MADRID-BOSTON PROJECT
FINAL ENVIRONMENTAL IMPACT STATEMENT

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Glossary and Abbreviations

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

ANFO	ammonium nitrate, fuel oil
A-weighting	The weighting network used to account for changes in level sensitivities as a function of frequency. The A-weighting network de-emphasizes the low frequencies in an effort to reflect the relative response of the human ear to noise.
Attenuation	A reduction in sound or vibration level achieved by various means (e,g., absorption by air, porous materials, barriers).
Background sound (i.e., baseline)	Sound encompassing all sources other than the sound of interest (i.e., sound other than the subject of study)
Barrier	An obstacle on the propagation path of sound (between a source and receiver) that is generally free of gaps within its extent and of sufficient mass to prevent significant transmission of sound through it.
CADNA/A	A computerized version of the algorithms contained in the ISO 9613 standards. This model includes geometrical divergence (distance attenuation), barrier effects due to intervening structures, ground effects, atmospheric absorption, and topography.
dB	decibel
dBA	decibel, A-weighted
DEIS	Draft Environmental Impact Statement
Day-night equivalent sound level (DNL / L_{dn})	A 24-hour equivalent continuous equivalent sound level with a 10 decibel penalty applied to the nighttime period. L_{dn} may also be referenced as DNL.
Daytime	Defined as the hours from 07:00 to 22:00
Daytime equivalent sound level (L_d)	The energy equivalent sound level determined over the daytime period. For the site under investigation it includes periods of respite and periods of work.
Decibel addition	Due to the nature of the decibel scale, the addition of two or more sound pressure levels (SPLs) is performed using logarithmic addition and considering the coherency of the sounds. For incoherent sounds denoted as SPL1, SPL2… SPL_n the addition is performed using the following formula: $SPL1 + SPL2 + \ldots SPL_n = 10 \log (10^{(SPL1/10)} + 10^{(SPL2/10)} + \ldots + 10^{(SPLn/10)})$ As an example: 50 dB + 50 dB = 53 dB

Decibels (dB)	A logarithmic unit used to quantify magnitudes of sound and vibration levels. Decibel (dB is the adopted abbreviation for the decibel) is the unit used to describe sound and noise levels. It is equivalent to 10 times the logarithm (to base 10) of the ratio of a given sound pressure to a reference pressure.
EAAs	Existing and Approved Authorizations
Energy equivalent sound level (L_{eq})	A continuous equivalent (energy-averages) sound level calculated over a specified 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 when describing environmental noise.
FEIS	Final Environmental Impact Statement
Frequency	The number of cycles peer second that a periodic signal such as sound wave oscillates usually expressed in hertz (Hz).
HA	Highly annoyed
HC	Health Canada
hr	hour
Hz	hertz
Hertz (Hz)	The unit of frequency equivalent to a number of cycles per second.
International Organisation for Standardisation (ISO)	An international body that provides scientific standards and guidelines related to various technical subjects and disciplines.
ISO	International Organization for Standardization
km	kilometre
Ld	daytime equivalent sound level
Ldn	day-night equivalent sound level
Leq	energy equivalent sound level
Ln	Night-time equivalent sound level
LSA	local study area
m	metre
Mitigation	Measures taken to reduce, eliminate, or control effects on the environment.
N/A	not applicable
NEF	Noise Exposure Forecast
Nighttime	Defined as the hours from 22:00 to 07:00.
Nighttime equivalent sound level (L_n)	The energy equivalent sound level determined over the nighttime period.
NIRB	Nunavut Impact Review Board
NTKP	Naonaiyaotit Traditional Knowledge Report

Noise	Any unwanted sound. Noise and sound are used interchangeable in this document.
Noise Exposure Forecast (NEF)	System used by Transport Canada to provide a measurement of actual and forecasted aircraft noise. Factors in the subjective reactions of the human ear to specific aircraft stimulus (loudness, frequency, duration, time of occurrence). Predicts community response to aircraft noise.
Noise level	Same as sound level.
Nunami Stantec	Nunami Stantec Ltd.
OSM	Office of US Surface Mining
Octave	The interval between two frequencies having a ration of two to one. The upper limit of an octave (octave band) is twice its lower limit. For example, the 500 Hz octave band has a lower limit of 353 Hz and an upper limit of 707 Hz.
PDA	Project development area
PoI	Point of Interest
PoR	Point of Reception
PPV	peak particle velocity
PWL	sound power level
Peak Particle Velocity (ppv)	The maximum instantaneous positive or negative peak of the vibration velocity signal
Point of Reception	The specific point associated with a receptor location for which effects are assessed.
Predictable Worst-Case Noise Impact	The noise impact associated with a planned and predictable mode of operation for stationary source(s), during the hour when the noise emissions from the stationary sources(s) have the greatest effect at a point of reception, relative to the applicable limit.
RSA	regional study area
Receptor	Any location that may be affected by project noise.
Sound	A wave motion in air, water, or other media. It is the rapid oscillatory compression changes in a medium that propagates to distant points. It is characterized by changes in density, pressure, motion, and temperature as well as other physical properties. Not all rapid changes in the medium are due to sound (e.g., wind distortion on a microphone diaphragm).
Sound level	Generally, sound level refers to the weighted sound pressure level obtained by frequency weighting, usually A- or C-weighted, and expressed in decibels.
Sound power	The rate with which acoustic energy radiates from a source.
Sound power level (PWL)	The total sound energy radiated by a source per unit time. The unit of measurement is Watt. The acoustic power radiated from a given sound source as related to a reference power level (i.e., typically 1E-12 watts, or 1 picowatt) is expressed as decibels. A sound power level of 1 Watt = 120 decibels (dB) relative to a reference level of 1 picowatt.

Sound Power Level (PWL)	This is a measure of the total power radiated by a source per unit time (i.e., rate of acoustical energy radiation). The unit of measurement is the Watt. The acoustic power radiated from a given sound source as related to a reference power level (i.e., typically 1E-12 watts, or 1 picowatt) and expressed as decibels. A sound power level of 1 watt = 120 decibels relative to a reference level of 1 picowatt. The sound power of a source is a fundamental property of the source and is independent of the surrounding environment.
Sound pressure	The root-mean square (RMS) of the instantaneous sound pressures during a specified time interval. The unit of sound pressure is in pascals (Pa).
Sound pressure level (SPL)	The magnitude of sound pressure expressed in decibels. Logarithmic ratio of the root mean square sound pressure to the sound pressure at the threshold of human hearing (i.e., 20 micropascals). The sound pressure level is defined by the following equation where P_o is the reference pressure. In air P_o is usually taken as 2.0 x10^{-5} pascal. $$SPL\ (dB) = 20 \log\left(\frac{P_{rms}}{P_0}\right)$$ The unit for sound pressure level is decibels (dB).
SPL	sound pressure level
TIA	Tailings Impoundment Area
TK	Traditional Knowledge
TK report	Banci, V. and R. Spicker. 2016. Inuit Traditional Knowledge for TMAC Resources Inc. Proposed Hope Bay Project, Naonaiyaotit Traditional Knowledge Project (NTKP). Prepared for TMAC Resources Inc. Kitikmeot Inuit Association: Kugluktuk, NU.
TMAC	TMAC Resources Inc.
tpd	metric tonnes per day
Valued Ecosystem Component (VEC)	Valued Ecosystem Component. Those aspects of the environment considered to be of vital importance to a particular region or community, including: a) resources that are either legally, politically, publically, or professionally recognized as important, such as parks, land selections, and historical sites; b) resources that have ecological importance; and resources that have social importance.

3. Noise and Vibration

The acoustic environment includes noise (unwanted sound) and vibration; it encompasses natural sounds (e.g., bird songs, rustling leaves) as well as anthropogenic sounds (e.g., traffic or industry noise) and vibration. The acoustic environment was selected as a VC for the assessment because noise and vibration from the Madrid-Boston Project have the potential to influence human health and well-being. Project-related activities may result in an increase in sound and vibration levels.

This chapter presents the baseline noise conditions and noise and vibration assessment of potential effects associated with Madrid-Boston Project construction and operation, including consideration of the existing Doris operational noise. The noise and vibration aspects that were warranted for assessment include:

- air-borne noise associated with Madrid-Boston Project mine construction;
- air-borne noise associated with Doris and Madrid-Boston Project mine operation;
- air-borne noise associated with aircraft;
- air-blast overpressures associated with quarry blasting; and
- ground-borne vibration associated with quarry blasting.

The results of this assessment are also directly linked to the studies contained in Human Health and Environmental Risk Assessment (Volume 6, Chapter 5) and the Terrestrial Wildlife and Wildlife Habitat chapter (Volume 4, Chapter 9).

3.1 CHANGES FROM THE DRAFT EIS

Nunami Stantec Limited (Nunami Stantec) was retained by TMAC Resources (TMAC) to update and refine the draft environmental impact study (DEIS) noise and vibration assessment, including refining emissions estimates, modeling assumptions, and re-assessing the Project noise effects. The updated assessment results are considered to be more representative of noise and vibration effects for each phase of the Project. The following provides a summary of the main updates that have been incorporated into the noise and vibration assessment since publication of the DEIS in December 2016:

- Updates in the site plan resulting in changes in source locations.
- Inclusion of assessment scenarios that address the potential for the Madrid North facility to be moved approximately 400-m north of the location assessed in the DEIS (referred to as the reference and alternative locations). The Madrid North facility was assessed in both locations in the FEIS.
- Updates to the mining rate and operating life of the Boston site. The mining rate in the FEIS has increased relative to the DEIS (1600 TPD in the DEIS to 2400 TPD in the FEIS) and the operating life has decreased.
- The number of surface vehicles in the emission inventory will be revised based on the updated mining rate at Boston and required vehicle trips between camps.
- Construction scenarios will include a revised equipment list to be more representative of typical mining construction activities.

- Boston Power Plant – in the DEIS 8 - 1.2 MW units were assumed operating. For the FEIS, only 6 - 1.2 MW units will be operating at any given time, with 2 on stand-by.
- Inclusion of two wind turbines that will supply the power necessary to operate the Doris mill and camp and will be located approximately 2.5 km and 3.0 km south of the existing Doris mill. The Doris Power Plant was conservatively assumed to still operate at maximum capacity. The expected worst case of the three potential alternative location for the turbines (Alternative 3 with the wind turbines almost due west of Roberts Bay) was used in assessment.
- Consideration of the potential noise impacts of siting two wind turbines near the Madrid North site and two wind turbines near the Boston site. These turbines will supply the power necessary to operate the Madrid concentrator and Boston mill and camp. The turbines servicing Madrid North will be located approximately 2 km south of the site, and the turbines servicing Boston will be located approximately 3 km northeast of the site.
- Assessment areas have been refined in the FEIS. For the noise and vibration assessment, this includes a smaller footprint for the local study area and regional study area.
- Use of latest Health Canada guidelines for assessing noise impacts from the Project on human receptors.
- Incorporation of terrain effects (absorption and obstruction due to topography) on noise attenuation.
- Inclusion of a Valued Components Assessment:
    - Refinement to the Definitions for Characterization of Residual Effects and Determinations of Significance.

The Nunami Stantec scope of work included updating the noise and vibration source emissions included in the assessment. This update incorporated refinements to the sound power levels based on updated Project information, sound and vibration propagation prediction methods, updating and refining the acoustic model inputs, running the models and updating the noise modelling results. Analysis and interpretation of the following aspects of the acoustic environment presented in this chapter were outside the scope of the Nunami Stantec updates, and the original assessments were relied upon by Nunami Stantec:

- Incorporation of Traditional Knowledge
- Baseline Ambient/Existing Noise monitoring
- TMAC Consultation and Engagement Informing VEC or VSEC Selection
- Receptor Locations
- Assessment of operational vibration
- Potential interactions between the Madrid-Boston Project and the other identified VECs
- Characterization of Baseline Conditions and Existing Conditions
- Cumulative Effects and Transboundary Effects Assessments

3.2 INCORPORATION OF TRADITIONAL KNOWLEDGE

The Inuit Traditional Knowledge for TMAC Resources Inc. Proposed Hope Bay Project, Naonaiyaotit Traditional Knowledge Project (NTKP) report was reviewed for information related to the current noise environment and baseline noise (Banci and Spicker 2016). There were no direct references relevant to the existing noise environment and noise baseline in the TK report.

3.3 VALUED COMPONENTS

3.3.1 Potential Valued Components and Scoping

Noise is an important environmental factor as a change in the noise environment may adversely affect wildlife, workers and local residents. Noise is defined as any undesirable sound that may irritate people, disturb rest or sleep, cause loss of hearing, or otherwise affect the quality of life of affected individuals.

In addition, noise may negatively affect wildlife causing them to avoid important habitats and/or change their key behaviours such as feeding, breeding or watching for predators, which can ultimately lead to reduced reproduction and increased mortality. Direct effects of high noise levels and shock waves on marine fish include mortality or internal injury (e.g. hearing, bleeding, ruptured swim bladder).

Ground-borne vibration and overpressure generated by blasting events are also important environmental factors as both can cause disturbances to local residents, workers, land users and wildlife. Vibration due to blasting has the potential to cause structural and cosmetic damage to off-site (non-Project) buildings/structures; however, in this circumstance the risk is negligible since the closest settlement is approximately 70 kilometres (km) from the Doris and Madrid-Boston Project sites.

The consultation effort for this Project has identified noise and vibration as a key consideration for stakeholders due to noise associated with Madrid-Boston mine construction; noise associated with Doris and Madrid-Boston mine operation; noise associated with aircraft; overpressures associated with quarry blasting; and ground-borne vibration associated with quarry blasting. Each of these important environmental aspects and stakeholder concerns further validate the rationale for including noise and vibration as a VEC in the EIS.

The scope of the assessment was identified based on regulatory considerations and guidance, professional judgment and community-based consultation.

3.3.1.1 TMAC Consultation and Engagement Informing VEC or VSEC Selection

Community meetings for the Madrid-Boston Project were conducted in each of the five Kitikmeot communities as described in Chapter 3 of Volume 2. The meetings are a central component of engagement with the public and an opportunity to share information and seek public feedback. Overall, the community meetings were well attended. Public feedback (questions, comments, and concerns) about the proposed Project was obtained through open dialogue during Project presentations, through discussions that arose during the presentation of Project materials and comments provided in feedback forms. No questions, comments, or concerns directly related to construction, operational or aircraft noise, or blasting overpressure and vibration were raised.

3.3.2 Valued Components Included in the Assessment

As a result of the scoping process (Volume 2, Chapter 4), noise (including overpressure) and vibration has been selected as a Valued Ecosystem Component (VEC). The Nunavut Impact Review Board (NIRB) has identified Noise and Vibration as a VEC in the publication guidelines for the Preparation of an Environmental Impact Statement for Hope Bay Mining Ltd.'s Madrid-Boston Hope Bay Belt Project (NIRB 2012) (NIRB Guidelines) as these effects may negatively affect land users, local residents, and wildlife. This chapter assesses the potential Project effects related to human receptor locations only. The assessment of Project effects on wildlife can be found in the Terrestrial Wildlife and Wildlife Habitat chapter (Volume 4, Chapter 9).

Measurable parameters have been selected help define and describe the potential effects of the Madrid-Boston Project activities to the environment, including consideration of the existing Doris Operations. Table 3.3-1 summarizes the potential environmental effects of the Madrid-Boston Project on the acoustic environment, the measurable parameters and the rationale for their selection. The Project effects will be assessed by using modeling to predict the noise and vibration levels at the Project receptors. The EIS Guideline requirements have been considered during this assessment along with professional judgement and applicable regulatory guidance.

Table 3.3-1. Potential Environmental Effects and Measurable Parameters for Acoustic Environment

Potential Environmental Effect	Measurable Parameter(s) and Unit of Measurement	Notes or Rationale for Selection of the Measurable Parameter
Change in Noise Levels	Equivalent Sound Level, L_{eq} (dBA) Day-Night Equivalent Sound Level, L_{dn} (dBA)	Requirement parameter by Federal Guidance from Health Canada - Daytime and night time combined (24-hour equivalent) noise level threshold for assessing potential annoyance, or the likelihood of complaints associated with Project Construction and Operational emissions.
	Peak blast overpressure sound level, L_{peak} (dB)	Parameter used to compare with thresholds for blast overpressure during blasting events.
Change in Vibration Levels	Peak Particle Velocity, PPV (mm/s)	Parameter used to compare with thresholds for vibration during blasting events

3.3.3 Valued Components Excluded from the Assessment

Ground-borne vibration associated with the regular construction and operation of Madrid-Boston Project are generally intermittent of continuous in nature. This type of vibration was excluded from the assessment due to their insignificant contribution beyond 50 metres of the project boundary. ERM has reviewed the proposed construction and operational sources associated with the Madrid-Boston Project for their potential vibration effects. This review focused on vibration generating sources, their potential locations and their proximity to receptors. This review has identified that the Madrid-Boston Project activities have little or no potential to generate perceptible vibration levels at off-site human and wildlife receptors. In addition, non-perceptible vibration levels are not known to cause damages to structures. Therefore, the magnitude of impacts would be negligible, if any at all. As such a quantitative study was not considered for vibration from regular construction and operation aspects of the Madrid-Boston Project. Vibration assessment from blasting during both construction and operation has been included in the assessment separately.

3.4 PROJECT OVERVIEW

3.4.1 Project Description

<u>The Doris Project</u>

The Doris Project was approved by NIRB in 2006 (NIRB Project Certificate 003) and licenced by NWB in 2007 (Type A Water Licence 2AM-DOH0713). The Type A Water Licence was amended in 2010, 2011 and 2012 and received modifications in 2009, 2010, and 2011.

Construction of the Doris Project began in early 2010. In early 2012, the Doris Project was placed into care and maintenance, suspending further Project-related construction and exploration activity along the Hope Bay Greenstone Belt. Following TMAC's acquisition of the Hope Bay Project in March of 2013, NWB renewed the Doris Project Type A Water Licence (Type A Water Licence 2AM-DOH1323), and TMAC advanced planning, permitting, exploration, and construction activities. In 2016, NIRB approved an amendment to Project Certificate 003 and NWB granted Amendment No. 1 to Type A Water Licence 2AM-DOH1323, extending operations from two to six years through mining two additional mineralized zones (Doris Connector and Doris Central zones) to be accessed via the existing Doris North portal. Amendment No. 1 to Type A Water Licence 2AM-DOH1323 authorizes a mining rate of approximately 2,000 tonnes per day of ore and a milling throughput of approximately 2,000 tonnes per day of ore. The Doris Project began production early in 2017.

The Doris Project includes the following components and facilities:

- The Roberts Bay offloading facility: marine jetty, barge landing area, beach laydown area, access roads, weather havens, fuel tank farm/transfer station, waste storage facilities and incinerator, and quarry;
- The Doris site: 280 person camp, laydown areas, service complex (e.g., workshop, wash bay, administration buildings, mine dry), two quarries (mill site platform and solid waste landfill), core storage areas, batch plant, brine mixing facilities, vent raise (3), air heating units, reagent storage, fuel tank farm/transfer station, potable water treatment, waste water treatment, incinerator, landfarm and handling/temporary hazardous waste storage, explosives magazine, and diesel power plant;
- Doris Mine works and processing: underground portal, overburden stockpile, temporary waste rock pile, ore stockpile, and ore processing plant (mill);
- Tailings Impoundment Area (TIA): Schedule 2 designation for Tail Lake with two dams (North and South dams), sub-aerial deposition of flotation tailings, emergency tailings dump catch basins, pump house, and quarry;
- All-season main road with transport trucks: Roberts Bay to Doris site (4.8 km, 150 to 200 tractor and 300 fuel tanker trucks/year);
- Access roads from Doris site used predominantly by light-duty trucks to: the TIA, the explosives magazine, Doris Lake float plane dock (previously in use), solid waste disposal site, and to the tailings decant pipe, from the Roberts Bay offloading facility to the location where the discharge pipe enters the ocean; and
- All-weather airstrip (914 m), winter airstrip (1,524 m), helicopter landing site and building, and Doris Lake float plane and boat dock.

Water is managed at the Doris Project through:

- freshwater input from Doris Lake for mining, milling, and associated activities and domestic purposes;
- freshwater input from Windy Lake for domestic purposes;
- process water input primarily from the TIA reclaim pond;
- surface mine contact water discharged to the TIA;
- underground mine contact water directed to the TIA or to Roberts Bay via the marine outfall mixing box (MOMB);
- treated waste water discharged to the TIA; and
- water from the TIA treated and discharged to Roberts Bay via a discharge pipeline, with use of a MOMB.

Hope Bay Regional Exploration Project

The Hope Bay Regional Exploration Project has been renewed several times since 1995. The current extension expires in June 2022. Much of the previous work for the program was based out of Windy Lake and Boston camps. These camps were closed in October 2008 with infrastructure either decommissioned or moved to the Doris site. All exploration activities are now based from the Doris site. Components and activities for the Hope Bay Regional Exploration Project include:

- operation of helicopters from Doris; and
- the use of exploration drills, which are periodically moved by roads and by helicopter as required.

Madrid Advanced Exploration

In 2017, the NWB issued a Type B Water Licence (2BB-MAE1727) for the Madrid Advanced Exploration Program to support continued exploration and a bulk sample program at the Madrid North and Madrid South sites, located approximately 4 km south of the Doris site. The program includes extraction of a bulk sample totaling 50 tonnes from each of the Madrid North and South locations, which will be trucked to the mill at the Doris site for processing and placement of tailings in the tailings impoundment area (TIA). All personnel will be housed in the Doris camp.

The Madrid Advanced Exploration Program includes the following components and activities.

- Use of existing infrastructure associated with the Doris Project:
  - camp facilities to support up to 70 personnel as required to undertake the advanced exploration activities;
  - mill to process ore;
  - TIA;
  - landfill and hazardous waste areas, particularly if closure and remediation becomes required for the Madrid Advanced Exploration Program infrastructure;
  - fuel tank farms; and
  - Doris airstrip and Roberts Bay facility for transport of personnel and supplies.
- Use of existing infrastructure at the Madrid and Boston areas:
  - borrow and rock quarry facilities: existing Quarries A, B, and D along the Doris-Windy all-weather road (AWR);
  - AWR between Doris and Windy Lake for transportation of personnel, ore, waste, fuel, and supplies; and
  - future mobilization of existing exploration site infrastructure, should it become necessary.
- Construction of additional facilities at Madrid North and South:
  - access portals and ramps for underground operations at Madrid North and at Madrid South;
  - 4.7 km extension of the existing AWR originating from the Doris to the Windy exploration area (Madrid North) to the Madrid South deposit, with branches to Madrid North, Madrid North vent raise, and the Madrid South portal;
  - development of a winter road route (WRR) from Madrid North to access Madrid South until AWR has been constructed;

- borrow and rock quarry facilities; two quarries referenced as Quarries G and H;
- waste rock and ore stockpiles;
- water and waste management structures; and
- additional site infrastructure, including compressor building, brine mixing facility, saline storage tank, air heating facility, four vent raises, workshop and office, laydown area, diesel generator, emergency shelter, fuel storage facility/transfer station.

