Rook I Project

Environmental Impact Statement

TSD X: Vibration Effect Analysis

VIBRATION EFFECT ANALYSIS TECHNICAL SUPPORT DOCUMENT FOR THE ROOK I PROJECT

Prepared for:

NexGen Energy Ltd.

Prepared by:

WSP Canada Inc.

December 2023

Executive Summary

A vibration analysis was undertaken for the Rook I Project (Project). The analysis evaluated potential vibration effects resulting from explosive blasting anticipated for the proposed Project and explosive blasting anticipated for the Fission Patterson Lake South Property, proposed by Fission Uranium Corp. and located approximately 5.2 km west of the proposed Project footprint.

Vibration was analyzed using two measurement indicators:

- peak particle velocity, which characterizes ground vibration; and
- peak pressure level, which characterizes overpressure in air or water.

Peak particle velocity and peak pressure level were predicted using empirical formulae from engineering handbooks and from regulatory guidance documents.

Vibration levels were predicted at sensitive receptors located within the study area that extends 10 km from the maximum disturbance area for the Project. Sensitive receptors were identified through engagement conducted by NexGen Energy Ltd. (NexGen) with local First Nations and Métis Groups (collectively referred to as Indigenous Groups) and local communities. These receptors correspond to the closest known human presence within the vibration study area and were used to predict the effects of vibration from blasting on fish habitat and people.

The vibration analysis also predicted effects from blasting at a conceptual receptor corresponding to the point within Patterson Lake nearest the anticipated location of Project blasting. This conceptual receptor was included to capture maximum vibration levels for comparison with Fisheries and Oceans Canada (DFO) thresholds.

Vibration effects were analyzed using thresholds from:

- Environment and Climate Change Canada (ECCC), which are primarily intended to protect against minor cosmetic damage to structures.
- Fisheries and Oceans Canada, which are intended to protect general fish habitat and fish spawning habitat.
- Australian and New Zealand Environment Council (ANZEC), which are intended to protect against human annoyance.

The vibration analysis concluded:

- Vibration from blasting activities would not result in human annoyance or cosmetic damage to structures at any of the sensitive receptors identified through NexGen's engagement with Indigenous Groups and local communities.
- Vibration from blasting activities would not result in adverse effects to general fish habitat or fish spawning habitat.

Abbreviations and Units of Measure

Abbreviation	Definition
ANZEC	Australian and New Zealand Environment Council
DFO	Fisheries and Oceans Canada
ECCC	Environment and Climate Change Canada
LSA	local study area
NexGen	NexGen Energy Ltd.
PPL	peak pressure level
PPV	peak particle velocity
Project	Rook I Project
RFD	reasonably foreseeable development
RSA	regional study area
UGTMF	underground tailings management facility

Unit	Definition
cm/s	centimetres per second
dBA	A-weighted decibel
dBL	linear decibel
kg	kilogram
km	kilometre
kPa	kilopascal
mm/s	millimetres per second

Table of Contents

TABLES

FIGURES

1.0 INTRODUCTION

NexGen Energy Ltd. (NexGen) is proposing to develop a new uranium mining and milling operation in northwestern Saskatchewan, called the Rook I Project (Project). The Project would be located approximately 40 km east of the Saskatchewan-Alberta border, 130 km north of the town of La Loche, and 640 km northwest of the city of Saskatoon (Figure 1-1). The Project would reside within Treaty 8 territory and the Métis Homeland. At a regional scale, the Project would be situated within the southern Athabasca Basin adjacent to Patterson Lake, along the upper Clearwater River system. Access to the Project would be from an existing road off Highway 955 (Figure 1-2), with on-site worker accommodation serviced by fly-in/fly-out access.

The Project would include the following key facilities to support the extraction and processing of uranium from the Arrow deposit for transportation off site (Figure 1-3):

- underground mine development;
- process plant buildings, including uranium concentrate packaging facilities;
- paste tailings distribution system;
- underground tailings management facility (UGTMF);
- potentially acid generating waste rock storage area;
- non-potentially acid generating waste rock storage area;
- special waste rock[1] and ore storage stockpiles;
- surface and underground water management infrastructure, including water management ponds, effluent treatment plant, and sewage treatment plant;
- conventional waste management facilities and fuel storage facilities;
- ancillary infrastructure, including maintenance shop, warehouse, administration building, and camp;
- airstrip and associated infrastructure; and
- access road to Project and site roads.

