep disturbance of an indoor night-time sound level (Ln) of no more than 30 dBA for continuous noise. [...] Unless specified otherwise, it is assumed by Health Canada that an outdoor-to-indoor transmission loss with windows at least partially open is 15 dBA (EPA 1974, WHO 1999). Fully closed windows are assumed to reduce outdoor sound levels by approximately 27 dBA (EPA 1974).* (Health Canada, 2011)

The predicted outdoor night-time noise levels shown in Table 5-1 (with design mitigations), when adjusted for indoor levels using the value of 15 dBA (for windows partially open) fall below the recommended threshold of 30 dBA.

Higher noise levels could occur in the immediate vicinity of the sources during all Project phases. Note that all scenarios modelled were chosen to be very conservative (where all non-continuous sources were assumed to be in operation at the same time and when source specifications were unknown, the loudest option was selected). Also note that only design mitigations were incorporated in the model. Additional mitigations for noise control are discussed in the *Noise Management Plan*, and could contribute to further reduce ambient noise levels. Elevated noise levels in work places (e.g., process plant facility) are assessed against OHS limits rather than ambient standards and will be mitigated with personal protective equipment (PPE) where needed.

Under the loudest scenarios, daytime and night-time noise levels differ from baseline by more than 1 dBA over a maximum extent of approximately 4 km in the East-West direction and 8 km in the North-South direction centered on the Project footprint. One to five dBA is the range of the typical threshold for an increase in sound level that is considered to be “barely perceptible” by the human ear (Health Canada, 2011). A similar threshold is assumed for animals.

6 MODEL LIMITATIONS AND UNCERTAINTY

The overall accuracy of the model predictions depends on the accuracy of the data input and the accuracy of the sound propagation model. In terms of the input data, conservative assumptions were made such as assuming that all non-continuous sources are in operation at the same time. When equipment specifications were unavailable, the loudest acoustical source was selected from the built-in model library.

For traffic related noise, emissions were calculated from estimated traffic volume, road surface, and vehicle speed, according to the US Federal Highway Administration Traffic Noise Model standard. This standard does not provide the option for a gravel or unpaved road surface and results for the average of all roads surfaces were used. At low vehicle speeds (30 km/h was assumed throughout the mine site and 50 km/h on the mine access road), the contribution to the overall road noise level for heavy and medium vehicles is 80% to 90% from propulsion (power unit, cooling fan, transmission) and 10% to 20% from tire/road interaction (Abbott *et al.,* 2010). The relative importance of road surface in the overall traffic noise is therefore low in this case.

In terms of the accuracy of the sound propagation model, one limitation is the chosen model resolution (DGM and calculation grid cell size). A higher resolution could potentially have identified more localized areas of elevated noise levels; however, given the uncertainty on the exact location of some of the sources and the much longer processing time associated with increased resolution, grid cell size of 100 m by 100 m was deemed adequate for the purposes of this modelling exercise.

The modelled scenarios didn’t account for sound attenuation offered by vegetated areas, which can provide an attenuation of about 6 dBA for 30 m of dense spruce (Peng *et al*., 2014). Also, the ISO 9613 model produces results representative of meteorological conditions favoring sound propagation (e.g., downwind or temperature inversion conditions), which do not occur all the time and the model predictions are therefore expected to be conservative. Finally, the ISO 9613 (1993; 1996) sound propagation algorithms have a published accuracy of +/-3 dB over source receiver distances between 100 m and 1,000 m. No estimate of accuracy is provided for distances greater than 1,000 m.

Overall, confidence is high that the model is not underestimating predicted noise levels.

7 CONCLUSION

In conclusion, the noise prediction scenarios modelled for each Project phase indicate that exceedances of standards (BC OGC / ERCB) are not expected to occur at the camp receptors. Design mitigations such as shielding and enclosures are very effective is reducing ambient noise levels. Other than the inclusion of basic design mitigations, the scenarios modelled are conservative in their assumptions, and confidence is high that the model is not underestimating predicted noise levels.

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