- Undertaking of advanced exploration access to aforementioned deposits through:
  - continue field mapping and sampling, as well as airborne/ground/downhole geophysics;
  - diamond drilling from the surface and underground; and
  - bulk sampling through underground mining methods and mine development.

Boston Advanced Exploration

The Boston Advanced Exploration Project Type B Water Licence No. 2BB-BOS1217 was renewed as Water Licence No. 2BB-BOS1727 in July 2017 and includes:

- the Boston camp (65 person), maintenance shops, workshops, laydown areas, water pumphouse, vent raise, warehouse, site service roads, sewage and greywater treatment plant, fuel storage and transfer station, landfarm, solid waste landfill and a heli-pad;
- mine works, consisting of underground development for exploration drilling and bulk sampling, waste rock and ore stockpiles;
- potable water and industrial water from Aimaokatalok Lake; and
- treated sewage and greywater discharged to the tundra.

3.4.1.1 The Madrid-Boston Project

The Madrid-Boston Project includes: the Construction and Operation of commercial mining at the Madrid North, Madrid South, and Boston sites; the continued operation of Roberts Bay and the Doris site to support mining at Madrid and Boston; and the Reclamation and Closure and Post-closure phases of all sites. Excluded from the Madrid-Boston Project for the purposes of the assessment are the Reclamation and Closure and Post-closure components of the Doris Project as currently permitted and approved.

Construction

Madrid-Boston construction will use the infrastructure associated with Existing and Approved Projects. This may include:

- an all-weather airstrip at the Boston exploration area and helicopter pad;
- seasonal construction and/or operation of a winter ice strip on Aimaokatalok Lake;
- Boston camp with expected capacity for approximately 65 people during construction
- Quarry D Camp with capacity for up to 180 people;
- seasonal construction/operation of Doris to Boston WRR;
- three existing quarry sites along the Doris to Windy AWR;
- Doris camp with capacity for up to 280 people;
- Doris airstrip, winter ice strip, and helicopter pad;

- Roberts Bay offloading facility and road to Doris; and
- Madrid North and Madrid South sites and access roads.

Additional infrastructure to be constructed for the proposed Madrid-Boston Project includes:

- expansion of the Doris TIA (raising of the South Dam, construction of West Dam, development of a west road to facilitate access, and quarrying, crushing, and screening of aggregate for the construction);
- construction of a cargo dock at Roberts Bay (including a fuel pipeline, mooring points, beach landing and gravel pad, shore manifold);
- construction of an additional tank farm at Roberts Bay (consisting of two 10 ML tanks);
- expansion of Doris accommodation facility (from 280 to 400 person), mine dry and administrative building, water treatment at Doris site;
- expansion of the Doris mill to accommodate concentrate handling on the south end of the building facility and rearrangement of indoor crushing and processing within the mill building;
- complete development of the Madrid North and Madrid South mine workings;
- incremental expansion of infrastructure at Madrid North and Madrid South to accommodate production mining, including vent raise, access road, process plant buildings;
- construction of a 1,200 tpd concentrator, fuel storage, power plant, mill maintenance shop, warehouse/reagent storage at Madrid North;
- all weather access road and tailings line from Madrid North to the south end of the TIA;
- AWR linking Madrid to Boston (approximately 53 km long, nine quarries for permitting purposes, four of which will likely be used);
- all-weather airstrip, airstrip building, helipad and heliport building at Boston;
- construction of a 2,400 tpd process plant at Boston;
- all infrastructure necessary to support mining and processing activities at Boston including construction of a new 300-person accommodation facility, mine office and dry and administration buildings, additional fuel storage, laydown area, ore pad, waste rock pad, diesel power plant and dry-stack tailings management area (TMA);
- infrastructure necessary to support ongoing exploration activities at both Madrid and Boston; and
- wind turbines near the Doris (2), Madrid (2), and Boston (2) sites.

Operation

The Madrid-Boston Project Operation phase includes:

- mining of the Madrid North, Madrid South, and Boston deposits by way of underground portals and Crown Pillar Recovery;
- operation of a concentrator at Madrid North;
- transportation of ore from Madrid North, Madrid South, and Boston to the Doris process plant, and transporting the concentrate from the Madrid North concentrator to the Doris process plant;
- extending the operation at Roberts Bay and Doris;

- processing the ore and/or concentrate from Madrid North, Madrid South, and Boston at the Doris process plant with disposal of the detoxified tailings underground at Madrid North, flotation tailings from the Doris process plant pumped to the expanded Doris TIA, and discharge of the TIA effluent to the marine environment;
- operation of a concentrator at Madrid North and disposal of tailings at the Doris TIA;
- operation of a process plant and wastewater treatment plant at Boston with disposal of flotation tailings to the Boston TMA and a portion placed underground and the detoxified leached tailings placed in the underground mine at Boston;
- operation of two wind turbines for power generation; and
- on-going maintenance of transportation infrastructure at all sites (cargo dock, jetty, roads, and quarries).

Reclamation and Closure

Areas which are no longer needed to carry out Madrid-Boston Project activities may be reclaimed during Construction and Operation.

At Reclamation and Closure, all sites will be deactivated and reclaimed in the following manner (see Volume 3, Chapter 5):

- Camps and associated infrastructure will be disassembled and/or disposed of in approved non-hazardous site landfills.
- Non-hazardous landfills will be progressively covered with quarry rock, as cells are completed. At final closure, the facility will receive a final quarry rock cover which will ensure physical and geotechnical stability.
- Rockfill pads occupied by construction camps and associated infrastructure and laydown areas will be re-graded to ensure physical and geotechnical stability and promote free-drainage, and any obstructed drainage patterns will be re-established.
- Quarries no longer required will be made physically and geotechnically stable by scaling high walls and constructing barrier berms upstream of the high walls.
- Landfarms will be closed by removing and disposing of the liner, and re-grading the berms to ensure the area is physically and geotechnically stable.
- Mine waste rock will be used as structural mine backfill.
- The Doris TIA surface will be covered by waste rock. Once the water quality in the reclaim pond has reached the required discharge criteria, the North Dam will be breached and the flow returned to Doris Creek.
- The Madrid to Boston AWR and Boston Airstrip will remain in place after Reclamation and Closure. Peripheral equipment will be removed. Where rock drains, culverts or bridges have been installed, the roadway or airstrip will be breached and the element removed. The breached opening will be sloped and armoured with rock to ensure that natural drainage can pass without the need for long-term maintenance.
- A low permeability cover, including a geomembrane, will be placed over the Boston TMA. The contact water containment berms will be breached and the liner will be cut to prevent collecting any water. The balance of the berms will be left in place to prevent localized permafrost degradation.

3.5 SPATIAL AND TEMPORAL BOUNDARIES

The noise and vibration assessment boundaries were defined in order to assess the effects due to the Madrid-Boston Project initiation at the Project receptors. These boundaries are defined independently for noise and vibration as their analysis and assessment are different from other VECs/VSECs.

The spatial boundaries used for the assessment of noise and vibration from the Madrid-Boston Project and its components were defined based on the extent of the Project and Project-related activities. The boundary around this was selected to capture the potential noise and vibration effects of the Project on the surrounding areas. These effects include noise and vibration from the Madrid-Boston Project, including consideration for the existing Doris operational noise.

The spatial boundaries of the assessment of the Madrid-Boston Project, and its components, were determined on the basis of the Madrid-Boston Project's potential effects on the particular biophysical, social and/or economic environment being addressed. The noise and vibration spatial boundaries considered:

- the physical or socio-economic extent of Madrid-Boston Project activities;
- the extent of ecosystems potentially affected by the Madrid-Boston Project; and
- the extent to which traditional and contemporary land and resource use, including protected areas, and other harvesting activities could potentially be affected by the Madrid-Boston Project.

For noise and vibration, a spatial boundary is defined as the area that could be potentially affected by noise and vibration sources from the Madrid-Boston Project, including consideration for the existing Doris operational noise. Three general spatial boundaries (identified in Figure 3.6-1) were used in the noise and vibration assessment and are further discussed later in Section 3.4.2:

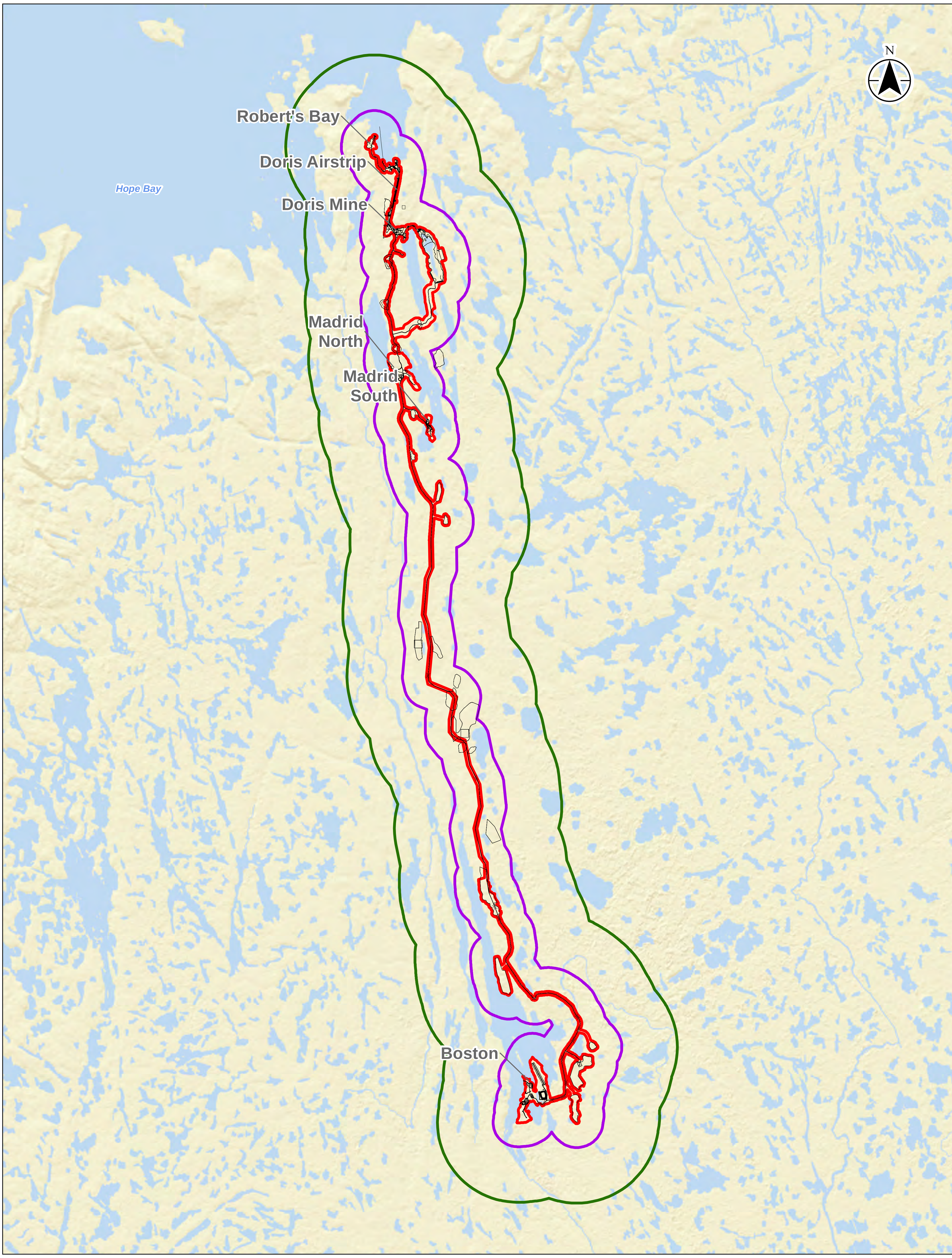
- Project Development Area (PDA) — this boundary is defined as the Madrid-Boston Project Property Line as provided by TMAC.
- Local Study Area (LSA) — The LSA encompasses the area where there is potential for noise and vibration effects (i.e., acoustic effect) to the environment from the Project.
- Regional Study Area (RSA) — a broader area where there is a potential for direct, indirect or cumulative environmental effects.

3.5.1 Project Development Area

The Project Development Area (PDA) is defined for the purpose of this assessment as the property line for the Madrid-Boston Project. The PDA includes engineering buffers around the footprints of structures. These buffers allow for refinement in the final placement of a structure through detailed design and necessary in-filed modifications during the Construction phase. Areas with buildings and other infrastructure in close proximity are defined as pads with buffers whereas roads are defined as linear corridors with buffers. The buffers for pads varied depending on the local physiography and other buffered features such as sensitive environments or riparian areas. The average engineering buffer for roads is 100 m on either side.

3.5.2 Local Study Area

The noise and vibration LSA was defined as that area where there exists the potential for immediate effects due to Madrid-Boston Project activities, ongoing normal activities, or to possible abnormal operating conditions. The LSA defined for acoustic environment extends 1.5 kilometres (km)



Legend

- Project Development Area (PDA)
- Local Study Area (LSA)
- Regional Study Area (RSA)

0 5 10 km

1:250,000 (At Original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 13N
2. Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS User Community

Stantec

Project Location
Hope Bay,
Nunavut

160930343 REVA
Prepared by SPE on 2017-12-11
Technical Review by BCC on 2017-12-11

Client/Project
TMAC - RESOURCES-HOPE BAY
NUNAMI STANTEC LIMITED

Figure No.
3.6-1

Title
Noise and Vibration LSA and RSA Boundaries

from the boundaries of the PDA. This buffer encompasses an area of 299 km^2. Sound and vibration are attenuated by distance as they propagate away from a source, are screened by intervening structures, are absorbed by the ground and atmosphere, as well as attenuated by other mechanisms. Among the Project acoustic effects (i.e., noise and vibration), noise has the potential to propagate to greater distances compared to vibration. Based on the surrounding topography and propagation of sound levels, the 1.5 km LSA represents the area where a change in baseline acoustic environment due to the Project may be expected.

3.5.3 Regional Study Area

The noise and vibration RSA was defined as the area within which there exists the potential for cumulative effects of the Madrid-Boston Project in combination with other past, present or reasonably foreseeable projects or activities are considered. The noise RSA is represented by a 5-km buffer around the PDA. This encompasses an area of 860 km^2. At a distance of 5 km from the PDA, the distance attenuation alone is adequate to reduce the sound pressure level and vibration level from a source to be at or below baseline acoustic conditions and thus the potential for cumulative effects of the Project with other projects or activities beyond 5 km is expected to be negligible.

3.5.4 Temporal Boundaries

The Madrid-Boston Project represents a significant development in the mining of the Hope Bay Greenstone Belt. Even though this Project spans the conventional Construction, Operation, Reclamation and Closure, and Post-closure phases of a mine project, the Madrid-Boston Project is a continuation of development currently underway. The Project has four separate operational sites: Roberts Bay, Doris, Madrid (North and South), and Boston. The development of these sites is planned to be sequential. As such, the temporal boundaries of this Project overlap with a number of Existing and Approved Authorizations (EAAs) for the Hope Bay Project and the extension of activities.

For the purposes of the EIS, distinct phases of the Project are defined (Table 3.5-1). It is understood that construction, operation and closure activities will, in fact, overlap among sites; this is outlined in Table 3.5-1 and further described in Volume 3, Chapter 2 (Project Description).

The assessment also considers a Temporary Closure phase should there be a suspension of Project activities during periods when the Project becomes uneconomical due to market conditions. During this phase, the Project would be under care and maintenance. This could occur in any year of Construction or Operation with an indeterminate length (one to two-year duration would be typical).

Table 3.5-1. Temporal Boundaries for the Effects Assessment for Noise and Vibration

Phase	Project Year	Calendar Year	Length of Phase (Years)	Description of Activities
Construction	1 – 4	2019 - 2022	4	• **Roberts Bay:** construction of access road (Year 1), marine dock and additional fuel facilities (Year 2 – Year 3) • **Doris**: expansion of the Doris TIA and accommodation facility (Year 1) • **Madrid North:** construction of concentrator and road to Doris TIA (Year 1 – Year 2) • **All-weather Road**: construction (Year 1 – Year 3) • **Boston**: site preparation and installation of all infrastructures including process plant (Year 2 – Year 5)

Phase	Project Year	Calendar Year	Length of Phase (Years)	Description of Activities
Operation	5 - 14	2023 - 2032	10	• **Roberts Bay**: shipping operations (Year 1 – Year 14) • **Doris**: processing and infrastructure use (Year 1 – Year 14) • **Madrid North:** mining (Year 1 – 13); ore transport to Doris process plant (Year 1 -13); ore processing and concentrate transport to Doris process plant (Year 2 – Year 13) • **Madrid South:** mining (Year 11 – Year 14); ore transport to Doris process plant (Year 11 – Year 14) • **All-weather Road**: operational (Year 4 – Year 14) • **Boston**: winter access road operating (Year 1 – Year 3) mining (Year 4 – Year 11); ore transport to Doris process plant (Year 4 – Year 6); and processing ore (Year 5 – Year 11)
Reclamation and Closure	15 - 17	2033 - 2035	3	• **Roberts Bay**: facilities will be operational during closure (Year 15 – Year 17) • **Doris**: camp and facilities will be operational during closure (Year 15 – Year 17); mine, process plant, and TIA decommissioning (Year 15 – Year 17) • **Madrid North:** all components decommissioned (Year 15 – Year 17) • **Madrid South:** all components decommissioned (Year 15 – Year 17) • **All-weather Road**: road will be operational (Year 15 – Year 16); decommissioning (Year 17) • **Boston**: all components decommissioned (Year 15 – Year 17)
Post-Closure	18 - 22	2036 - 2040	5	• **All Sites:** Post-closure monitoring
Temporary Closure	Not Applicable	Not Applicable	Not Applicable	• **All Sites:** Care and maintenance activities, generally consisting of closing down operations, securing infrastructure, removing surplus equipment and supplies, and implementing on-going monitoring and site maintenance activities

3.6 EXISTING CONDITIONS FOR THE ACOUSTIC ENVIRONMENT

This section includes a summary of the observed and measured data which was provided by ERM as part of the submitted DEIS (Reference). Portions of the provided data which are relevant to this assessment have been included while the complete provided reports are included in Appendix D of Appendix V4-3A.

3.6.1.1 Data Sources

Noise monitoring was conducted on the Hope Bay Belt in 2007, 2008 (Golder 2007; Appendix C of Appendix V4-3A; 2008) and 2010 (Rescan 2010; Appendix C of Appendix V4-3A) as part of the required studies for the Doris North Gold Mine Project. Anthropogenic noise was present in the Doris Project area in all monitoring years due to activities associated with exploration and development. To describe baseline noise levels for Madrid-Boston Project, only data unaffected by anthropogenic noise are referenced herein. This includes data reported in the 2007 Noise Baseline Report (Golder 2007) and the 2010 Noise Compliance Report (Rescan 2010).

3.6.1.2 Methods

As reported in Golder Associates 2007 and Rescan 2010, noise monitoring surveys performed for the Doris North Mine Project, baseline noise data was collected using Brüel & Kjær Model 2250 sound level meters. Each instrument’s microphone was protected by a wind screen/weather shield and bird spikes, and was positioned vertically upward to eliminate the effect of wind directly on the microphone. Each sound level meter was calibrated before sampling.

Noise Monitoring in 2007

The July 2007 noise survey (Golder 2007) consisted of monitoring at three sites: NM-1, NM-2/3, and NM-4. The locations were selected to characterize areas potentially affected by Doris Project activity, based on their proximity to proposed infrastructure. The 2007 report excluded the influence of helicopter noise from the calculated hourly daytime and night time noise levels to provide an approximation of natural background conditions. Due to significant levels of construction and helicopter noise, NM-1 was found to be an unsuitable monitoring site for measuring baseline noise and was excluded from this characterization of baseline noise environment. Figure 3.2-1 is a map of the Doris and Madrid-Boston projects and the monitoring sites used in the characterization of baseline noise.

Noise Monitoring in 2008

Noise monitoring was conducted in 2008 (Golder 2008) at three sites: NM-1, NM-4, and a new site, NM-5, located approximately 1.5 km northwest of NM-2/3. Due to significant anthropogenic noise at all monitoring sites, the 2008 noise survey year did not provide suitable reference sites for baseline noise and all 2008 data were excluded from this baseline characterization.

Noise Monitoring in 2010

During May and July of 2010 noise monitoring was conducted at 12 locations within a 15 km radius of the Doris Site (Rescan 2010). These locations were selected to characterize areas potentially affected by Doris Project activity, based on their proximity to proposed infrastructure and sensitive wildlife zones (i.e., caribou and raptor habitats).

Due to anthropogenic noise associated with the construction phase of Doris during the 2010 monitoring program, only sites which were not affected by frequent helicopter traffic (i.e., sites influenced by fewer than three flights during the monitoring period) and construction noise were selected to be included in the baseline. These four sites (S14, S15, S16 and S17) are located 12 to 15 km from the Doris Site (refer to Figure 3.8-1) and are included in the noise baseline. Helicopter noise events and noise related to technician deployment at the beginning and end of each monitoring period was excluded from the calculated noise levels at each site. Data recorded at these four locations (S14, S15, S16 and S17) provides an indication of existing noise conditions in the absence of anthropogenic emissions, and in the absence of the Madrid-Boston Project site being assessed.

All applicable locations for monitoring conducted on the Hope Bay Belt in 2007, 2008 (Golder 2007; 2008; Annex B of Appendix V4-3A) and 2010 (Rescan 2010; Annex B of Appendix V4-3A) are shown in Figure 3.6-2. A summary of the monitoring sites utilised for characterizing baseline noise is provided in Table 3.6-1.