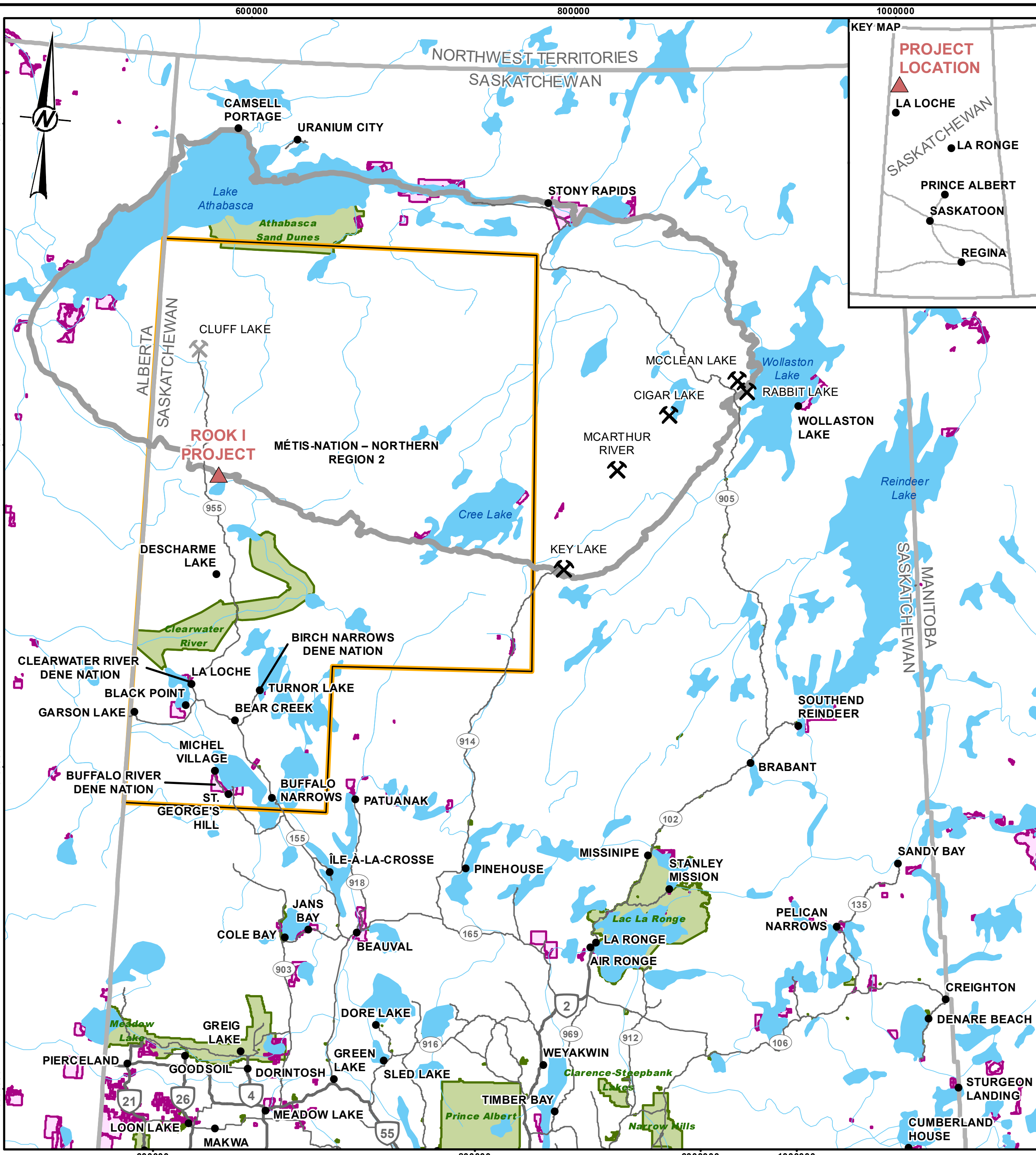
This technical support document to the Environmental Impact Statement (EIS) analyzes potential vibration effects from the proposed Project. Vibration from the Project could influence aquatic and terrestrial ecosystems, as well as the people that use natural resources or ecosystem services (e.g., surface water, fish, plants, wildlife). For the proposed Project, the only potential source of vibration that could create adverse effects to the social and biophysical environment would be explosive blasting. Explosive blasting would be required during Construction and Operations. Accordingly, this technical support document to the EIS analyzes potential vibration effects from Project blasting. Vibration from Project blasting could influence aquatic and terrestrial ecosystems, as well as the people that use natural resources or ecosystem services (e.g., surface water, fish, plants, and wildlife). The