Table 3.6-1. Summary of Monitoring Sites for Characterizing Baseline Noise

Site ID	Start Date	Start Time	Duration (hours)	Approximate Distance from Doris	Terrain Type	Plate Number
NM-2/3	July 25, 2007	6:00 AM	27	1 km northwest	Rocky with some vegetation	3.6-1
NM-4	July 25, 2007	10:00 AM	20	3 km southeast	Tail Lake and rock outcrops	3.6-2
S14	May 16, 2010	11:46 AM	24	12 km east and downwind	Snow cover	–
S14	July 26, 2010	4:16 AM	20	12 km east and downwind	Vegetation cover	3.6-3
S15	May 22, 2010	6:00 PM	24	15 km east and downwind	Snow cover	–
S15	July 24, 2010	5:00 PM	24	15 km east and downwind	Vegetation cover	3.6-4
S16	July 24. 2010	1:15 PM	24	15 km east and downwind	Vegetation cover	3.6-5
S17	July 24, 2010	3:00 PM	24	12 km east and downwind	Vegetation cover	3.6-6

Figure 3.6-2
Selected Monitoring Sites for Baseline Noise

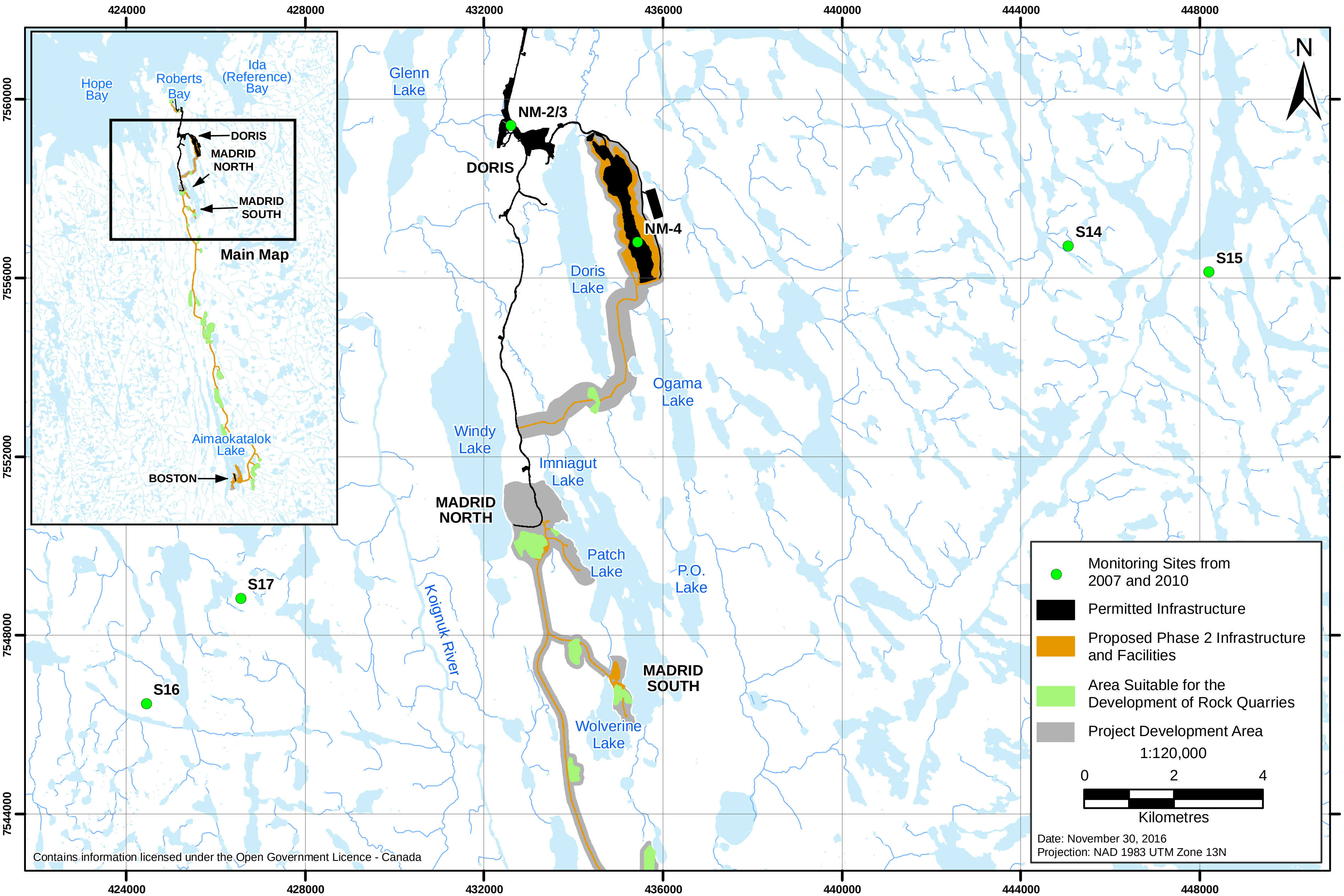


Plate 3.6-1. NM-2/3 Noise Monitoring Station in July 2007.

Plate 3.6-2. NM-4 Noise Monitoring Station in July 2007.

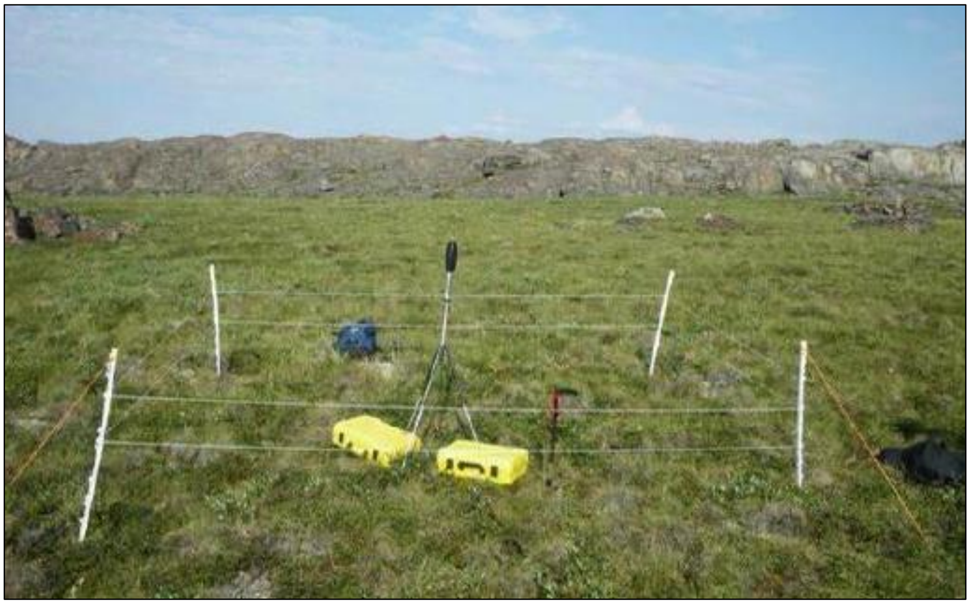


Plate 3.6-3. S14 Noise Monitoring Station in July 2010.

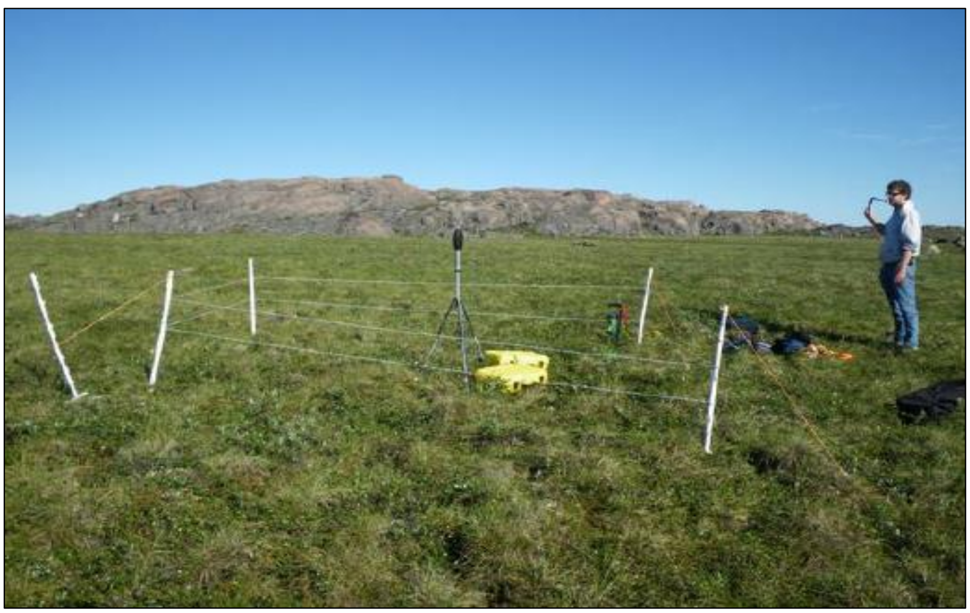


Plate 3.6-4. S15 Noise Monitoring Station in July 2010.

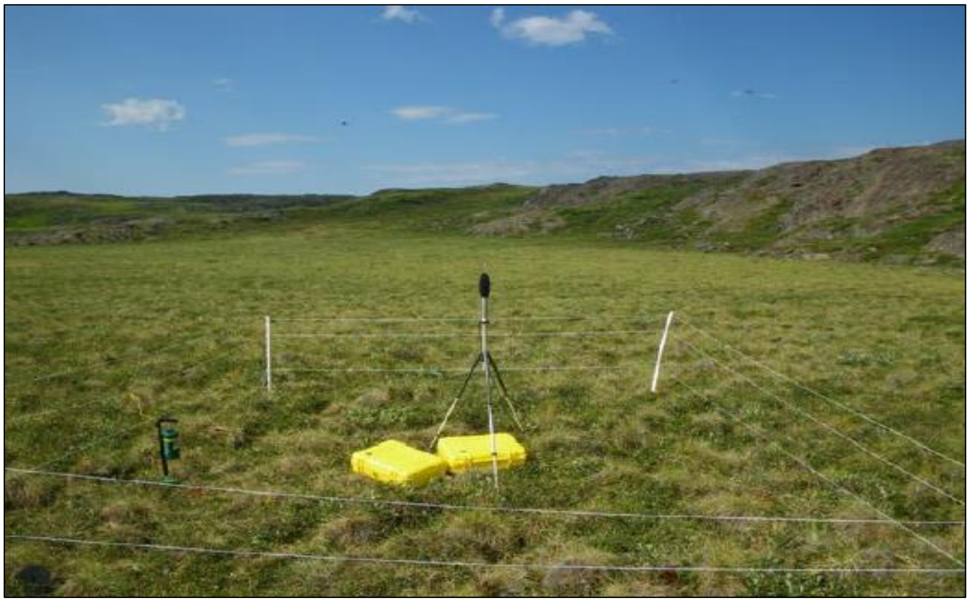


Plate 3.6-5. S16 Noise Monitoring Station in July 2010.

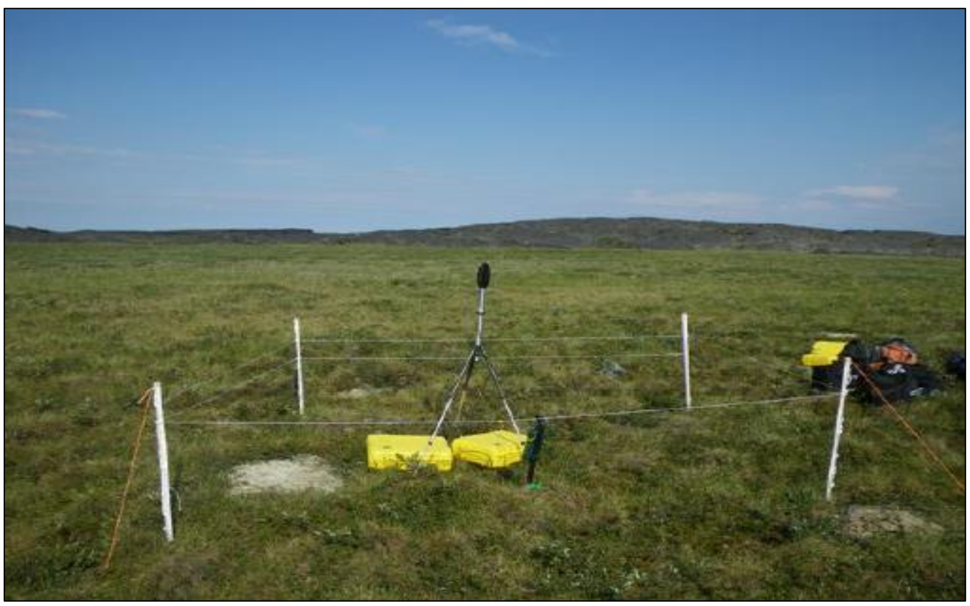


Plate 3.6-6. S17 Noise Monitoring Station in July 2010.

3.6.2 Baseline Noise Metrics

Noise is typically measured as a sound pressure level, in A-weighted decibels (dBA), at a specific location. The A-weighting is designed to match the average frequency response of the human ear. Measurement parameters (in dBA) reported for both the 2007 and 2010 survey periods included the L_{eq} values.

A baseline L_{eq} value for each monitoring site was calculated as the logarithmic average of the recorded hourly L_{eq} values obtained during the survey for the daytime and night time periods. **L_{eq}** is the continuous equivalent (energy average) A-weighted sound pressure level in decibels (dB) over a time period.

Specific L_{eq}-based metrics such as L_d, L_n, and L_{dn} were not reported in the noise monitoring studies of 2007 and 2010. The "L_d" (L_{eq} day) metric is the L_{eq} occurring between the hours of 7:00 am and 10:00 pm, while "L_n" (L_{eq} night) describes the L_{eq} occurring between 10:00 pm and 7:00 am. The "L_{dn}" metric is a 24-hour L_{eq} with a 10 dBA weighting applied to the evening nighttime hours to account for increased sensitivity to noise at night.

Characterizing noise in terms of L_d, L_n, and L_{dn} is important for assessing noise effects because guidelines for human health provide noise thresholds based on these metrics.

3.6.3 Characterization of Baseline Conditions

Eight monitoring events from a total of six monitoring locations were selected from the 2007 and 2010 Doris noise monitoring programs to determine representative baseline noise levels for the Doris and Madrid-Boston Project areas. Sources of natural noise included animals, waves, and frequent winds. Anthropogenic noise included occasional helicopter traffic. Noise associated with this study such as helicopter visits to the site was removed from the data set.

Across the monitoring locations, mean ambient L_{eq} noise levels ranged from 22.9 to 53.3 dBA (see Table 3.6-2). In some cases, the L_{eq} values observed within the Hope Bay Project area exceeded levels assumed to represent the baseline conditions of rural areas, which are approximately 35 dBA during the nighttime and around 45 dBA during the daytime (Alberta AER 2007) or less than or equal to 45 dBA L_{dn} as reported Health Canada Guidelines (Health Canada 2017).

Table 3.6-2. Summary of Baseline Noise Results with Wind Speed

Station	Monitoring Dates	Monitoring Period	Mean L_{eq} (dBA)[1]	Mean Wind Speed (km/h)
NM-2/3	July 25 – 26, 2007	27 h	30.0	19.1
NM-4	July 26 – 27, 2007	20 h	47.2	28
S14	May 15 – 16, 2010	24 h	46.8	20.3
S14	July 24 – 25, 2010	24 h	50.2	30.3
S15	May 23 – 24, 2010	24 h	22.9	11.3
S15	July 24 – 25, 2010	24 h	41.5	32
S16	July 24 – 25, 2010	24 h	53.3	27.4
S17	July 24 – 25, 2010	24 h	48.6	29.2

[1] L_{eq} values are logarithmic means of hourly levels.

In general, mean L_{eq} values increased proportionally with mean wind speed across reference sites (Pearson correlation coefficient: $r = 0.79$). The lowest mean L_{eq} values were recorded at sites NM-2/3 and S15 (May 2010) and correlate with the lowest mean wind speeds experienced at all sites. In contrast, the highest mean L_{eq} values were observed at sites S14 (July 2010) and S17, which were among the sites that experienced the highest mean wind speeds (Table 3.2-2). These baseline noise levels are considered representative of the baseline noise environment consisting primarily of natural noise sources, as rare anthropogenic noise was removed from the overall noise levels reported.

The calculated L_d, L_n, L_{dn} values for each monitoring station are presented in Table 3.6-3.

Table 3.6-3. Summary of Calculated Baseline L_d, L_n, and L_{dn} Noise Levels

Station	L_d (dBA)	L_n (dBA)	L_{dn} (dBA)
NM-2/3	30.3	29.2	35.8
NM-4	48.3	43.9	51.2
S14	48.9	28.5	47.0
S14	51.9	44.2	52.9
S15	23.9	21.1	28.3
S15	41.5	31.7	41.6
S16	46.8	32.9	53.4
S17	50.7	38.6	50.0

3.7 PROJECT-RELATED EFFECTS ASSESSMENT

3.7.1 Characterization of Residual Environmental Effects on Acoustic Environment

Table 3.7-1 summarizes how residual environmental effects are characterized in terms of direction, magnitude, extent, duration, frequency and reversibility. Quantitative measures or definitions for qualitative categories are provided where applicable.

Table 3.7-1. Characterization of Residual Environmental Effects on Acoustic Environment

Characterization	Description	Quantitative Measure or Definition of Qualitatitive Categories
Direction	The relative change compared to baseline conditions.	**Positive** – predicted levels of a measureable parameter do not contribute to an increase or lead to a decrease in sound or vibration levels compared to baseline conditions at any POR. **Negative** – predicted levels of a measureable parameter contribute to an increase in sound or vibration levels compared to baseline conditions at any PoR.
Magnitude	The predicted value of a measureable parameter compared to established thresholds.	**Low** – Project noise or vibration emissions will not exceed applicable criteria. **High** – Project noise or vibration emissions will exceeed the applicable criteria.
Geographic Extent	The geographical area in which the residual environmental effect occurs.	**PDA** – The residual environmental effect is limited to the PDA. **LSA** – The residual environmental effect is limited to the LSA. **RSA** – The residual environmental effect is limited to the RSA.
Duration	The length of time required until the residual environmental effect can no longer be measured or percieved.	**Short -term** – The residual environmental effect is limited to construction or active closure (0-5 years) or for periods of less than one year during operation. **Medium Term** – The residual environmental effect extends through the operating life of the Project. **Long-term** – the residual environmental effect extends beyond closure.
Frequency	Identifies how often the residual effect occurs within a given time.	**Single Event** – the event occurs only once. **Multiple Irregular Event** – the residual environmental effect occurs sporadically, at irregular intervals, without any predictable pattern. **Multiple Regular Event** – The residual environmetnal effect occurs on a regular basis and at regular intervals. **Continuous** – The residual environmental effect occurs continuously.

Characterization	Description	Quantitative Measure or Definition of Qualitatitive Categories
Reversibility	Pertains to whether a measureable parameter of the VC can be returned to baseline conditions after the Project activity ceases.	**Reversibile** – The residual environmental effect is reversed after activity completion. **Irreversible** – the residual environmental effect is permanent and the VC will not return to its baseline condition.

3.7.2 Significance Thresholds for Residual Environmental Effects

An adverse residual effect on the acoustic environment is considered significant if the Project noise or vibration emissions (in any phase) at any identified receptor location exceeds the quantitative limits as shown in Table 3.7-2.

A complete list of the noise and vibration indicators and thresholds is provided in Table 3.7-2. Predicted project noise and vibration levels for each receptor location were compared to these thresholds to qualify potential effects. Discussion and justification for these thresholds is provided in the noise and blast study (Appendix V4-3A). It should be noted that Health Canada guidance distinguishes thresholds for construction noise based on annoyance according to the construction schedule. As detailed in Table 3.7-2, as the construction schedules detail periods of greater than one year, they are assessed against the same thresholds as operational noise.

3.7.3 Methods

To provide a full understanding of the potential effects for the Project, the Madrid-Boston components and activities were assessed as well as in the context of the approved projects (Doris and exploration) within the Hope Bay Greenstone Belt. The process used for this effects assessment process was:

- Identify the main sources associated with the Approved Project and predict existing Project effects according to provided source list at applicable receptors;
- Identify Madrid-Boston Project components and predict Madrid-Boston construction and operational effects at applicable receptors;
- Examine and predict the potential effects from blasting and air traffic;
- Identify mitigation or management measures to eliminate or reduce the potential effects;
- Determine any potential incremental effects between the Approved and Madrid-Boston Project Components;
- Identify residual effects (potential effects that would remain after mitigation and management measures have been applied) for all Project phases; and
- Determine the significance of the combined residual effects.

This noise and vibration study has been completed in accordance with relevant policy, standards and guidelines. The indicators selected above were selected based on professional judgement, current best practices and the following relevant guidance:

- Health Canada – Guidance for Evaluating Human Health Impacts in Environmental Assessment: NOISE (2017).
- International Organization for Standardization (ISO). 1996a. ISO 9613-1, Attenuation of sound during propagation outdoors – Part 1: Calculation of the absorption of sound by the atmosphere. Geneva, Switzerland.

Table 3.7-2. Key Indicators and Thresholds used in this Assessment

Phase	Factor	Receptor Type	Indicator	Applicable Period	Description	Indicator / Threshold	Regulation/Guideline
Construction and Operation	General Noise	Human Dwelling with Sleeping Quarters	L_{AMax}	24 hour	A maximum noise level associated with sources operating at maximum utilization, which could potentially lead to sleep disturbance at night.	56 dBA	Health Canada
			%HA	24 hour	Percent highly annoyed (%HA) measures the percent of population that would issue a complaint based on a statistical analysis of population behavior regarding project-related noise.	6.5%	
		Human Daytime Activities	L_{dn}	24 HR	Noise emitted during day and night weighted over the full day, with a 10 dBA penalty added for night time (22:00 to 7:00) emissions.	62 dBA	Health Canada
Operation	Aircraft Noise	Human	NEF Contour	Daytime	Noise exposure threshold for assessing potential annoyance associated with Project Operational aircraft emissions. NEF25 represents that some annoyance likely, NEF 30 No Development Proceeds	Greater than NEF25	Transport Canada
Blasting	Overpressure	Human	L_{peak}	Any time	Overpressure threshold for assessing potential annoyance due to blasting	120 dbZ	Health Canada
	Vibration		PPV	Any time	Ground-borne vibration threshold	12.5 mm/s	OSM, DIN-4150

- International Organization for Standardization (ISO). 1996b. ISO 9613-2, Attenuation of sound during propagation outdoors – Part 2: General method of calculation. Geneva, Switzerland.
- International Organization for Standardization (ISO). 2003a. ISO 1996-1:2003, Acoustics – Description, measurement and assessment of environmental noise - Part 1: Basic quantities and assessment procedures. Geneva, Switzerland.
- World Health Organisation (WHO), Geneva - *Guidelines for Community Noise* (2009).