[1] Special waste rock is mine rock that is mineralized with insufficient grade to be considered ore (i.e., greater than 0.03% of triuranium octoxide [U_3O_8] and less than 0.26% U_3O_8). All special waste would be temporarily stored in the special waste rock stockpile.

vibration analysis provides information that is used to support the assessments of biophysical, cultural, and socio-economic valued components.

Vibration specifically supports the effects assessments for the following components:

- fish and fish habitat (EIS Section 11);
- wildlife and wildlife habitat (EIS Section 14);
- cultural and heritage resources and Indigenous land and resource use (EIS Section 16); and
- other land and resource use (EIS Section 17).



LEGEND

- POPULATED PLACE
- URANIUM MINING FACILITY (ACTIVE)
- URANIUM MINING FACILITY (DECOMMISSIONED)
- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- WATERCOURSE
- ATHABASCA BASIN BOUNDARY
- INDIAN RESERVE
- PROVINCIAL PARKS
- WATERBODY
- PROJECT LOCATION
- MÉTIS NATION-SASKATCHEWAN NORTHERN REGION 2

0 100 200
1:3,500,000 KILOMETRES

REFERENCE(S)
1. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
2. PARKS OBTAINED FROM IHS MARKIT CANADA ULC.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT
NexGen Energy Ltd.
ROOK I PROJECT

TITLE
LOCATION OF THE ROOK I PROJECT

CONSULTANT
wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	JMC	2023-10-25	SCALE AS SHOWN	REV. 0
GIS	NO	2023-10-25	FIGURE 1-1	
CHECK	JMC	2023-10-25		
REVIEW	MM	2023-10-25		

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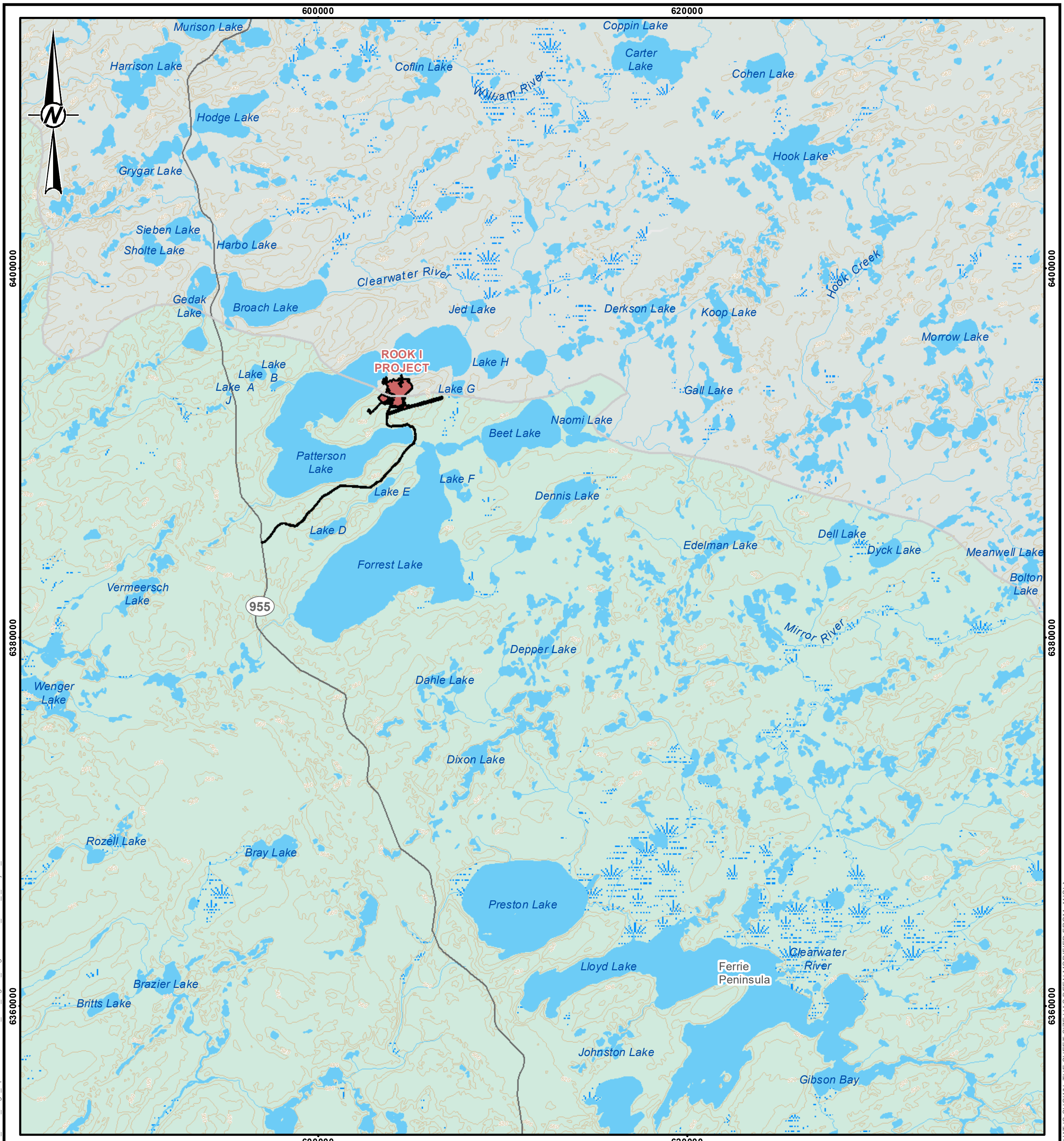


LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- SECONDARY HIGHWAY
- WATERCOURSE
- ATHABASCA BASIN
- WATERBODY
- WETLAND
- WOODED AREA
- PROPOSED PROJECT FOOTPRINT

0 5 10

1:300,000 KILOMETRES

REFERENCE(S)
1. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021.
2. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

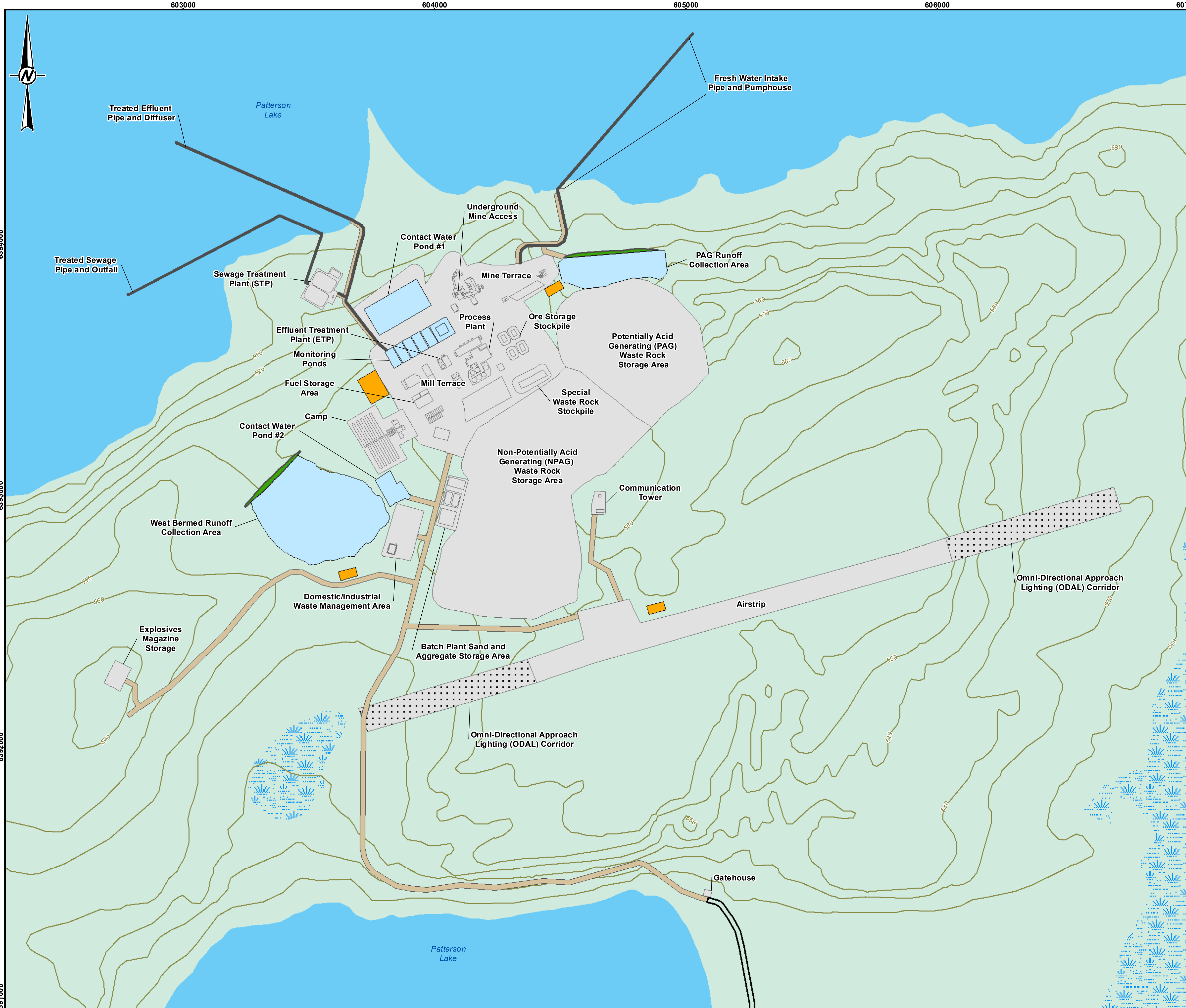
TITLE

REGIONAL AREA OF THE ROOK I PROJECT

CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	JMC	2023-10-25	SCALE AS SHOWN	REV. 0
GIS	NO	2023-10-25	**FIGURE 1-2**	
CHECK	JMC	2023-10-25		
REVIEW	MM	2023-10-25		



LEGEND

- ELEVATION CONTOUR (10 m INTERVAL)
- WATERBODY
- WETLAND
- WOODED AREA
- INTAKE OR DISCHARGE PIPE
- ACCESS ROAD
- CONTACT WATER CONTAINMENT BERM
- OMNI-DIRECTIONAL APPROACH LIGHTING (ODAL) CORRIDOR
- PROJECT INFRASTRUCTURE
- SITE ROAD
- TOPSOIL STORAGE AREA
- WATER MANAGEMENT POND

0 0.5 1

1:15,500 KILOMETRES

REFERENCE(S)

1. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021 AND UPDATED JUNE 8, 2021 .
2. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

LAYOUT OF INFRASTRUCTURE AND FACILITIES FOR THE ROOK I PROJECT

CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	JV	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-10-25	**FIGURE 1-3**	
CHECK	JMC	2023-10-25		
REVIEW	MM	2023-10-25		

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2.0 METHODS