3.7.4 Potential Effects and Interactions with Project

An interaction matrix summarizing the potential interactions with noise and vibration and the Madrid-Boston Project is provided in Volume 2, Chapter 4. Table 3.7-3 presents the key components of the Madrid-Boston Project and the potential interaction with noise and vibration indicators. An overview of each phase as relevant to noise and vibration is also provided below.

Noise sources introduced by the Madrid-Boston Project may also increase noise levels at wildlife receptors and result in loss of habitat and wildlife disturbance. These potential effects are discussed in the Terrestrial Wildlife and Wildlife Habitat chapter (Volume 4, Chapter 9).

3.8 ASSESSMENT OF RESIDUAL ENVIRONMENTAL EFFECTS ON THE ACOUSTIC ENVIRONMENT

The noise and vibration study was completed in accordance with the following methods:

- **General Construction and Operation Noise:** The predictive analysis was performed using the commercially available software package CADNA/A, a computerized version of the algorithms contained in the ISO 9613-1 and 9613-2 standards. This model includes geometrical divergence (distance attenuation), barrier effects due to intervening structures, ground effects, atmospheric absorption, and topography. The model considers a downwind condition, in which for the purpose of analysis the wind direction is always from each source location to each POR location.
- **Maximum Noise:** Maximum noise levels were estimated based on worst-case scenarios of all vehicles operating on site simultaneously, including vehicle pass-bys.
- **Aircraft Noise:** Transport Canada NEF Contour Software in conjunction with CADNA/A was used to calculate the potential noise effect of air traffic.
- **Blasting:** Bureau of Mines prediction formulas were used to predict air-blast overpressure and ground-borne vibration levels for blasting during construction (AWR) and operation (mines). These equations take into account site factors, maximum explosive charge per delay and distance propagation. Calculations were based on provided explosives usage data for the Projects.

3.8.1 Points of Reception

The points of reception (PORs) for this study were determined by ERM using GIS analysis of spatial data (site layout, known dwelling/property boundaries, known habitat regions, etc.). Based on this analysis, 12 locations were identified as potential human PORs within the RSA. These locations are shown in Figure 3.8-1. Wildlife receptors identified by ERM within the RSA are presented and discussed in the Terrestrial Wildlife and Wildlife Habitat chapter (Volume 4, Chapter 9).

Table 3.7-3. Potential Madrid-Boston Project Interactions with the VEC Noise and Vibration

		Effects on Humans						
		Sleep disturbance	Interference with speech communication	Complaints	High annoyance	Noise induced rattling	Noise induced hearing loss	Cosmetic and structural damage to buildings
Construction	Surface mine, mill and accommodation facility construction (as applicable to Madrid North and South, Boston)	X		X	X			
	Cargo Dock construction at Doris	X		X	X			
	Local site roads, Boston airstrip, equipment laydown areas, pad areas construction	X		X	X			
	Tailings expansion at Doris	X		X	X			
	Road Transport (light and heavy vehicles associated with construction, personnel or goods)	X		X	X			
	Air Transport (Doris and Boston Airstrips)	X		X	X			
Operation	Surface mine, mill and accommodation facility operation (as applicable to Madrid North and South, Boston)	X		X	X			
	Cargo Dock use at Doris	X		X	X			
	Quarry use and activity	X		X	X			
	Local site roads, equipment laydown areas use and operation	X		X	X			
	Road Transport(light and heavy vehicles associated with construction, personnel or goods)	X		X	X			
	Air Transport (Doris and Boston Airstrips)	X		X	X			
Reclamation and Closure	Surface mine, mill, tailings and accommodation facility closure (as applicable to Madrid North and South, Boston)	X		X	X			
	Cargo Dock closure at Doris	X		X	X			
	Local site roads, Boston airstrip, equipment laydown areas, pad areas closure	X		X	X			
	Road Transport (light and heavy vehicles associated with closure, personnel or goods)	X		X	X			
	Air Transport (Doris and Boston Airstrips)	X		X	X			

Four of the 12 locations were identified as worker accommodations associated with the Project, and were therefore not required to be part of the assessment. Six of the 12 locations are associated with daytime land uses, including hiking, hunting and fishing. Two of the 12 locations have been identified by ERM as cabins. While the exact activities at these cabins are unknown, for the purposes of the assessment, they were assumed to be potentially used as sleeping quarters. The 8 human receptors identified within the RSA included in the effects assessment are listed in Table 3.8-1.

Table 3.8-1. Human Receptors within the RSA

Point of Reception ID	Receptor Type	UTM13 (NAD 83) Coordinates (m)		Elevation (m)	Distance to Nearest Project Infrastructure (m)	Closest Project Area
		Easting	Northing			
R_H-C1	Cabin	435299	7562924	11.2	2,106	Doris
R_H-C2	Spring and Summer Camp	436579	7569440	7.0	4,950	Roberts Bay Vessel Passage
R_H010	Human Receptor (non-habitation)	437052	7520536	62.4	2,105	Madrid-Boston Road
R_H011	Human Receptor (non-habitation)	439356	7510386	74.8	1,058	Madrid-Boston Road
R_H012	Human Receptor (non-habitation)	440418	7503938	69.0	826	Boston
R_H-F2	Recreational Fishing Area	443743	7507934	82.7	485	Madrid-Boston Road
R_H-F3	Recreational Fishing Area	435464	7560803	12.6	156	Doris
R_H-H1	Hunting Area	443076	7504032	86.5	1,781	Madrid-Boston Road

3.8.2 Modeling Scenarios

The Environmental Noise and Vibration Study Report (Appendix V4-3A) considered all phases of the Madrid-Boston Project, including existing Doris operation noise. A review of the Madrid-Boston Project schedule and associated activities was conducted during the set-up of the acoustic model. The planned project (temporal boundaries Section 3.6.4) was examined for time periods in which the highest acoustic emissions may be produced during these phases. Due to the parallel development of the new sites and simultaneous mining operations, several construction/operation scenarios were assessed.

The Environmental Noise and Vibration Study Report (Appendix V4-3A) includes a discussion of the modelling scenarios included in the assessment as representative of the expected 'worst-case' acoustical effects. The project description and current operation of the Doris Site was used to compile lists of appropriate activities and equipment usage for each scenario. The modelled scenarios are as follows:

- Project Construction, including:
  - Construction of Madrid-Boston Cargo Dock at Roberts Bay, including existing (Doris Project) operations;
  - Construction of an expanded accommodations at Doris including existing (Doris Project) operations;
  - Alternate and Preferred construction noise from Madrid North;
  - Construction noise from Madrid South;
  - Construction noise from Boston;
  - Construction of the Doris TIA Dams;
  - Construction at Quarry D; and
  - Road traffic and construction during construction at the above sites.

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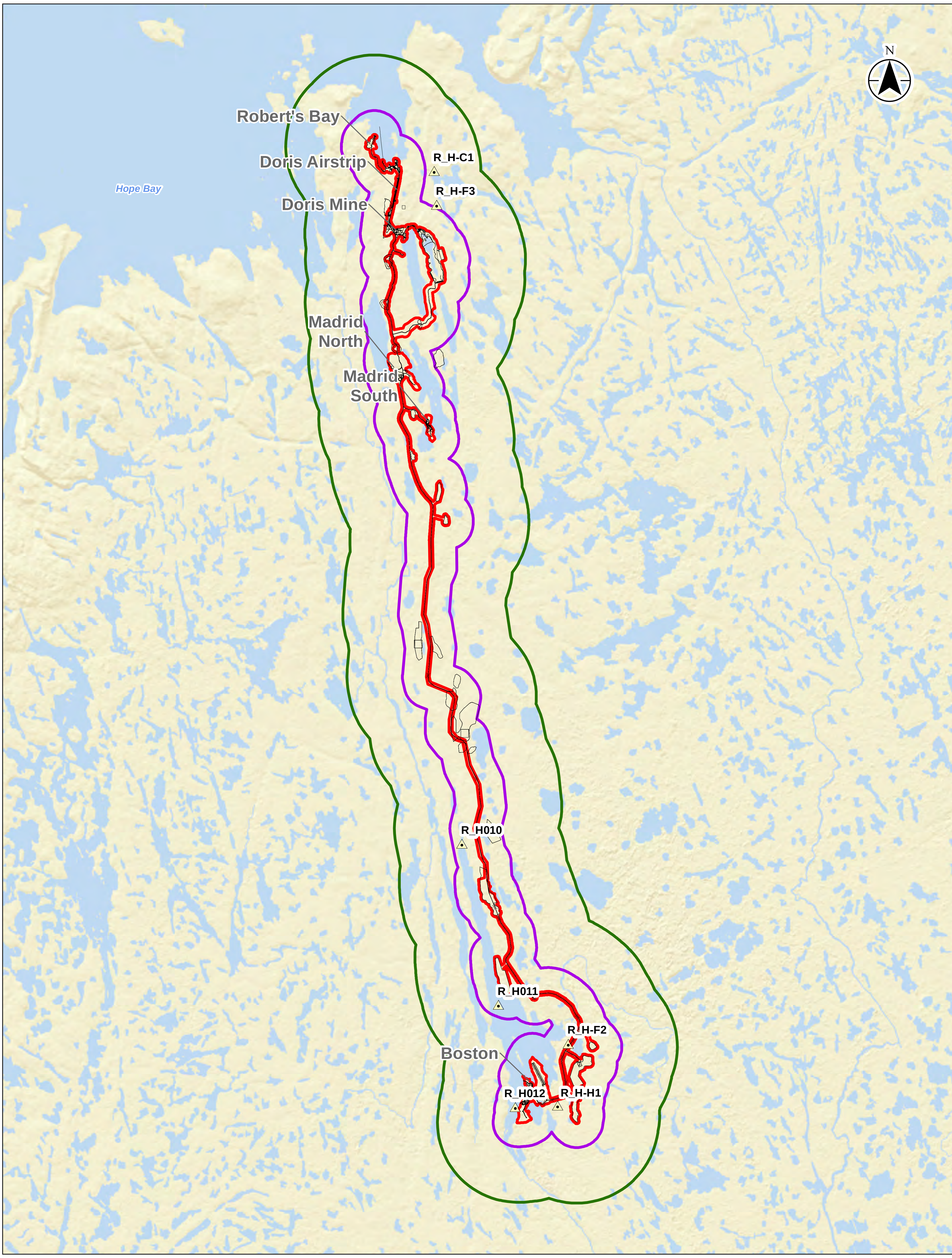

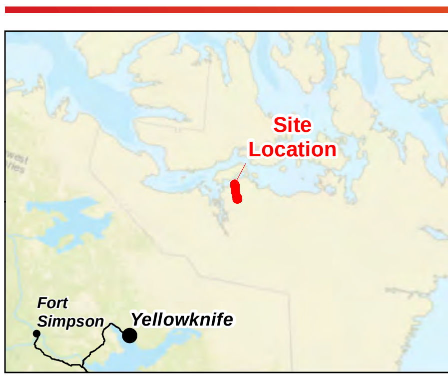

Legend

- Human Receptor
- Project Development Area (PDA)
- Local Study Area (LSA)
- Regional Study Area (RSA)

0 5 10 km

1:250,000 (At Original document size of 11x17)

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Project Location
Hope Bay,
Nunavut

160930343 REVA
Prepared by SPE on 2017-12-11
Technical Review by BCC on 2017-12-11

Client/Project
TMAC - RESOURCES-HOPE BAY
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Figure No.
3.8-1

Title
Human Receptors Located within the RSA

Notes
1. Coordinate System: NAD 1983 UTM Zone 13N
2. Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS User Community

- Project Operations, including:
  - Operation of Madrid-Boston Cargo Dock at Roberts Bay;
  - Future processing operations at Doris after mine closure;
  - Operation noise from Madrid North, including the processing plant, power plant, air compression and fans, and mobile equipment such as dozers, haul trucks, forklift, graders, and fuel trucks;
  - Operation noise from Madrid South, including power generation and air compression, and mobile equipment such as dozers, haul trucks, forklift, graders, and fuel trucks;
  - Operation noise from Boston, including the processing plan, power plant, air compression and fans, and mobile equipment such as dozers, haul trucks, forklift, graders, and fuel trucks;
  - Road traffic between the mine sites and other areas, including Roberts Bay or the Tailings Impoundment Area;
  - Blasting noise and vibration from quarrying;
  - Wind Turbine noise from the operation of wind turbines near Doris, Madrid North, and Boston; and
  - Aircraft noise from the Doris and Boston airstrips from the operation of fixed wing aircraft and helicopters.

Based on the Project Schedule, the predicted effects from these scenarios are considered representative of the highest noise and vibration emission levels.

The potential noise effects during Reclamation and Closure, Post-closure and other potential phases, such as Temporary Closure, are expected to be less than during the Construction and Operation phases. The assessment results and discussion related to the Construction phase of the Project are also applicable to these phases. Therefore, no further discussion of these phases is included in the assessment.

Crown pillar recovery will be utilized at the Madrid North and Boston sites at locations within the PDA where ore is at or near surface. The process entails removing overburden by way of an excavated trench at surface, and collapsing the ore into the underground workings with underground blasting methods. The ore is then mucked out from the underground void and the trench is backfilled with waste rock and overburden. Crown pillar recovery at both sites will occur in localized areas of the PDA and is anticipated to be of short duration (several months) after which the area is backfilled and reclaimed at surface. The noise and vibration effects due to this process are expected to be similar or less in magnitude than blasting of the Portal entrance (and would not occur concurrently) and therefore was not explicitly included in the noise and vibration assessment.

3.8.2.1 Construction Noise

Site preparation and construction phases of the Project include a wide assortment of construction equipment and machinery as well as marine traffic and road traffic between the different Project locations. Earth moving equipment including excavators, dozers, graders, and loaders will be required for preparation of the surface infrastructure, including the portal, vent raises, and buildings. Additional equipment will be used to erect permanent structures, including forklifts, and elevated work platforms. Support vehicles, including pickup trucks, passenger vans, water and fuel trucks and RTVs will also be used to move people and supplies to the construction sites.

A representative source list was developed based on a reasonable number of mobile equipment units expected to be used for the applicable Project phase. Not all construction equipment is expected to be used at the same time for the entire duration, and therefore the assessment includes an estimated utilization rate for each of the sources that are not expected to operate continuously.

Construction at Doris and Roberts Bay is expected to occur while mining and shipping activities continue. The acoustic model for construction activities at Doris and Roberts Bay therefore includes the ongoing operations for mining and processing such as ore stockpiling and handling, processing plant activities, power generation, air handling to the underground mine, waste management, and support vehicle operations for supplies and personnel.

The noise levels due to the Project construction activities were predicted using a computerized noise model at all receptors within the RSA.

3.8.2.2 Construction Blasting

There are approximately twenty areas which have been identified as suitable for the Development of Rock Quarries for the purpose of constructing the AWR. This scenario represents blasting analysis during the Construction phase. These quarries would not be used simultaneously, but sequentially as the construction of the road progresses. Potential overpressure and ground-borne vibration levels were predicted using vibration propagation modelling for the construction of the AWR and were based on a predictable worst case scenario and GIS analysis to establish the zone of influence around each potential quarry. For the Quarry blasting, TMAC provided that 1000 kg/day of blasting agent (ANFO, ammonium nitrate, fuel oil) will be used with three blasts occurring per day. The daily amount of explosive used for the quarry location along with the approximate blasts per day and number of holes was used to determine the predicable worst case scenario. Further information regarding this analysis can be found in the Environmental Noise and Vibration Study Report in Appendix V4-3A.

3.8.2.3 Operational Noise

The operation scenarios included in the assessment were based on times where production rates were highest and therefore represent the potential for the highest noise and vibration effects within the spatial boundaries. Current equipment and operational information was used as inputs to the acoustic model representing the existing noise sources at Doris. Equipment lists and operational information for the existing Doris mine were used to predict the relevant noise and vibration sources at the other sites for the Project operating at different production rates. In addition to material handling and support vehicle activities that are similar to those required during construction, noise from operations also includes air handlers for the underground mines, raw ore stockpiling and handling, ore processing (at Madrid North and Boston), and power generation. Complete source lists and details can be found in the Environmental Noise and Vibration Study Report (Appendix V4-3A). The residual noise effects due to Project operation was assessed for each identified scenario and was used to determine any required mitigation and/or noise management procedures.

3.8.2.4 Operational Blasting

A predictable worst case was assumed to be the point at which blasting activities occurred nearest to the surface. As the mine operation progresses, the mine would be underground and therefore the effects would be more limited and shielded from the surrounding receptors. The portal locations and raised vent locations were used as reference points in determining a zone of influence as these would be the areas where the blasting could be experienced nearest the surface.

A predicable worst case blasting scenario was determined from provided daily explosive amounts and blasting information. Table 3.8-2 shows the amount of blasting agent (ANFO) to be used per day at each site. Of the four mines active during the phases of this Project, the predicable worst case was used as the scenario with the highest amount of explosive per blast. This maximum blasting scenario was used along with the locations, number of daily blasts and the amount of blasting agent per blast for the analysis. Bureau of Mines prediction methods were then used to model this scenario and determine a zone of influence for potential over pressure and ground-borne vibration levels for all mines. The zone of influence is the distance at which the defined compliance limit of 120 dB for noise and 12.5 mm/s for vibration is predicted. This analysis results in the zone of influence for each of these locations represents the predicable worst case as it is likely that not only will the amount of explosive be lesser than the maximum, but the blast location will continue to be further from the surface as the Project continues. Further information regarding this analysis can be found in the Environmental Noise and Vibration Study Report in Appendix V4-3A.

Table 3.8-2. Blasting Details for Mines

Mine Site	# of Blasts per Day	Amount of ANFO per day (kg/day)
Doris, underground. Emissions out of mine portal	7	3,070
Madrid North, underground. Emissions out of mine portal	7	6,420
Madrid South, underground. Emissions out of mine portal	7	3,370
Boston, underground. Emissions out of mine portal	7	4,815

3.8.2.5 Aircraft

The analysis of potential noise effects from the aircraft traffic associated with the Project was assessed using Transport Canadas NEF software. This software includes a database of sound information for many potential aircrafts and requires inputs such as runway coordinates, flight paths and aircraft movements. The runway coordinates were input from existing data and the proposed Boston airstrip design documents. Standard aircraft operating procedures were assumed from background data and include a 3-degree approach angle.

For the Doris airstrip, the aircraft used were provided as Boeing 737-200 and Bombardier Dash 8. The Doris airstrip is described as accommodating air traffic of each of these aircraft four times per week. As a predictable worst case assessment of the potential noise effect of this activity, each aircraft was assumed to land and take off once per day. For completeness, as the direction of approach or take off is not known, the analysis also includes one landing and take-off for each aircraft in the other direction per day.

For the Boston airstrip, the design included usage by the Boeing 737-200 Jet and Dash 8 Turbo propeller as well as a Lockheed Hercules C130. As with the Doris airstrip, the traffic at this airstrip is described as flights four times per week per aircraft. For modeling purposes, the modelled scenario for one day includes one takeoff and landing per aircraft. As with Doris, the preferred direction of landing and takeoff is not known so the modelling includes an additional daily flight for each aircraft in the other direction.

Modelling outputs for these scenarios include isopleths displaying the NEF contours for the airstrips and are included in this chapter. Further details regarding the airstrip traffic and modelling methods can be found in the Environmental Noise and Vibration Study Report in Appendix V4-3A.

The analysis of helicopter traffic was broken into two scenarios as provided by TMAC. The first is considered a base case and includes general traffic at the Doris and Boston Helipads, Commuting between the two helipads and transporting equipment for summer drilling at a specified location from the Boston helipad. The modelled base case scenario includes:

- four flights from each helipad and travel representing general activity around each helipad;

- four flights each from Doris and Boston and travel between the sites representing commuting between the sites; and
- the delivery and return of the equipment to the summer drilling site once per day for summer drilling.

The second scenario represented for completeness is a summer drilling support scenario and includes transporting equipment from Doris, Boston and Windy helipads to additional drilling sites. These nine sites were provided by TMAC and have been conservatively modelled 5/9 sites being supported in one day.

Each of these was modelled in CADNA/A to provide an Ldn value which can then be compared to the existing conditions at the site and assessed against the operations criteria.

3.8.3 Resultant Levels and Comparison to Thresholds

3.8.3.1 General Construction Noise

The predicted sound pressure levels and their comparisons with the applicable acoustic thresholds for the 8 human PORs during construction are shown in Tables 3.8-3 to 3.8-5. POR R_H_C1 and R_H_C2 are compared to the Health Canada criteria for changes to percent highly annoyed and to the noise criterion established for sleep disturbance due to the possibility that these receptor locations include sleeping quarters. For PORs that are associated with daytime activities, the Health Canada criterion of 62 dBA L_{dn} was used. As recommended by Health Canada, the assessment criteria used for construction are the same as those used for operations since construction is anticipated to last more than one year.

For PORs where low-frequency noise can be high, Health Canada suggests including an adjustment to the L_{dn} value in proportion to the low frequency sound level (Health Canada 2017). For the daytime use PORs where low frequency is high, this adjustment has been included as part of the assessment.

The sound pressure levels during construction were predicted to be below the applicable assessment criteria for the human receptors identified within the RSA.