This subsection of the technical support document describes the methods used to analyze potential vibration effects from Project blasting. It describes the measurement indicators used to characterize vibration levels, the regulatory thresholds used to characterize vibration effects, the study area and receptors used in the analysis, and the methods used to predict vibration levels from blasting activities.

2.1 Measurement Indicators

Vibration from explosive blasting was analyzed using two measurement indicators:

- **Peak particle velocity (PPV):** characterizes ground vibration (i.e., the physical shaking of the ground as a result of an explosive detonation) and is expressed in millimetres per second (mm/s).
- **Peak pressure level (PPL):** characterizes overpressure (i.e., the movement of air or water as a result of an explosive detonation) and is expressed in linear decibels (dBL) in air or kilopascals (kPa) in water.

People experience overpressure differently than audible sound because most of the energy associated with explosive overpressure occurs at frequencies too low to be perceived by the human ear or auditory system. Therefore, it is not appropriate to compare audible noise levels, expressed in A-weighted decibels (dBA), to PPL values, expressed in linear decibels. For example, an audible noise level of 115 dBA is extremely loud, while a PPL of 115 dBL is barely perceptible and inaudible.

Vibration from explosives can cause disturbance to the people that use natural resources or ecosystem services. Vibration from explosives can also cause disturbance, injury, or death to fish. Wildlife can perceive ground vibration; therefore, vibration can affect wildlife habitat use around the Project.