Table 3.8-3. Human Receptors (with Sleeping Quarters) Construction Noise Assessment Results with Comparison to Health Canada Thresholds for Annoyance

Point of Reception ID	Baseline Ldn (dBA)	Baseline %HA	Predicted Sound Pressure Level (dBA)			Total L_{dn} (dBA) (Predicted + Baseline)	Predicted + Baseline %HA	Difference in %HA	Compliance with Health Canada Criteria for %HA
			L_d	L_n	L_{dn}				
R_H-C1	50	2.19	35.1	35.1	41.5	50.6	2.36	0.17	Yes
R_H-C2			< 20	< 20	< 20	50.0	2.19	0.00	Yes

Table 3.8-4. Human Receptors (with Sleeping Quarters) Construction Noise Assessment Results with Comparison to Health Canada Thresholds for Sleep Disturbance

Point of Reception ID	Predicted L_{AMax} (dBA)	Complies with Health Canada Criteria for Sleep Disturbance
R_H-C1	37	Yes
R_H-C2	< 20	Yes

Table 3.8-5. Human Daytime Use Receptors Construction Noise Assessment Results with Comparison to Health Canada Thresholds for Annoyance

Point of Reception ID	Baseline Ldn (dBA)	Predicted Sound Pressure Levels (dBA)			Low Frequency Adjustment (dBA)[1]		Adjusted Ldn (dBA) Predicted + Baseline	Total L_{dn} (dBA) (Predicted + Baseline)	Below 62 dBA L_{dn} Health Canada Guidelines
		L_d	L_n	L_{dn}	N_d	N_n			
R_H010	50	23.9	23.9	30.3	0	0	30.3	50.0	Yes
R_H011		20.3	20.3	26.7	0	0	26.7	50.0	Yes
R_H012		49.4	49.4	55.8	0.7	0.4	56.3	57.2	Yes
R_H-F2		39.0	39.0	45.4	0.1	0.1	45.5	51.3	Yes
R_H-F3		42.6	42.6	49.0	0	0	49.0	52.5	Yes
R_H-H1		26.8	26.8	33.2	0	0	33.2	50.1	Yes

[1] *Follows Health Canada Guidelines when Low-Frequency Noise Levels are High (Health Canada 2017)*

3.8.3.2 Operations Noise

The predicted sound pressure levels and their comparisons with the applicable acoustic thresholds for the 8 human PORs due to Project-related operation activities are shown in Tables 3.8-6, 3.8-7, and 3.8-8. POR R_H_C1 and R_H_C2 are compared to the Health Canada criteria for changes to percent highly annoyed and to the noise criterion established for sleep disturbance due to the possibility that these POR locations include sleeping quarters. For PORs that are associated with daytime activities, the Health Canada criterion of 62 dBA L_{dn} was used. The predicted results incorporated mitigation related to the design of the processing plant structure and the power generation facility structure and exhaust.

Table 3.8-6. Human Receptors (with Sleeping Quarters) Operations Noise Assessment Results with Comparison to Health Canada Thresholds for Annoyance

Point of Reception ID	Baseline L_{dn} (dBA)	Baseline %HA	Predicted Sound Pressure Level (dBA)			Total L_{dn} (dBA) (Predicted + Baseline)	Predicted + Baseline %HA	Difference in %HA	Compliance with Health Canada Criteria for %HA
			L_d	L_n	L_{dn}				
R_H-C1	50	2.19	33.9	33.9	40.4	50.4	2.32	0.13	Yes
R_H-C2			33.8	33.8	43.3	50.8	2.44	0.25	Yes

Table 3.8-7. Human Receptors (with Sleeping Quarters) Operations Noise Assessment Results with Comparison to Health Canada Thresholds for Sleep Disturbance

Point of Reception ID	Predicted L_{AMax} (dBA)	Complies with Health Canada Criteria for Sleep Disturbance
R_H-C1	34.6	Yes
R_H-C2	33.8	Yes

For PORs where low-frequency noise can be high, Health Canada suggests including an adjustment to the L_{dn} value in proportion to the low frequency sound level (Health Canada 2017). For the daytime use PORs where low frequency is high, this adjustment has been included as part of the assessment. The sound pressure levels were predicted to be below the applicable assessment criteria for the human PORs identified within the RSA.

Table 3.8-8. Human Daytime Use Receptors Operations Noise Assessment Results with Comparison to Health Canada Thresholds for Annoyance

Point of Reception ID	Baseline L_{dn} (dBA)	Predicted Sound Pressure Levels (dBA)[1]			Low Frequency Adjustment (dBA)[2]		Adjusted L_{dn} (dBA) Predicted + Baseline	Total L_{dn} (dBA) (Predicted + Baseline)	Below 62 dBA L_{dn} Health Canada Guidelines
		L_d	L_n	Ld_n	N_d	N_n			
R_H010	50	23.9	23.9	30.3	0	0	30.3	50.0	Yes
R_H011		20.3	20.3	26.7	0	0	26.7	50.0	Yes
R_H012		51.3	51.3	57.7	5.8	3.5	61.6	61.9	Yes
R_H-F2		39.3	39.3	45.7	0.1	0.1	45.8	51.4	Yes
R_H-F3		42.0	42.0	48.4	0	0	48.4	52.3	Yes
R_H-H1		29.2	29.2	35.6	0	0	35.6	50.2	Yes

[1] *Includes mitigation to the design of the processing plant and generator facility (see Section 3.9.5).*
[2] *Follows Health Canada Guidelines when Low-Frequency Noise Levels are High (Health Canada 2017).*

Isopleths for L_{AMax} and %HA are shown for the receptors with potential sleeping quarters in Figures 3.8-2 and 3.8-3, respectively. Isopleths of the predicted L_{dn} dBA values (with low frequency adjustments) are shown in Figures 3.8-4 and 3.8-5, respectively.

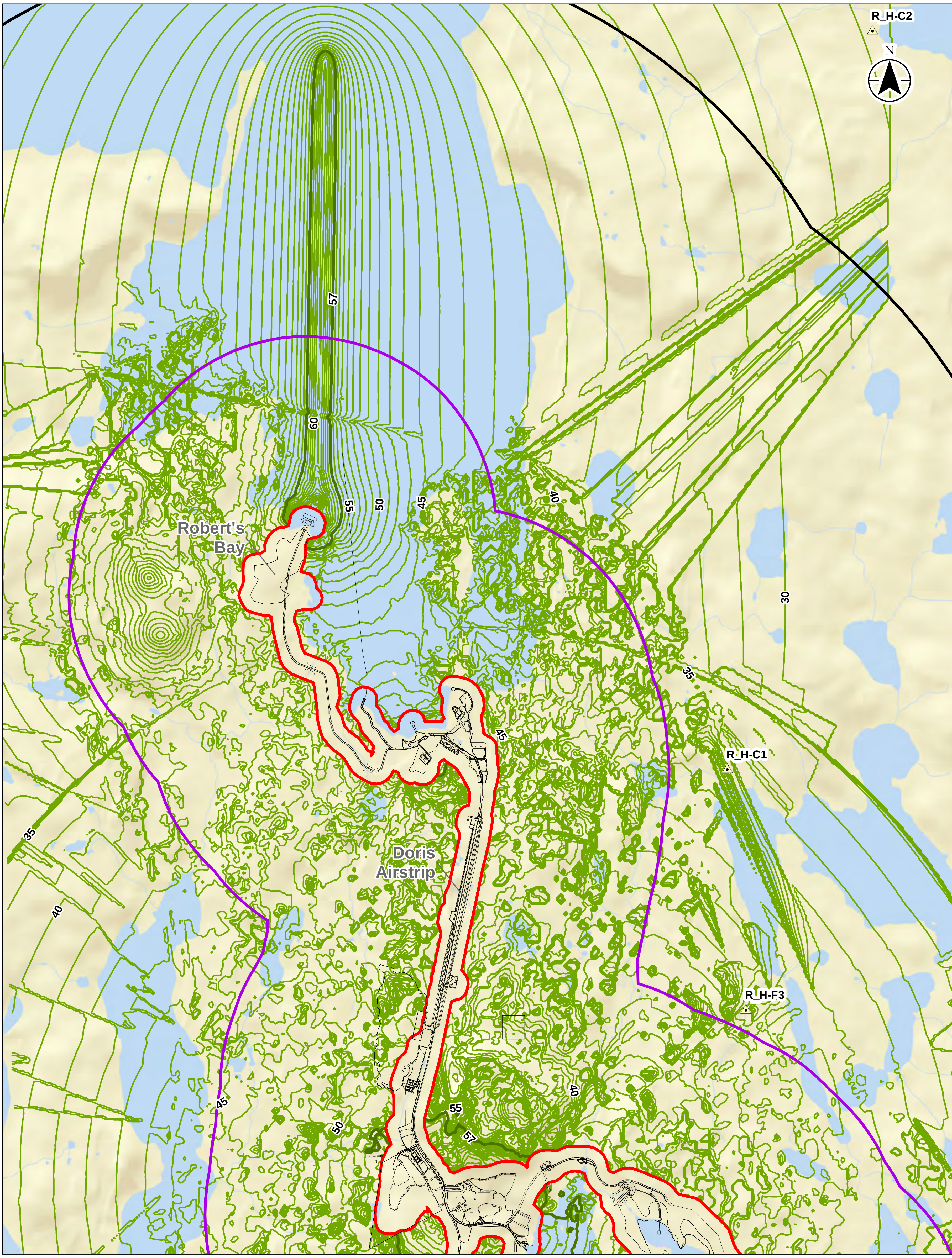
3.8.3.3 Blasting Noise and Vibration

For the purposes of the noise assessment at the mines, the predicable worst case blasting scenario was used and applied at the surface locations of the mine openings. The zone of influence for this scenario was calculated to be 320 m from the blast site. As discussed above this is a predicable worst case scenario and all blasting scenarios are expected to experience a lesser zone of influence as the explosive quantity is less and the blast site moves below the ground surface. The zones of influence are located within the LSA. Within the life of mine, this predicable worst case blasting scenarios considered a maximum effect likely only experienced a few times.

Quarry blasting noise was assessed using the same method as the mine blasting however the 320-metre zone of influence is modelled as extending from the perimeter of the designated possible quarry locations as the blast could occur at any point within the boundary. For the quarry locations, the zone of influence does not extend outside the LSA.

Blasting vibration at the mines was also assessed to determine a zone of influence for the predictable worst case scenario. The zone of influence for vibration was assessed to be 540 metres for the maximum blasting scenario across all four mines. The zone of influence is contained within the LSA for the assessed area. As with the noise scenario, this predicable worst case scenario is considered a maximum effect likely only experienced a few times within the life of mine. Figures showing the predictable worst case zone of influence for the vibration from construction blasting at the quarries and the operational blasting at the mines are shown in Figures 3.8-6 through 3.8-9.

The zone of influence for the quarry locations was also applied at the perimeter of the potential quarry locations. This zone of influence is predicted to be contained within the LSA for the Project.



Legend

- Human Receptor
- Predicted Contour LAMax (dBA)
- Project Development Area (PDA)
- Local Study Area (LSA)
- Regional Study Area (RSA)

0 0.7 1.4 km
1:35,000 (At Original document size of 11x17)

Notes
1. Coordinate System: NAD 1983 UTM Zone 13N
2. Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS User Community

Project Location
Hope Bay,
Nunavut

160930343 REVA
Prepared by SPE on 2017-12-11
Technical Review by BCC on 2017-12-11

Client/Project
TMAC - RESOURCES-HOPE BAY
NUNAMI STANTEC LIMITED

Figure No.
3.**8**-2

Title
Predicted LAMax (dBA) from Project Operations near Roberts Bay and Doris

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Legend

- Human Receptor
- Predicted Contour Ha (dBA)
- Project Development Area (PDA)
- Local Study Area (LSA)
- Regional Study Area (RSA)

0 0.7 1.4 km

1:35,000 (At Original document size of 11x17)

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Project Location
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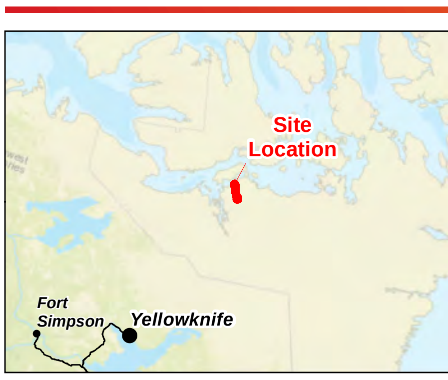
Figure No.
3.8-3

Title
Predicted Percent Highly Annoyed from Project Operations near Roberts Bay and Doris

Notes
1. Coordinate System: NAD 1983 UTM Zone 13N
2. Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS User Community



Legend

- Human Receptor
- Predicted Contour Ldn (dBA)
- Project Development Area (PDA)
- Local Study Area (LSA)
- Regional Study Area (RSA)

0 0.7 1.4 km

1:35,000 (At Original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 13N
2. Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS User Community

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Figure No.
3.**8**-4

Title
Predicted Ldn (dBA) from Project Operations near Roberts Bay and Doris

Legend

- Human Receptor
- Predicted Contour Ldn (dBA)
- Project Development Area (PDA)
- Local Study Area (LSA)
- Regional Study Area (RSA)

0 0.6 1.2 km

1:30,000 (At Original document size of 11x17)

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Project Location
Hope Bay,
Nunavut

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Figure No.
3.**8**-5

Title
Predicted Ldn (dBA) from Project Operations near Boston

Notes
1. Coordinate System: NAD 1983 UTM Zone 13N
2. Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS User Community

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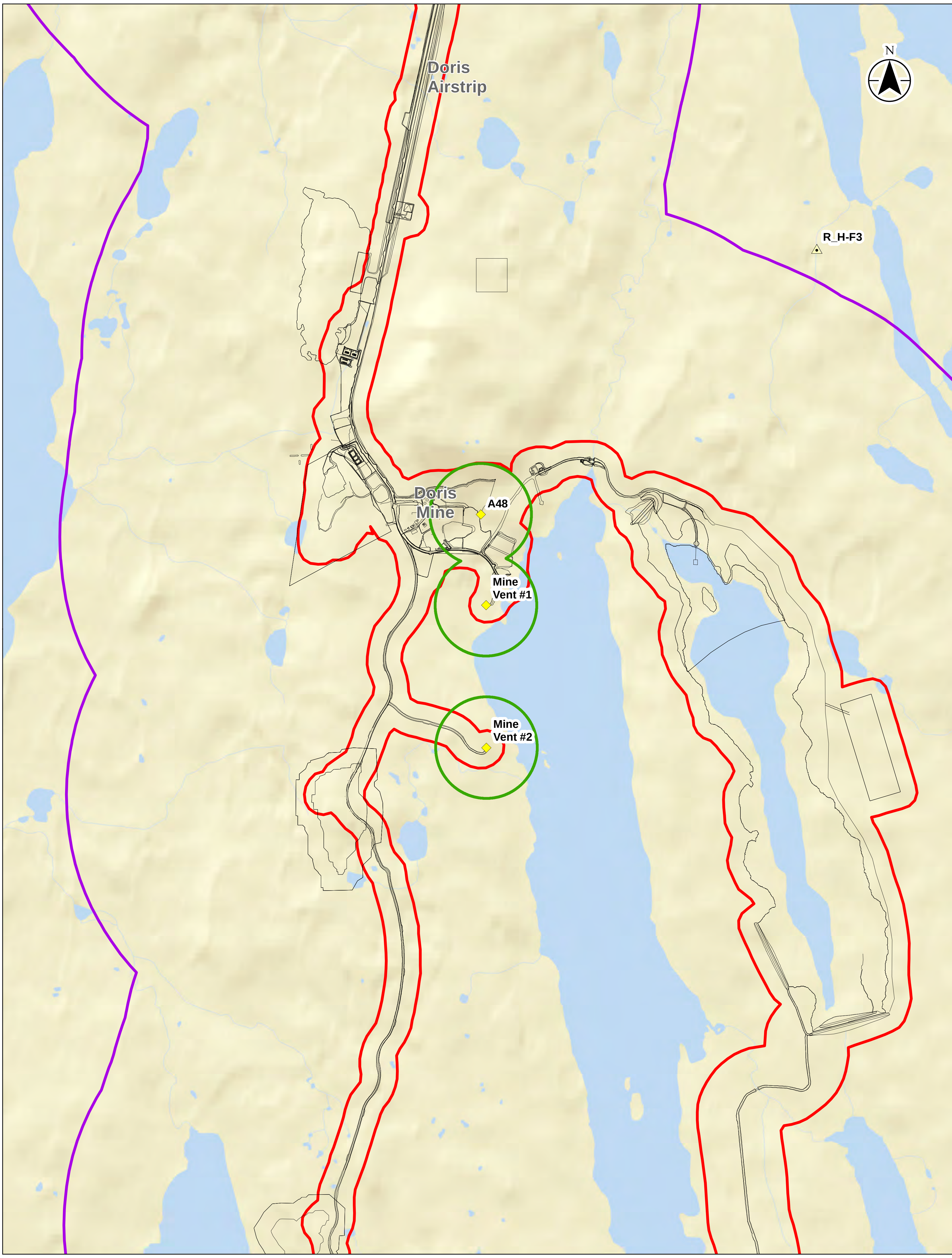

Legend

- Human Receptor
- Noise Source
- Noise Zone of Influence (120 dBA)
- Project Development Area (PDA)
- Local Study Area (LSA)
- Regional Study Area (RSA)

0 0.5 1 km

1:25,000 (At Original document size of 11x17)

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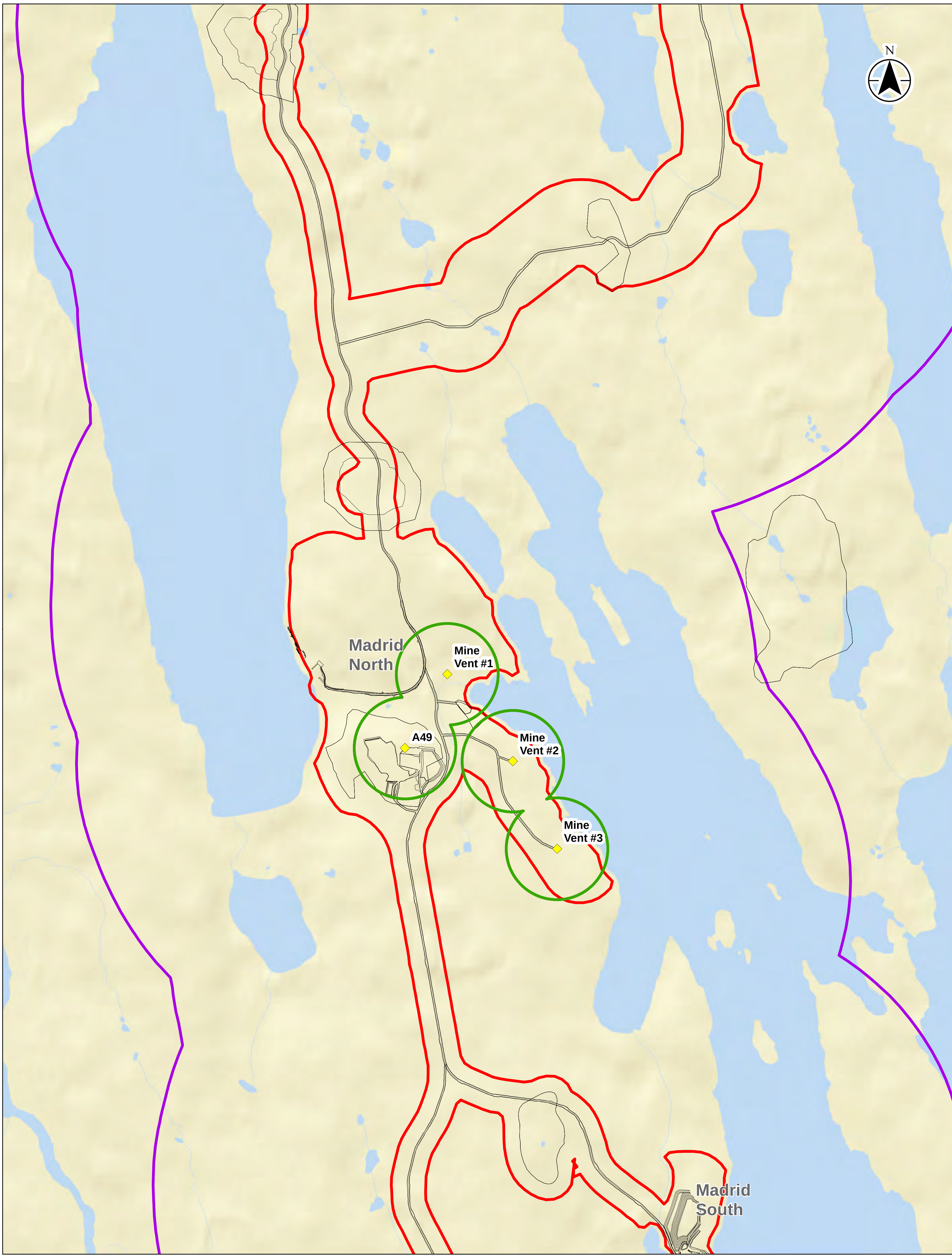
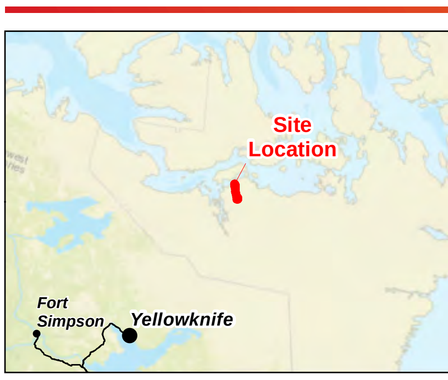
Figure No.
3.**8**-6a

Title
Doris Mine Blasting Noise Zone of Influence

Notes
1. Coordinate System: NAD 1983 UTM Zone 13N
2. Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS User Community





Legend

- Noise Source
- Noise Zone of Influence (120 dBA)
- Project Development Area (PDA)
- Local Study Area (LSA)
- Regional Study Area (RSA)

0 0.5 1 km
1:25,000 (At Original document size of 11x17)

Notes
1. Coordinate System: NAD 1983 UTM Zone 13N
2. Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS User Community