2.1.1 Regulatory Guidance and Thresholds

Vibration from Project blasting was analyzed using thresholds from:

- Environment and Climate Change Canada (ECCC) *Environmental Code of Practice for Metal Mines* (Environment Canada 2009);
- Fisheries and Oceans Canada (DFO) *Guidelines for the Use of Explosives in or near Canadian Fisheries Waters* (Wright and Hopky 1998) and associated recommendations (Cott and Hanna 2005); and
- Australian and New Zealand Environment Council (ANZEC) *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration* (ANZEC 1990).

The PPV and PPL vibration thresholds from ECCC, DFO, and ANZEC are presented in Table 2-1.

Table 2-1: Vibration Thresholds

Measurement Endpoint	ECCC Cosmetic Damage Threshold	DFO Fish Protection Threshold	ANZEC Human Annoyance Threshold
ground vibration; PPV	12.5 mm/s	13 mm/s	5 mm/s
overpressure; PPL	128 dBL	50 kPa	115 dBL

ECCC = Environment and Climate Change Canada; DFO = Fisheries and Oceans Canada; ANZEC = Australian and New Zealand Environment Council; PPV = peak particle velocity; PPL = peak pressure level; dBL = linear decibel; kPa = kilopascal.

Vibration thresholds from Environment Canada (2009) are primarily intended to protect against minor cosmetic damage to structures and are applicable at receptors located “beyond the boundaries of the mine property”. Vibration thresholds from DFO are intended to protect general fish habitat and fish spawning habitat. The DFO PPV threshold applies “in a spawning bed during the period of egg incubation” (Wright and Hopky 1998), and the DFO PPL threshold applies to general fish habitat. Vibration thresholds from ANZEC are intended to protect against human annoyance and are applicable at “sensitive sites” such as “residences” (ANZEC 1990). There are no regulatory standards or accepted thresholds for analyzing vibration effects on terrestrial wildlife.

2.2 Study Area

A maximum disturbance area of 981 ha was used for the assessment of terrain and soils, vegetation, and wildlife and wildlife habitat to address uncertainty in the final design of the Project. The maximum disturbance area represents the smallest scale of assessment and an area where the potential direct effects of the anticipated Project on soils, vegetation, and wildlife can be assessed accurately and precisely. The spatial boundary of the maximum disturbance area was delineated by applying buffers to the outer edges of the anticipated Project infrastructure. The spatial boundary was also constrained to the shoreline of Patterson Lake (Figure 2-1).

The study area for the vibration analysis was defined as a 10 km buffer surrounding the maximum disturbance area for the Project (Figure 2-1). This study area is large enough to characterize any vibration effects from the Project, as well as any potential cumulative effects from the Patterson Lake South Property, which is a reasonably foreseeable development (RFD) proposed by Fission Uranium Corp. (Fission 2019, 2021).

Receptors within the vibration study area were primarily identified through NexGen’s engagement with local First Nations and Métis Groups (collectively referred to as Indigenous Groups) and local communities. A review was completed of the comments provided on the Rook I Project Description by the Clearwater River Dene Nation (CRDN 2019), Métis Nation – Saskatchewan (MN-S 2019), and Ya’thi Néné Land and Resources (YNLRO 2019). Indigenous Knowledge and Traditional Land Use Studies completed by the Clearwater River Dene Nation (Technical Support Document [TSD] V.1: CRDN; TSD V.2: CRDN), Métis Nation – Saskatchewan (TSD IV: MN-S), Birch Narrows Dene Nation (TSD II: BNDN), Buffalo River Dene Nation (TSD III: BRDN), and Ya’thi Néné Land and Resources (TSD VI: YNLR) were also reviewed. Receptors identified through this process are shown in Figure 2-1. These receptors correspond to the closest known human presence within the vibration study area. These same receptors were used in the assessment of potential noise effects (EIS Section 7.3, Noise) and in the analysis of potential light effects (TSD XI, Light Effects Analysis Report).