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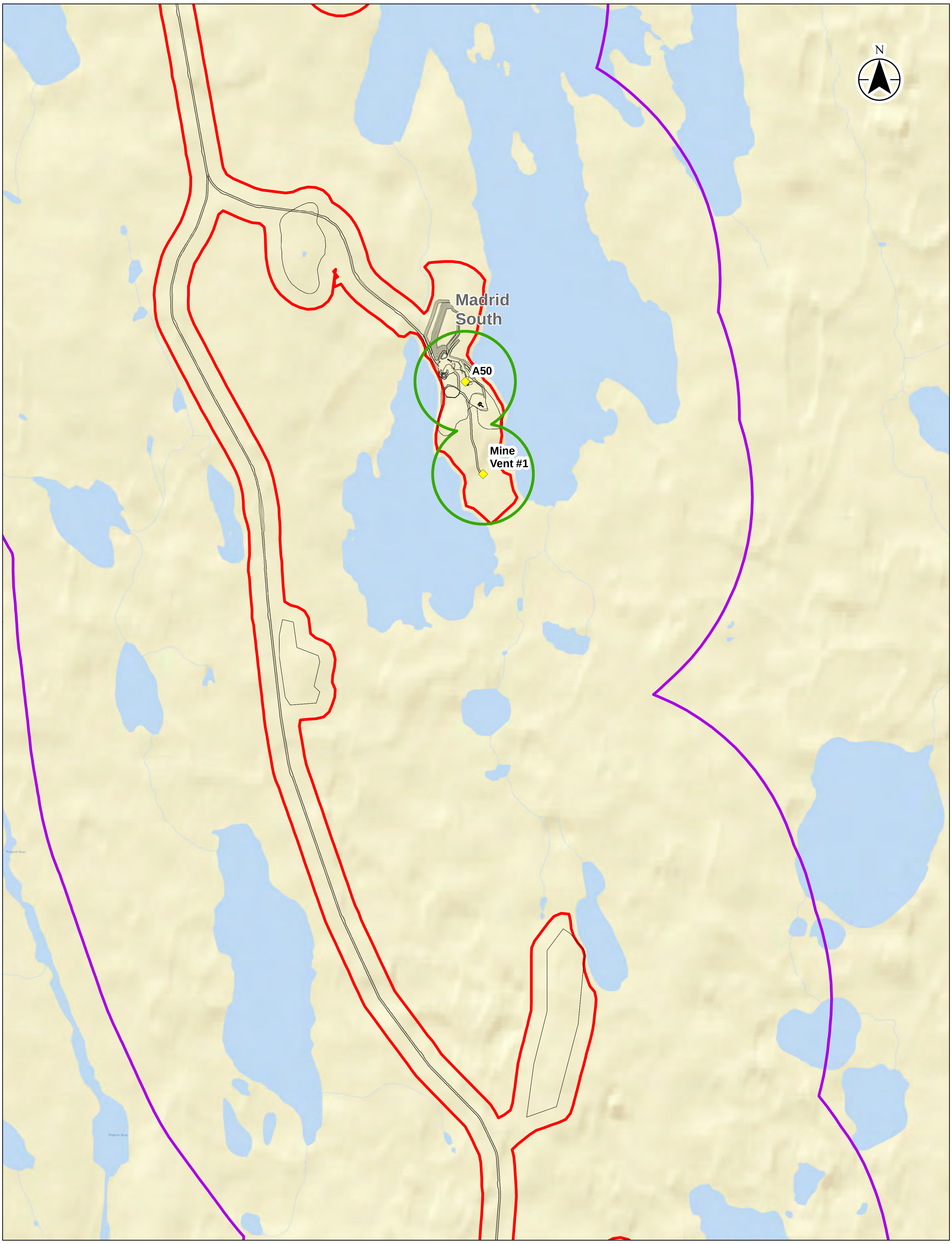
Figure No.
3.**8**-6b

Title
Madrid North Blasting Mine Noise Zone of Influence



Legend

- Noise Source
- Noise Zone of Influence (120 dBA)
- Project Development Area (PDA)
- Local Study Area (LSA)
- Regional Study Area (RSA)

0 0.5 1 km
1:25,000 (At Original document size of 11x17)

Notes
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2. Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS User Community

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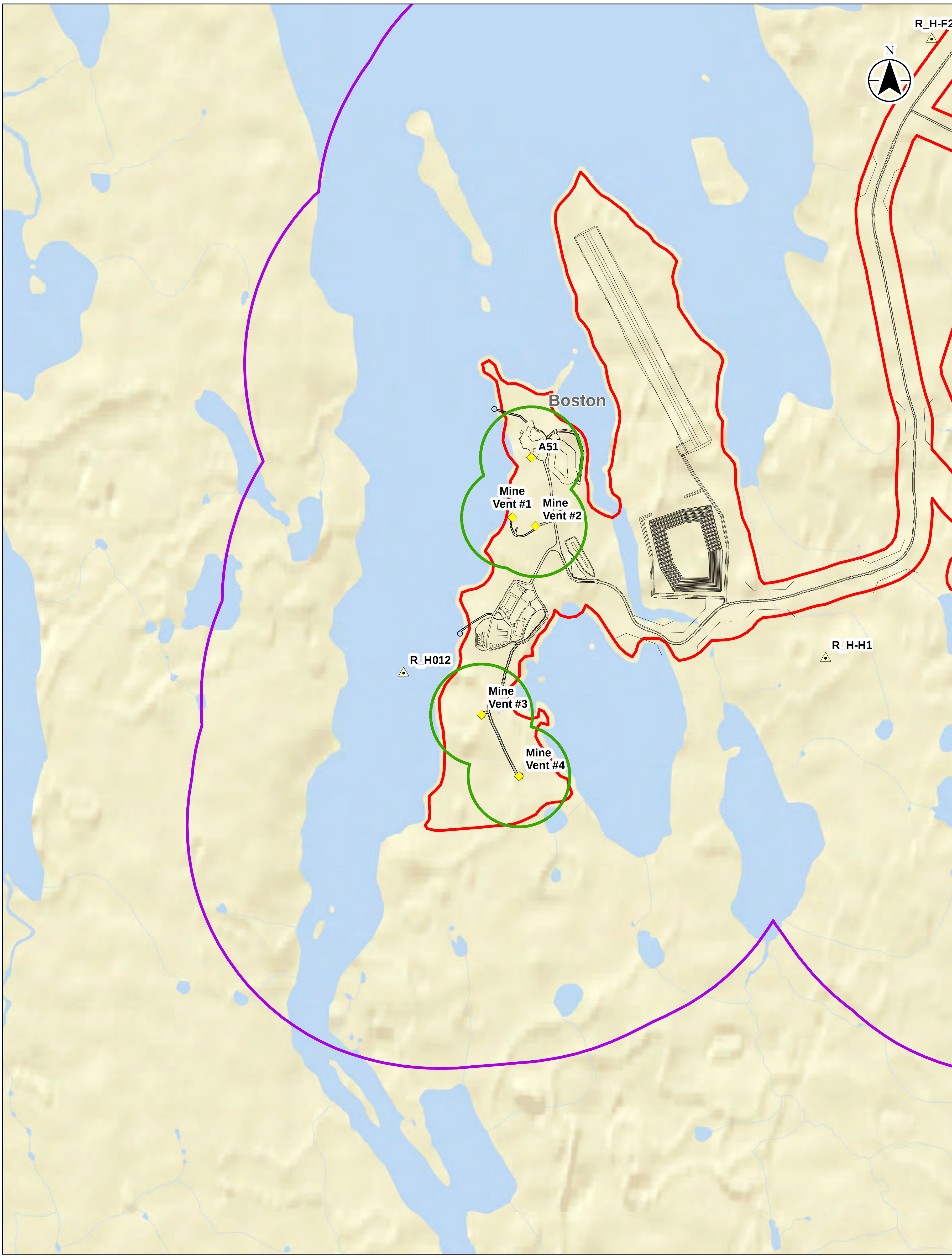
Figure No.
3.**8**-6c

Title
Madrid South Blasting Mine Noise Zone of Influence

\\cd1215-f01\work_group\01609\Active\160930343\drawing\Figures\Atmospherics\ReportFigures\VC\160930343_VC_Fig03-10-6_Blasting-Noise_HumanRecp.mxd Revised: 2017-12-11 By: searles



Legend

- Human Receptor
- Noise Source
- Noise Zone of Influence (120 dBA)
- Project Development Area (PDA)
- Local Study Area (LSA)
- Regional Study Area (RSA)

0 0.5 1 km

1:25,000 (At Original document size of 11x17)

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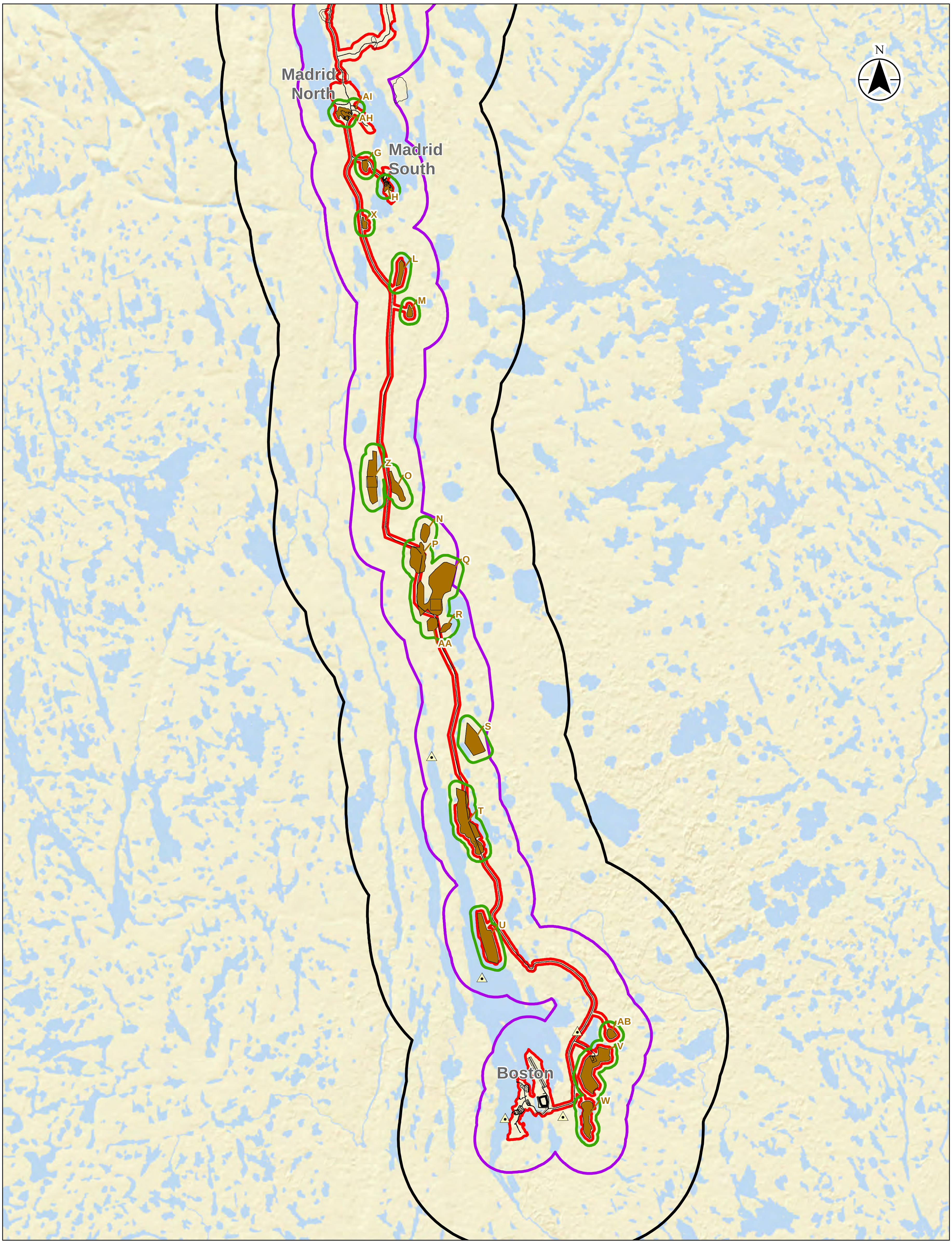
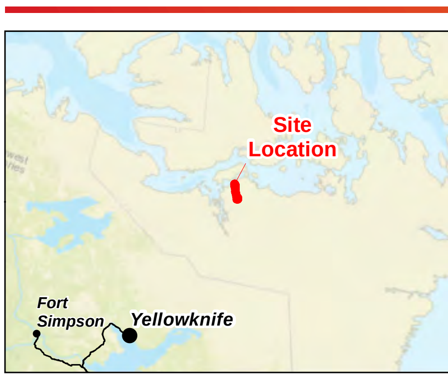
Figure No.
3.**8**-6d

Title
Boston Mine Blasting Noise Zone of Influence

Notes
1. Coordinate System: NAD 1983 UTM Zone 13N
2. Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS User Community





Legend

- Human Receptor
- Project Development Area (PDA)
- Local Study Area (LSA)
- Regional Study Area (RSA)
- Area Suitable for the Development of Rock Quarries
- Quarry Noise Zone of Influence (120 dBA)

0 3.5 7 km

1:180,000 (At Original document size of 11x17)

Notes

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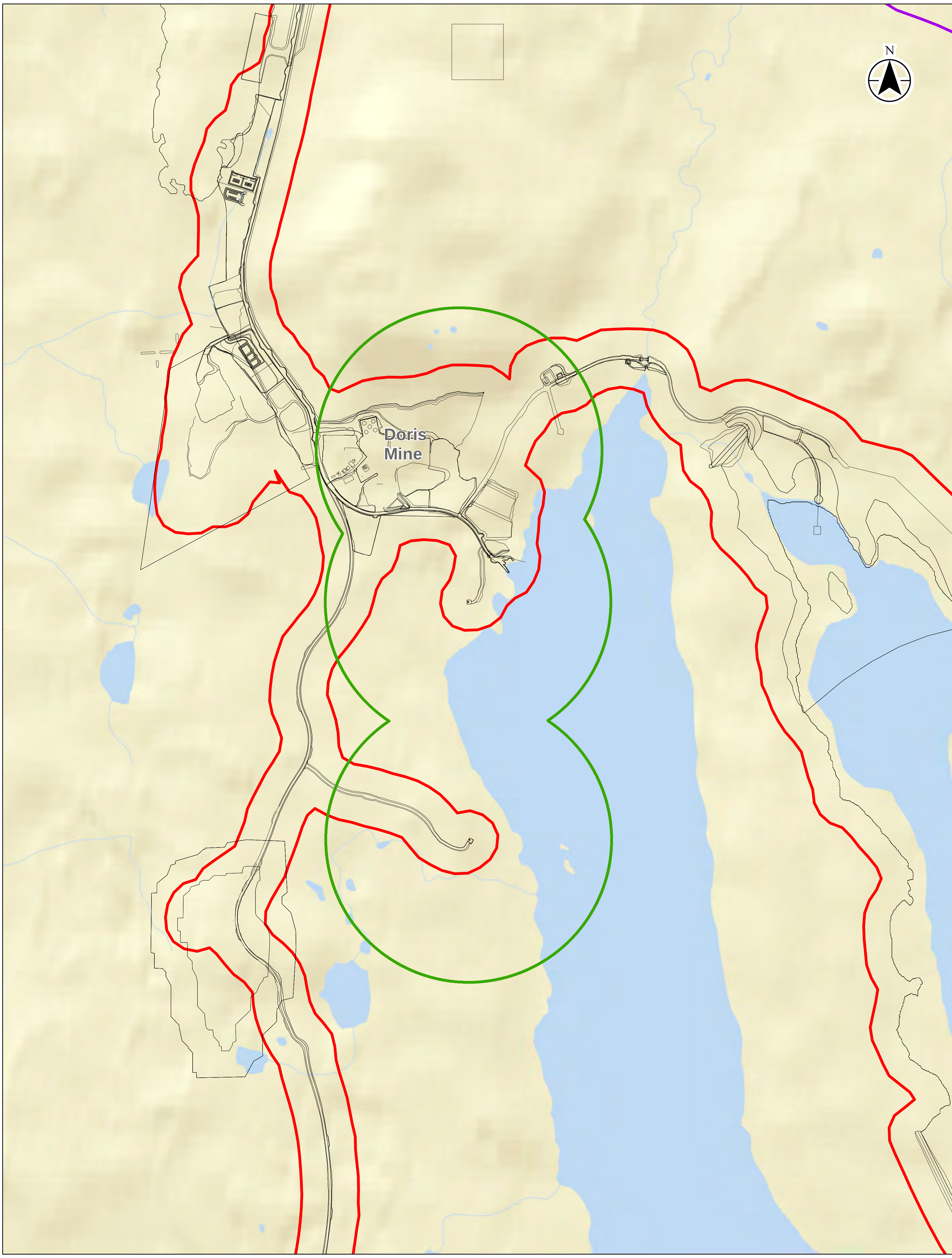
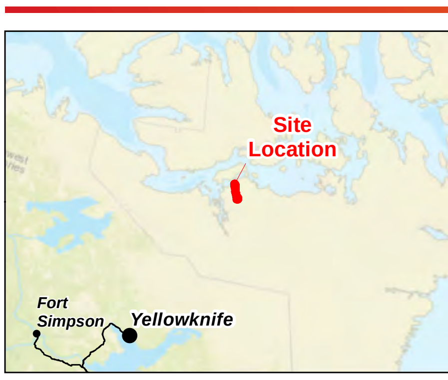
Figure No.
3.**8**-7

Title
Quarry Blasting Noise Zone of Influence

\\cd1215-f01\work_group\01609\Active\160930343\drawing\Figures\Atmospherics\ReportFigures\VC\160930343_VC_Fig03-10-8_Blasting-Vibration_HumanRecp.mxd Revised: 2017-12-11 By: searles





Legend

- Vibration Zone of Influence (Threshold 12.5mm/s)
- Project Development Area (PDA)
- Local Study Area (LSA)
- Regional Study Area (RSA)

0 0.3 0.6 km

1:15,000 (At Original document size of 11x17)

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Notes

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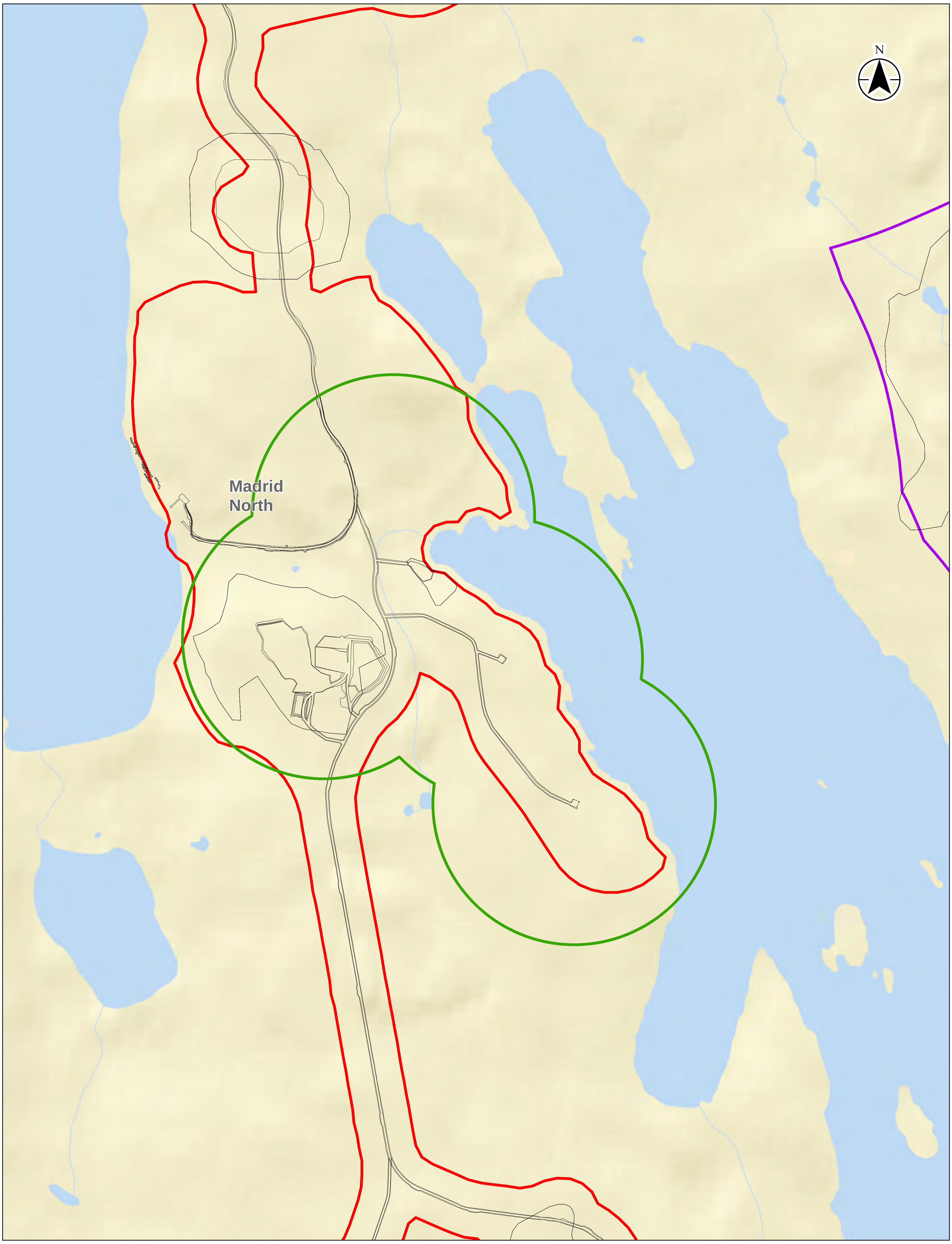
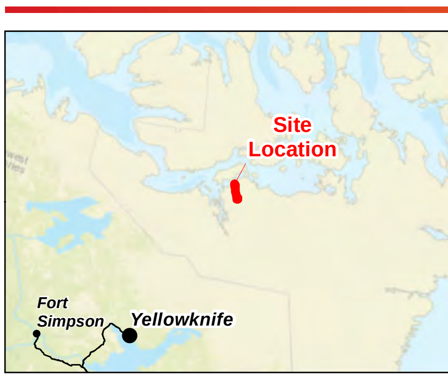
Figure No.
3.**8**-8a

Title
Doris Mine Blasting Vibration Zone of Influence





Legend

- Vibration Zone of Influence (Threshold 12.5mm/s)
- Project Development Area (PDA)
- Local Study Area (LSA)
- Regional Study Area (RSA)