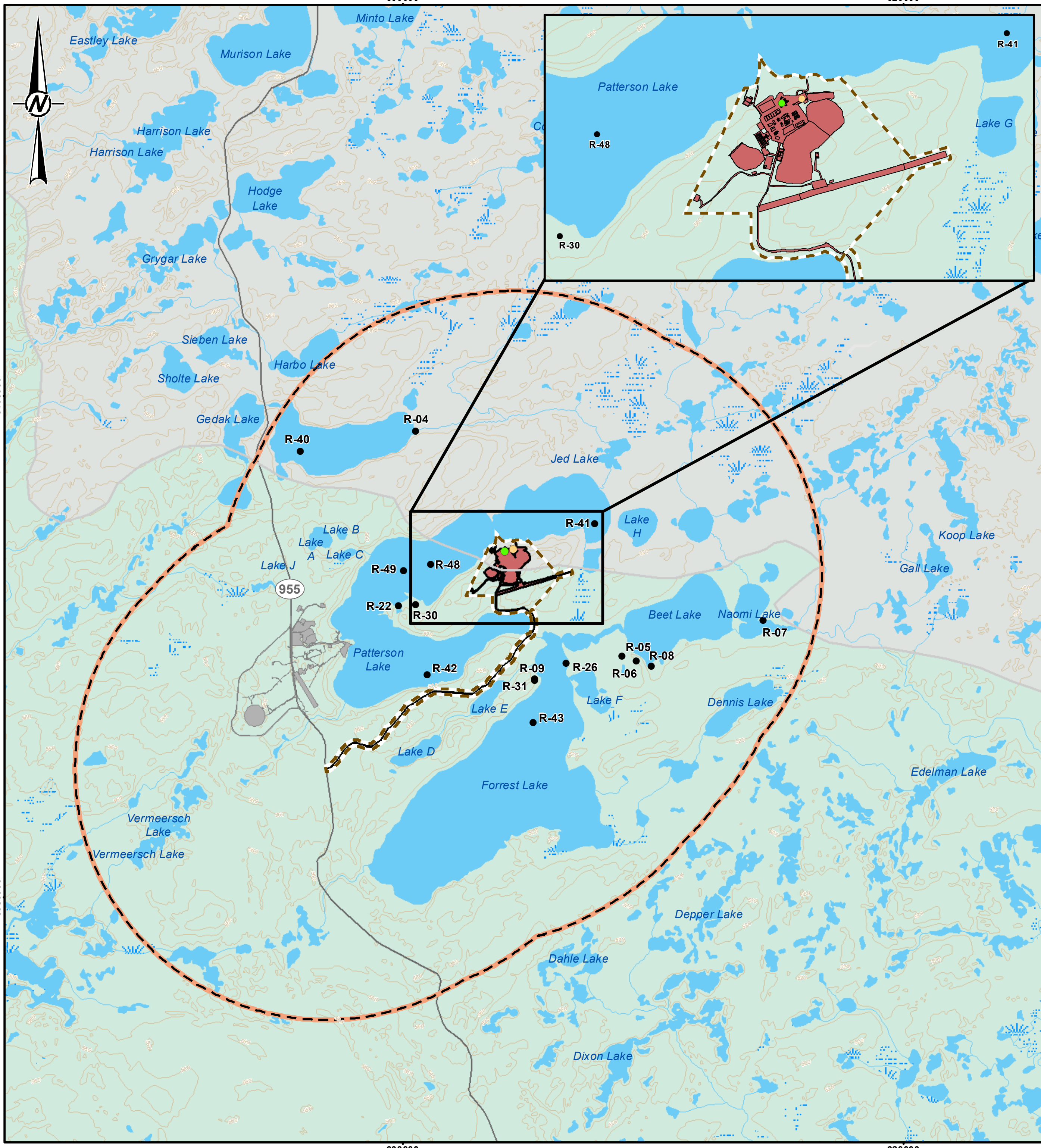
One conceptual receptor was also considered in the vibration analysis. The conceptual receptor corresponds to the point within Patterson Lake nearest the anticipated location of Project blasting (R-Fish). This conceptual receptor was included in the analysis to capture maximum vibration levels for comparison with DFO thresholds.

The vibration thresholds relevant to different terrestrial and aquatic receptors are outlined in the list below and are presented in Table 2-2 along with the receptors considered in the vibration analysis.

- **Terrestrial receptors:** Vibration was analyzed using PPV and PPL thresholds from the ECCC and ANZEC documents. Thresholds from DFO are not applicable for terrestrial receptors.
- **Human receptors at angling locations:** Vibration was analyzed using PPL thresholds from ECCC and ANZEC documents to characterize effects on human users over water. Vibration was also analyzed using

PPV and PPL thresholds from DFO to characterize effects on fish under water. The PPV thresholds from the ECCC and ANZEC are intended to characterize ground vibration and, therefore, are not relevant at these aquatic receptors.