0 0.3 0.6 km

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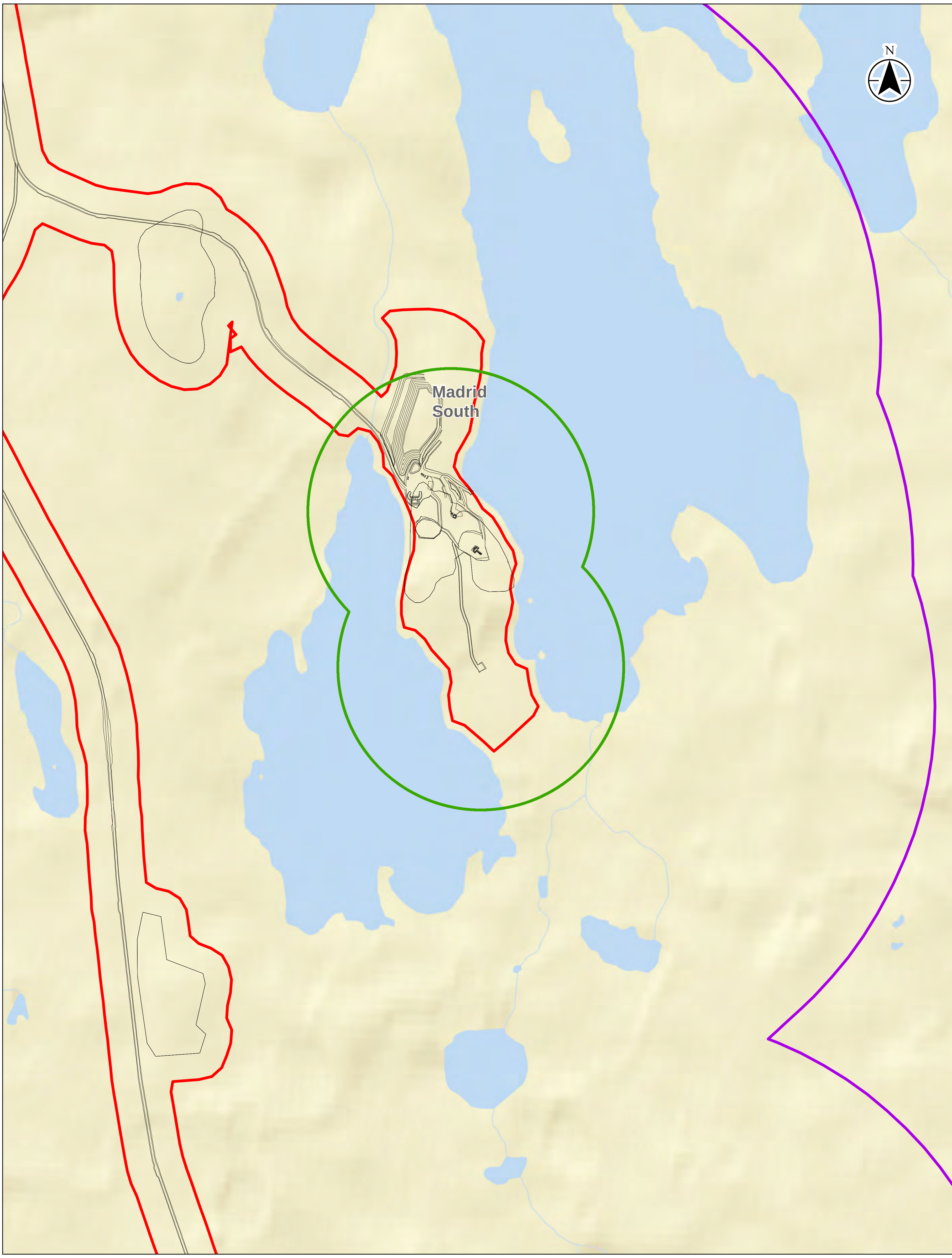
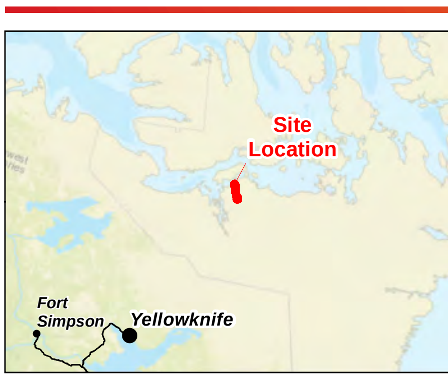
Figure No.
3.**8**-8b

Title
Madrid North Blasting Mine Vibration Zone of Influence

\\cd1215-f01\work_group\01609\Active\160930343\drawing\Figures\Atmospherics\ReportFigures\VC\160930343_VC_Fig03-10-8_Blasting-Vibration_HumanRecp.mxd   Revised: 2017-12-11 By: searles





Legend

- Vibration Zone of Influence (Threshold 12.5mm/s)
- Project Development Area (PDA)
- Local Study Area (LSA)
- Regional Study Area (RSA)

0 0.3 0.6 km

1:15,000 (At Original document size of 11x17)

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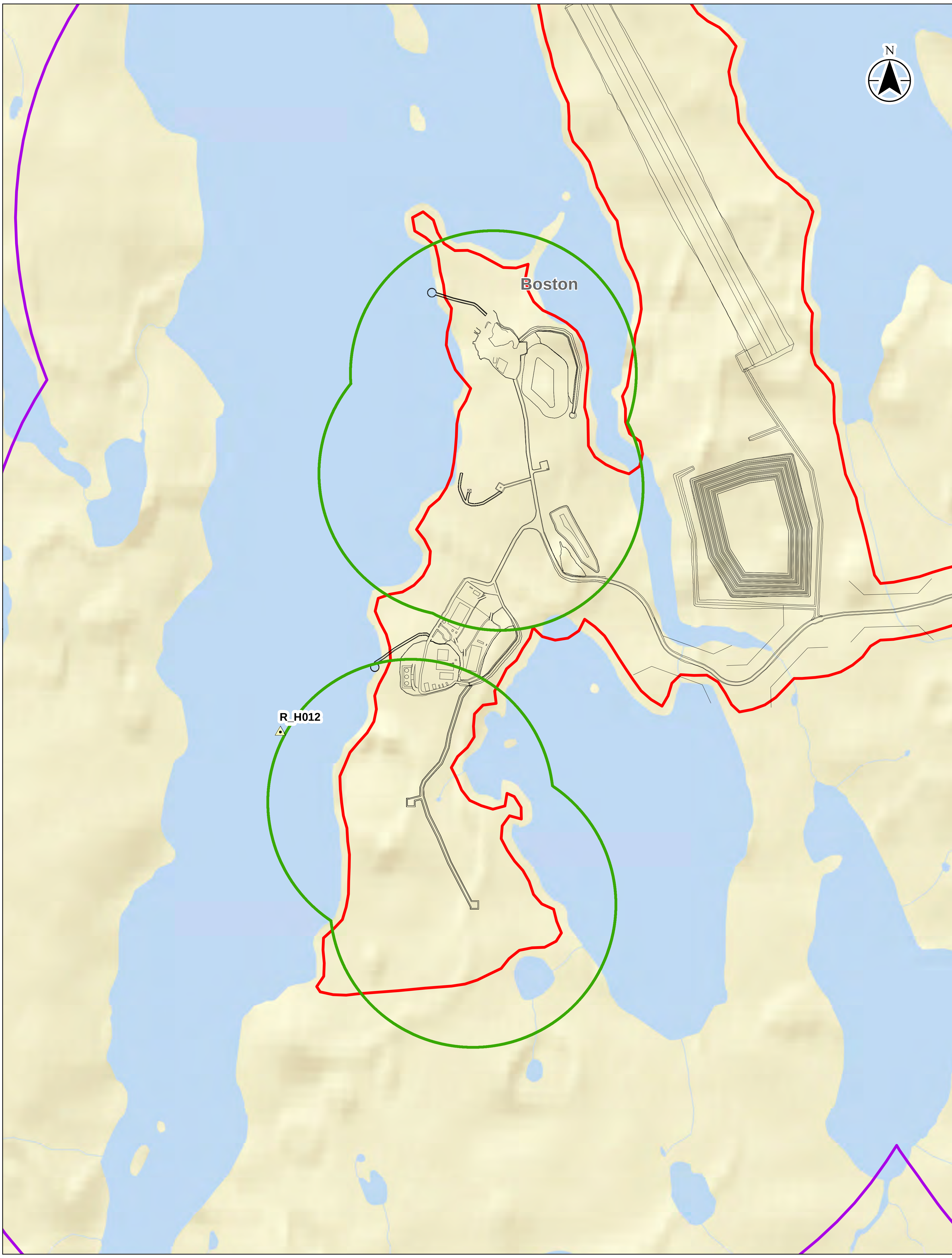
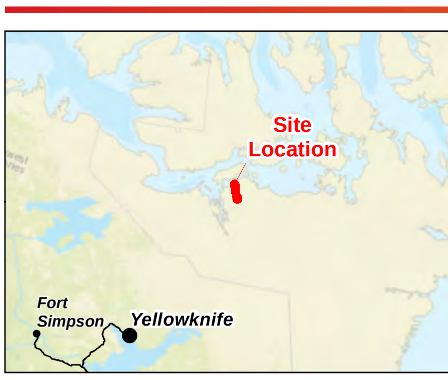
Figure No.
3.**8**-8c

Title
Madrid South Blasting Mine Vibration Zone of Influence

\\cd1215-f01\work_group\01609\Active\160930343\drawing\Figures\Atmospherics\ReportFigures\VC\160930343_VC_Fig03-10-8_Blasting-Vibration_HumanRecp.mxd Revised: 2017-12-11 By: searles





Legend

- Human Receptor
- Vibration Zone of Influence (Threshold 12.5mm/s)
- Project Development Area (PDA)
- Local Study Area (LSA)
- Regional Study Area (RSA)

0 0.3 0.6 km

1:15,000 (At Original document size of 11x17)

Notes

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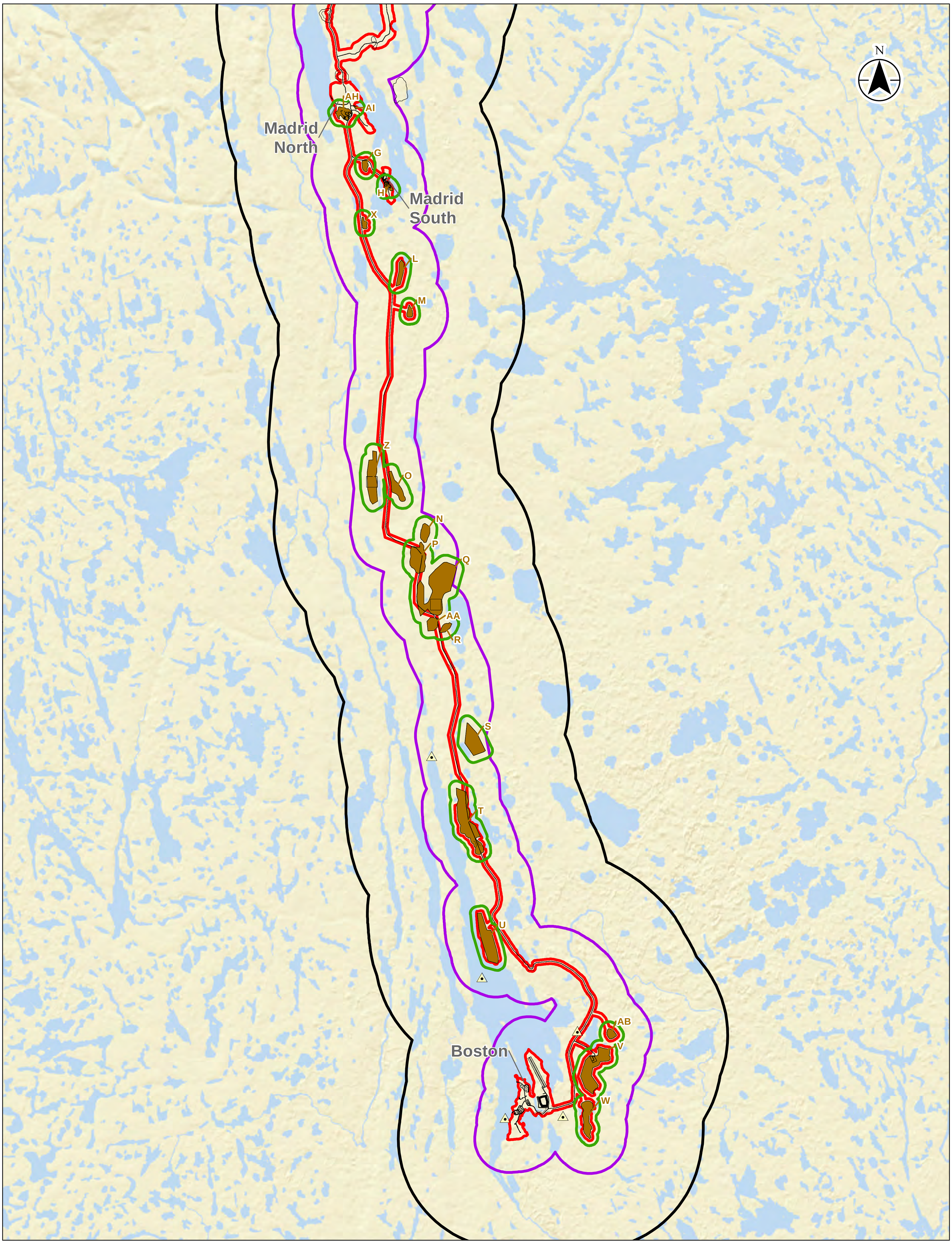
Figure No.
3.**8**-8d

Title
Boston Mine Blasting Vibration Zone of Influence



Legend

- Human Receptor
- Project Development Area (PDA)
- Local Study Area (LSA)
- Regional Study Area (RSA)
- Area Suitable for the Development of Rock Quarries
- Quarry Vibration Zone of Influence (Threshold 12.5mm/s)

0 3.5 7 km

1:180,000 (At Original document size of 11x17)

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Figure No.
3.8-9

Title
Quarry Blasting Vibration Zone of Influence

Notes
1. Coordinate System: NAD 1983 UTM Zone 13N
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3.8.3.4 Aircraft Noise

NEF Contours for the Doris and Boston Airstrips are shown in Figure 3.8-10. The NEF 25 contour corresponds to 57 dBA and anything above this level is likely to produce some level of annoyance. The Doris site does not include any human PORs within this boundary to experience annoyance and the Boston site includes only R-H-H1 which is not predicted to be greater than NEF25 (i.e., not NEF26). The NEF25 level is considered in compliance with the thresholds. No PORs are within the NEF30 contour.

The predicted noise contours for the two helicopter scenarios presented are shown in Figures 3.8-11 and 3.8-12. The contours illustrate examples of the potential noise effect of helicopter traffic. The L_{dn} value of 62 dBA represents the Health Canada limit for the activity. Tables 3.8-9 and 3.8-10 show the predicted values at the human PORs for each of the helicopter scenarios and compares them to the applicable criteria. Receptor R-H-C1 is the only human POR with an effect from helicopter noise predicted which is comparable to the %HA criteria. The calculated increase in %HA is 0.95%. All modelled human receptors are predicted to be in compliance with Health Canada criteria for both the base case and summer drilling support scenarios.

Table 3.8-9. Predicted Ldn Values for Helicopter Activity for the Basecase Scenario for Human Receptors

Point of Reception ID	Baseline L_{dn} (dBA)	Baseline %HA	Predicted Sound Pressure Level from Helicopter Activity (dBA)			Total L_{dn} (dBA) (Predicted + Baseline)	Compliance with Health Canada Criteria
			L_d	L_n	L_{dn}		
R_H006	50	2.19	37.8	n/a	49.6	52.8	Yes
R_H010			38.9	n/a	50.7	50.7	Yes
R_H011			47.5	n/a	59.3	59.7	Yes
R_H012			45.3	n/a	57.1	57.1	Yes
R_H-C1			37.8	n/a	49.6	52.8	Yes
R_H-F2			44.9	n/a	56.7	56.7	Yes
R_H-F3			42.4	n/a	54.2	55.6	Yes
R_H-H1			24.8	n/a	36.6	36.6	Yes

Table 3.8-10. Predicted Ldn Values for Helicopter Activity for the Summer Drilling Support Scenario for Human Receptors

Point of Reception ID	Baseline L_{dn} (dBA)	Baseline %HA	Predicted Sound Pressure Level from Helicopter Activity (dBA)			Total L_{dn} (dBA) (Predicted + Baseline)	Compliance with Health Canada Criteria
			L_d	L_n	L_{dn}		
R_H011	50	2.19	37.6	n/a	49.4	52.7	Yes
R_H012			40.2	n/a	52.0	54.1	Yes
R_H-F2			23.4	n/a	35.2	50.1	Yes
R_H-F3			24.8	n/a	36.6	50.2	Yes
R_H-H1			24.4	n/a	36.2	50.2	Yes

3.8.4 Summary of Findings

Construction Noise

Sound pressure levels during Project construction at the 12 human PORs are predicted to comply with the applicable assessment criteria. The maximum change in %HA was predicted to be 0.17%, below the Health Canada criterion of 6.5% for annoyance. The maximum predicted LAMax was 37 dBA, below the 57 dBA Health Canada criterion for sleep disturbance. The maximum Ldn (predicted plus baseline) was 57.2 dBA, which is below the 62 dBA Health Canada criterion.

Acoustic model prediction results for Human receptors near Doris indicated that higher sound pressure levels than during future operations when mining is expected to be discontinued. Conversely, human receptors near Madrid North, Madrid South, and Boston are predicted to experience higher sound pressure levels during operations than during construction.

Further discussion and presentation of results related to wildlife receptors are provided in the Terrestrial Wildlife and Wildlife Habitat chapter (Volume 4, Chapter 9).

Operation Noise

Sound pressure levels during Project operations at the 12 human PORs are predicted to comply with the applicable assessment criteria. The maximum change in %HA was predicted to be 0.25%, below the Health Canada criterion of 6.5% for annoyance. The maximum predicted LAMax was 34.6 dBA, below the 56 dBA Health Canada criterion for sleep disturbance. The maximum Ldn (predicted plus baseline) was 61.9 dBA, which is below the 62 dBA Health Canada criterion.

Further discussion and presentation of results related to wildlife receptors are provided in the Terrestrial Wildlife and Wildlife Habitat chapter (Volume 4, Chapter 9).

Aircraft Noise (Doris and Boston Airstrip)

The predicted NEF contours show compliance with the applicable criteria at all human receptors. Aircraft scenarios are modelled for a predicable worst case and include both directions and therefore are considered conservative.

Helicopter Noise (Basecase and Operations Scenarios)

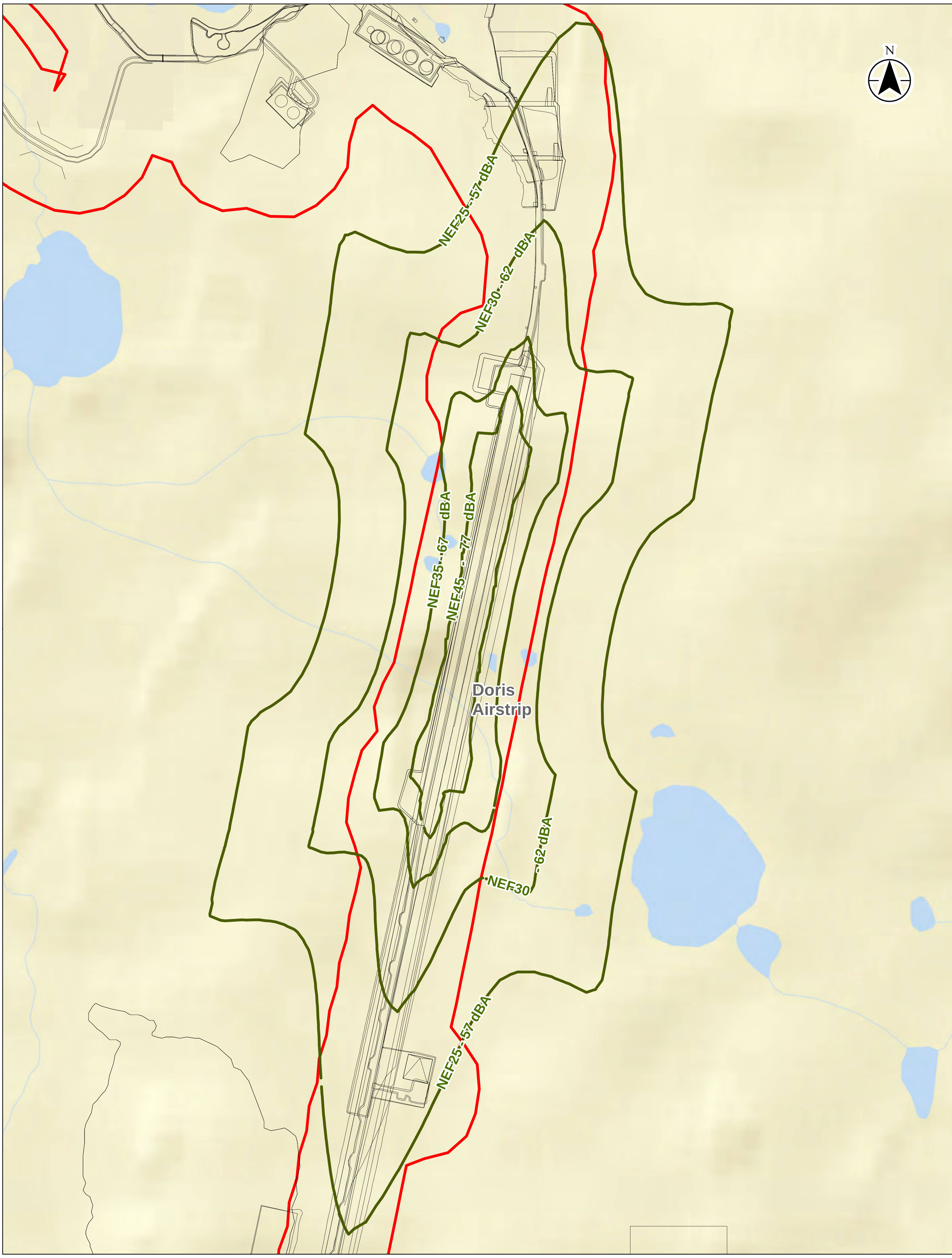
All modelled human receptors are predicted to be in compliance with Health Canada criteria for both modelled scenarios. The maximum Ldn predicted is 60 dBA for the basecase which is below the criterion of 62 dBA. These scenarios are also representing a predictable worst case and so are considered a conservative assessment.

Blasting Vibration

The human threshold of 12.5mm/s for blasting vibration is shown as the zone of influence 540 metres from the blast sites. This zone of influence is within the LSA and does not reach the modelled human receptors.

Blasting Noise

The human threshold of 120 dB for blasting noise is shown as the zone of influence 320 metres from the blast sites. This zone of influence is within the LSA and does not reach the modelled human receptors.



Legend

- Noise Exposure Contour
- Project Development Area (PDA)
- Local Study Area (LSA)
- Regional Study Area (RSA)

0 0.15 0.3 km

1:8,000 (At Original document size of 11x17)

Notes

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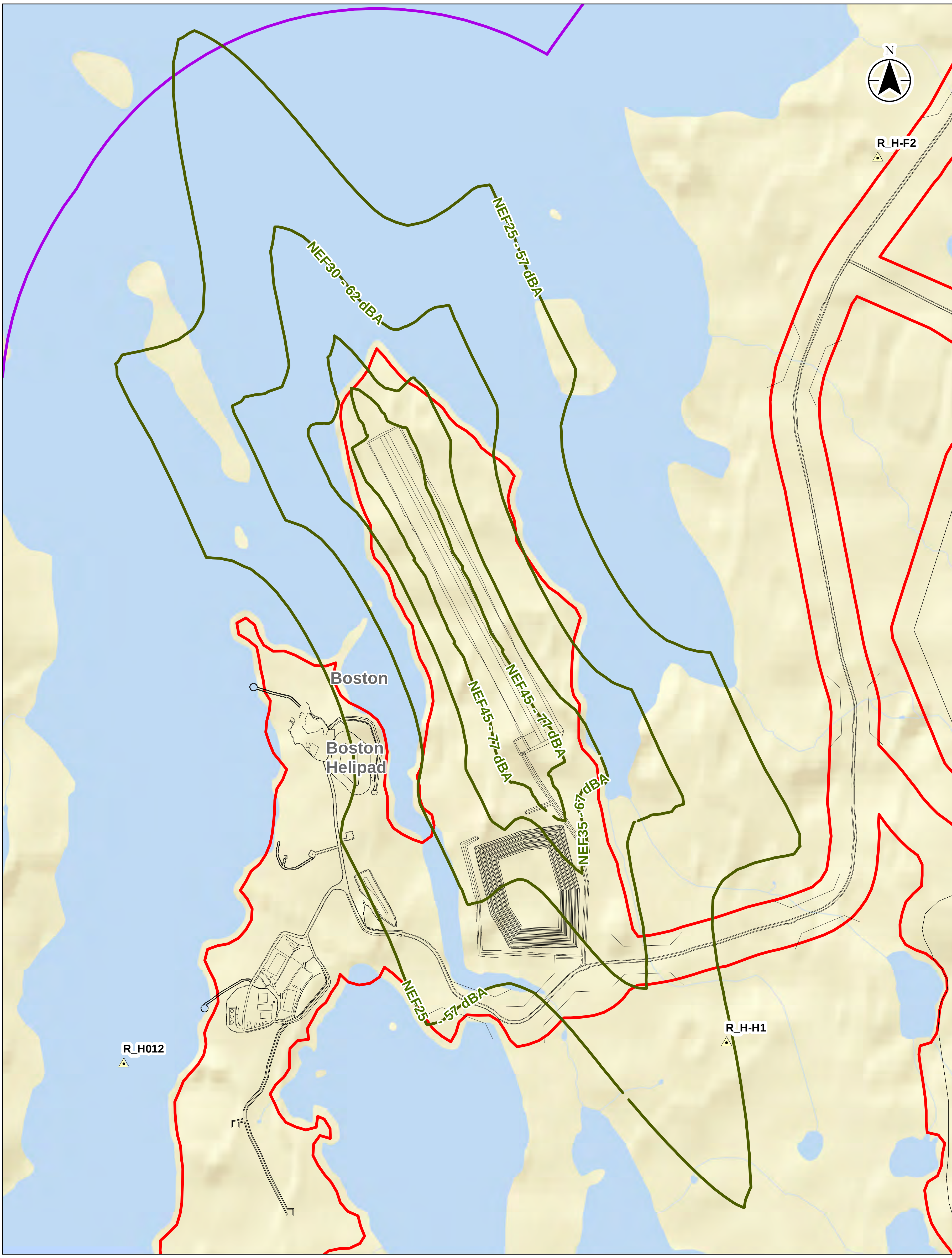
Figure No.
3.**8**-10a

Title
Doris Air Strip Noise Exposure Contours (Operation Phase)



Legend

- Human Receptor
- Noise Exposure Contour
- Project Development Area (PDA)
- Local Study Area (LSA)
- Regional Study Area (RSA)

0 0.35 0.7 km

1:17,500 (At Original document size of 11x17)

Notes

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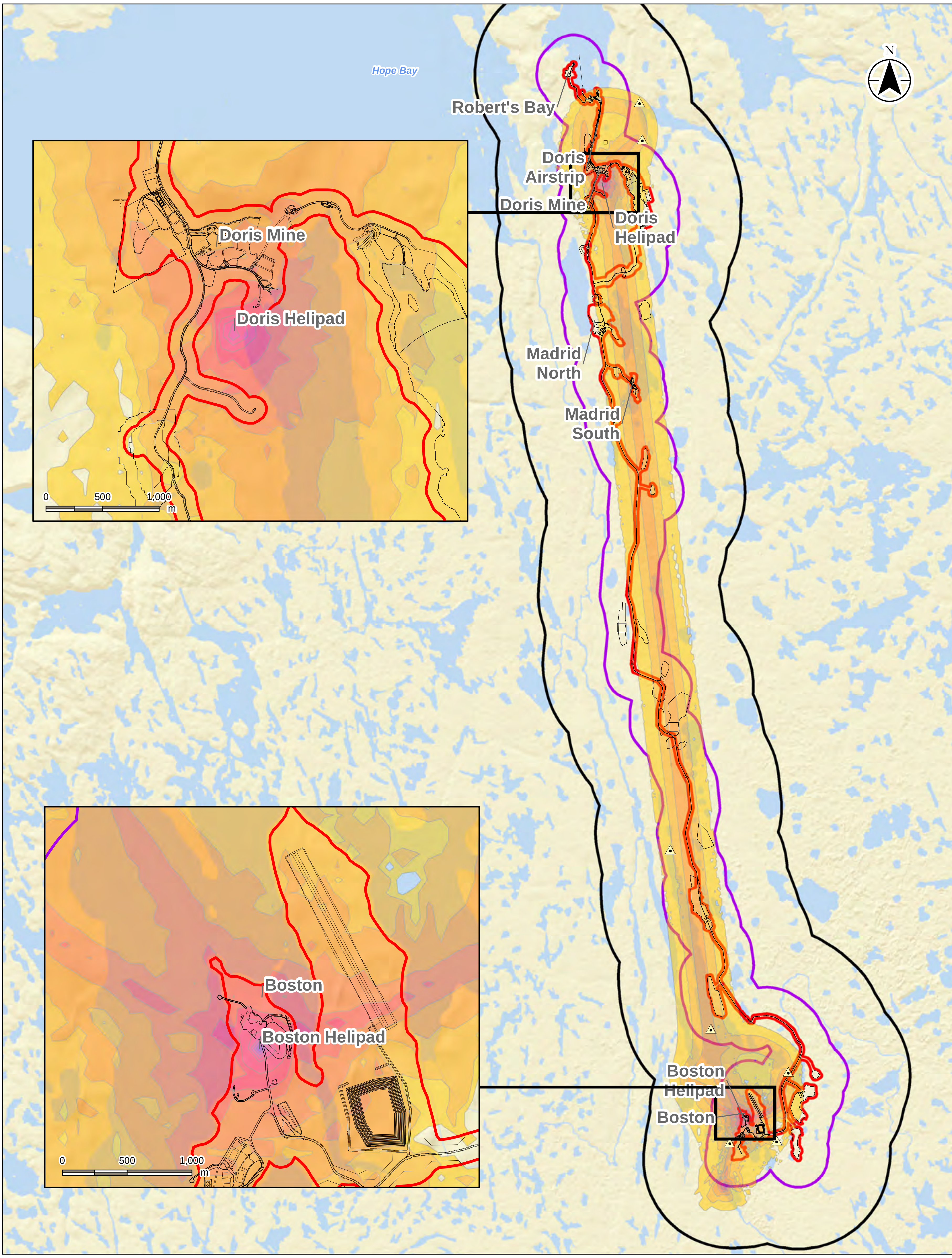
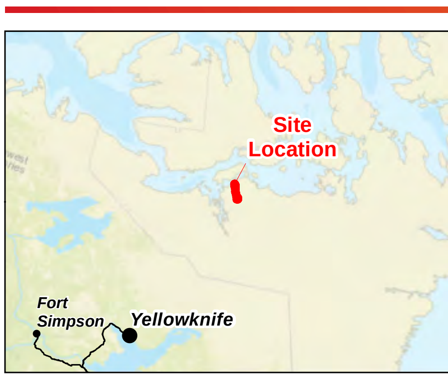
Figure No.
3.9-10b

Title
Boston Air Strip Noise Exposure Contours (Operation Phase)





Legend

- Human Receptor
- Project Development Area (PDA)
- Local Study Area (LSA)
- Regional Study Area (RSA)

Predicted Noise Contours for Helicopter Activity (Ldn, dBA)

- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60
- 60 - 65
- 65 - 70
- 70 - 75
- 75 - 80
- 80 - 85
- 85 - 90
- 90 - 95

0 4.5 9 km

1:225,000 (At Original document size of 11x17)

Notes

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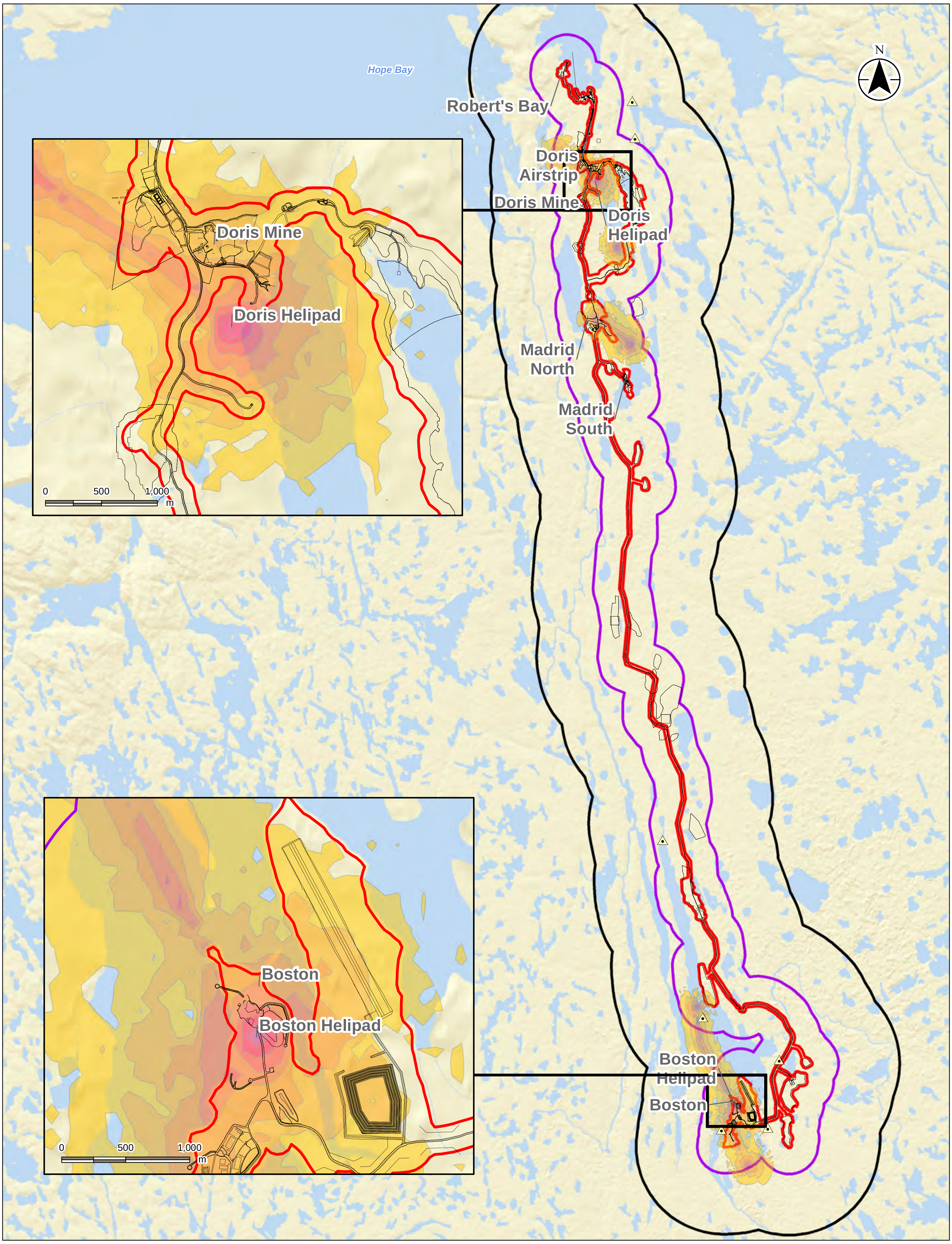
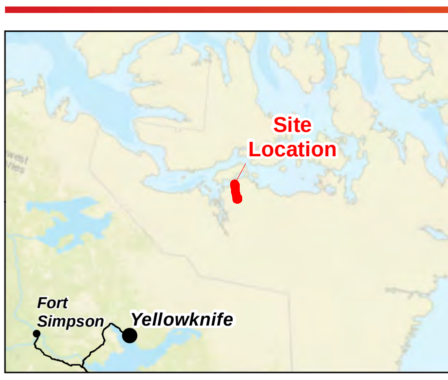
Figure No.
3.8-11

Title
Predicted Noise Contours for Helicopter Activity (Basecase)





Legend

- Human Receptor
- Project Development Area (PDA)
- Local Study Area (LSA)
- Regional Study Area (RSA)

Predicted Noise Contours for Helicopter Activity (Ldn, dBA)

- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60
- 60 - 65
- 65 - 70
- 70 - 75
- 75 - 80
- 80 - 85
- 85 - 90

0 4.5 9 km

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Figure No.
3.**8**-12

Title
Predicted Noise Contours for Helicopter Activity (Summer Drilling Support)

3.8.5 Mitigation and Adaptive Management

Mitigation measures that are recommended to reduce the Project noise effects should be technically, environmentally, and economically feasible and aim to avoid, reduce, control, eliminate, offset, or compensate potential Project effects.

3.8.5.1 Construction Phase Noise Mitigation and Management

The predicted sound pressure levels during Project construction activities have assumed the following best practices are followed:

- Ensure equipment is fitted with appropriate mufflers and silencers, and is regularly maintained;
- Ensure equipment is well maintained; and
- Vehicles follow posted speed limits.

3.8.5.2 Operation Phase Noise Mitigation and Management

The predicted sound pressure levels during Project construction activities have assumed the following best practices are followed:

- Ensure equipment is fitted with appropriate mufflers and silencers, and is regularly maintained;
- Ensure equipment is well maintained;
- Vehicles follow posted speed limits;
- Design haul roads to optimise the haulage route to avoid receptors, and to minimise the distance travelled which will reduce the overall noise generation; and
- Schedule take-off and landing for aircraft to certain times of the day, and optimise flight paths to avoid adversely affected human and wildlife receptors.

In addition to best practices, the following mitigation measures were included in the predictions of residual environmental effects of the Project during Operation:

1. The use of silencers for the generator exhausts at the Boston site;
2. Ore enters the Boston processing plant from the east; and

- The power plant enclosure at Boston be constructed to meet a minimum acoustic performance for transmission loss.

3.8.5.3 Best Management Practices

The recommendations for construction noise, operational noise, blasting (overpressure and vibration) and aircraft noise mitigation and management measures described above should be implemented into the best mining practices established for Madrid-Boston. These best mining practices can be incorporated into Madrid-Boston during the detailed design to eliminate, minimize, control, or reduce adverse effects on VECs. This is of particular relevance to the avoidance and optimisation recommendations provided for operational noise, blasting and aircraft noise, each of which is afforded the opportunity to during the detailed design phase such that no adverse effects occur.

3.8.5.4 Noise Abatement Plan

In accordance with Section 9.4.15 of the EIS Guidelines (NIRB) a Noise Abatement Plan will be developed to provide operators and other on-site personnel with information on potential noise emission sources and how to mitigate noise emissions where possible. The plan may include but not be limited to:

- applicable standards, guidelines and regulations that related to noise emissions associated with the Project;
- an description (and results) of an environmental noise follow-up monitoring program, if required;
- a summary of the Noise and Vibration Technical Data Report (Appendix V4-3A) conclusions, including a description of noise control methods to be employed to mitigate noise emissions where possible;
- a best practices guide for equipment operators and on-site personnel to review to become aware of potential noise emission sources and how to mitigate noise emissions where possible; and
- a description of roles and responsibilities to maintain and update the plan, and to respond to potential noise complaints.

The Noise Abatement Plan will be finalised prior to the commencement of Project Operations.

3.8.5.5 Proposed Monitoring Plans and Adaptive Management

The need for any corrective actions to on-site noise and vibration management or additional control measures can be determined through follow-up monitoring and adaptive management of the Project. Noise and vibration monitoring may occur where practical following the detailed design of the Madrid-Boston Project. Noise and blast monitoring should be carried out (if required) by a qualified professional using appropriate and calibrated measurement devices.

3.8.6 Characterization of Project-related Residual Effects

The characterization of residual effects for noise and vibration are summarised in Table 3.8-11. Further discussion regarding the characterization of residual effect for each source assessed is provided below.

- **Construction Noise:** the residual effect of construction noise is deemed **not significant** as the predicted noise levels from Project sources are below the applicable noise criteria. Since reclamation and closure are anticipated to have fewer sources within the PDA than during construction, those phases are also deemed **not significant.**
- **Operation Noise:** the residual effect of noise during Project operations is deemed **not significant** as the predicted noise levels from Project sources are below the applicable noise criteria.
- **Aircraft Noise (Doris and Boston Airstrip):** the residual effect of aircraft noise is deemed **not significant** as the predicted effect of the aircraft traffic is predicted to be low.
- **Helicopter Noise:** The residual effect of the helicopter noise is predicted to be **not significant** as the predicted values are in compliance with applicable criteria for the modelled scenarios.
- **Blasting Noise and Vibration:** the residual effect of quarry noise and blasting overpressure and vibration is deemed **not significant**. The successful implementation of the recommendations described here (or others that achieve similar noise level reductions) will reduce the magnitude and probability of the predicted effects occurring.

Table 3.8-11. Summary of Residual Effects and Overall Significance Rating

Residual Effect	Attribute Characteristic						Overall Significance Rating	
	Direction *(positive, variable, negative)*	**Magnitude** *(negligible, low, moderate, high)*	**Duration** *(short, medium, long)*	**Frequency** *(infrequent, intermittent, continuous)*	**Geographic Extent** *(PDA, LSA, RSA, beyond regional)*	**Reversibility** *(reversible, reversible with effort, irreversible)*	**Significance** *(not significant, significant)*	**Confidence** *(low, medium, high)*
Construction								
Sleep disturbance	Negative	Low	Medium	Intermittent	RSA	Reversible	Not Significant	High
Annoyance	Negative	low	Medium	Intermittent	RSA	Reversible	Not Significant	High
Operation								
Sleep disturbance	Negative	Low	Medium	Intermittent	RSA	Reversible	Not Significant	High
Annoyance	Negative	Low	Medium	Intermittent	RSA	Reversible	Not Significant	High
Aircraft	Negative	Low	Medium	Infrequent	RSA	Reversible	Not Significant	High
Blasting (Noise)	Negative	Low	Medium	Infrequent	RSA	Reversible	Not Significant	High
Blasting (Vibration)	Negative	Low	Medium	Infrequent	LSA	Reversible	Not Significant	High

[1] *Discussion of the potential residual effects of noise and vibration on wildlife (disturbance and habitat loss) is given in the Terrestrial Wildlife and Wildlife Habitat chapter (Volume 4, Chapter 9).*

3.9 CUMULATIVE EFFECTS ASSESSMENT

3.9.1 Methods Overview

The assessment of cumulative effects followed the methodology outlined in Effects Assessment Methodology (Volume 2, Chapter 4). The assessment consisted of the following steps:

- identification of the potential for Doris and Madrid-Boston project residual effects to interact with the residual effects from other past, existing, or reasonably foreseeable future human activities and projects within the specified spatial and temporal boundaries;
- characterization of potential cumulative effects and the identification and description of additional mitigation measures for those potential effects;
- identifying the cumulative residual effects after the implementation of mitigation and management measures; and
- determining the significance of any cumulative residual effects, which will explicitly consider the portion of the residual effect from the Project contributing to the cumulative effect relative to other projects and activities.

The cumulative residual effects from interacting projects and activities may be created by additive or synergistic processes. An additive effect increases the effect in a linear fashion, whereas a synergistic effect may be greater than the sum of the contributing effects.

3.9.2 Potential Interactions of Residual Effects with Other Projects

Potential noise, overpressure or vibration effects are typically restricted to within 5-km of a source (i.e., construction or operational activities with the potential to generate nose, overpressure of vibration emissions).

As there are no present and future projects within 5-km of the Doris and Madrid-Boston PDA there is limited or no potential interaction of residual effects with other projects such that cumulative effects are unlikely to occur.

The only project within this 5-km geographic overlap is the existing Doris Project which is located within the PDA and was considered in the previous assessment (Section 3.5).

Hence, there is no potential for a cumulative effect from noise and vibration on human and wildlife receptors. Potential cumulative effects are not assessed further.

3.10 TRANSBOUNDARY EFFECTS

The residual effect identified for noise and vibration from Doris and Madrid-Boston is expected to remain within the LSA, which is located within Nunavut. As such, no transboundary effects on noise are predicted.

3.11 IMPACT STATEMENT

The acoustic environment was included as a VEC for the EIS. An assessment of the potential noise and vibration effects on the acoustic environment due to Madrid-Boston Project construction and operation was completed. Effects on wildlife are assessed in the Terrestrial Wildlife and Wildlife Habitat chapter (Volume 4, Chapter 9).

The effects assessment included the identification of key indicators and thresholds for the evaluation of potential effects, and provided an assessment of residual effects including mitigation.

The overall significance of the residual effect of sleep disturbance and annoyance due to activities associated with the Madrid-Boston Project construction and operation was determined to be **not significant**.

Further discussion of the residual effects of noise and vibration on humans is provided in the Human Health and Environmental Risk Assessment (Volume 6, Chapter 5). Discussion of the potential residual effects of noise and vibration on wildlife (disturbance and habitat loss) is given in the Terrestrial Wildlife and Wildlife Habitat chapter (Volume 4, Chapter 9).

A cumulative effects assessment was conducted because a residual Project effect was predicted. The closest past, present and future projects that could potentially interact with the Hope Bar Project is located outside the spatial boundary of the cumulative effects assessment and, hence, there are no potential cumulative effects on noise and vibration.

3.12 REFERENCES

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