- **Aquatic receptor corresponding to the shortest distance between Patterson Lake and the anticipated location of Project blasting:** Vibration was analyzed using PPV and PPL thresholds from DFO. Because this receptor is assumed to be under water, thresholds from ECCC and ANZEC are not relevant at this receptor.



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- SECONDARY HIGHWAY
- WATERCOURSE
- ATHABASCA BASIN
- WATERBODY
- WETLAND
- WOODED AREA
- PROPOSED PROJECT FOOTPRINT
- MAXIMUM DISTURBANCE AREA
- FISSION PATTERSON LAKE SOUTH PROPERTY FOOTPRINT
- PROJECT EXHAUST SHAFT
- PROJECT PRODUCTION SHAFT
- VIBRATION RECEPTORS
- VIBRATION STUDY AREA

0 5 10

1:225,000 KILOMETRES

REFERENCE(S)

1. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021
2. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
3. FISSION (FISSION URANIUM CORP.) OBTAINED FROM 2019 TECHNICAL REPORT ON THE PRE-FEASIBILITY STUDY OF THE PATTERSON LAKE SOUTH PROPERTY USING UNDERGROUND MINING METHODS.

PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

VIBRATION STUDY AREA AND RECEPTORS

CONSULTANT

wsp

PROJECT		20144150	PHASE	3102 - 3
DESIGN	VY	2023-10-25	SCALE AS SHOWN	REV. 0
GIS	NO	2023-10-25		
CHECK	VY	2023-10-25	FIGURE 2-1	
REVIEW	AF	2023-10-25		

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Table 2-2: Vibration Receptors and Relevant Thresholds

Receptor Identification Code[a]	Universal Transverse Mercator Coordinates (Zone 12)		Receptor Description	Relevant Thresholds
	Easting (m)	Northing (m)		
R-04	600523	6398606	Cabin[b]	Terrestrial receptor: PPV and PPL thresholds from ECCC and ANZEC.
R-05	608757	6389632	Lodge[b]	Terrestrial receptor: PPV and PPL thresholds from ECCC and ANZEC.
R-06	609329	6389420	Cabin (old cabin)[b]	Terrestrial receptor: PPV and PPL thresholds from ECCC and ANZEC.
R-07	614387	6391050	Cabin[b]	Terrestrial receptor: PPV and PPL thresholds from ECCC and ANZEC.
R-08	609942	6389235	Camp (tourist camp)[b]	Terrestrial receptor: PPV and PPL thresholds from ECCC and ANZEC.
R-09	605286	6388706	Camp (tourist camp)[b]	Terrestrial receptor: PPV and PPL thresholds from ECCC and ANZEC.
R-22	599851	6391630	Fishing (nets)[b]	Human receptor at angling location: PPL thresholds from ECCC and AZEC; PPV and PPL thresholds from DFO.
R-26	606543	6389350	Plane crash[b]	Terrestrial receptor: PPV and PPL thresholds from ECCC and ANZEC.
R-30	600546	6391678	Historical camp[b]	Terrestrial receptor: PPV and PPL thresholds from ECCC and ANZEC.
R-31	605282	6388662	Camp (rough camp)[b]	Terrestrial receptor: PPV and PPL thresholds from ECCC and ANZEC.
R-40	595924	6397789	Fishing[b]	Human receptor at angling location: PPL thresholds from ECCC and ANZEC; PPV and PPL thresholds from DFO.
R-41	607681	6394910	Fishing[b]	Human receptor at angling location: PPL thresholds from ECCC and ANZEC; PPV and PPL thresholds from DFO.
R-42	600992	6388870	Fishing[b]	Human receptor at angling location: PPL thresholds from ECCC and ANZEC; PPV and PPL thresholds from DFO.
R-43	605233	6386971	Fishing[b]	Human receptor at angling location: PPL thresholds from ECCC and ANZEC; PPV and PPL thresholds from DFO.
R-48	601140	6393297	Fishing[b]	Human receptor at angling location: PPL thresholds from ECCC and ANZEC; PPV and PPL thresholds from DFO.
R-49	600042	6393020	Fishing[b]	Human receptor at angling location: PPL thresholds from ECCC and ANZEC; PPV and PPL thresholds from DFO.
R-Fish	n/a[c]	n/a[c]	Point within Patterson Lake nearest the anticipated location of Project blasting; minimum separation distance 345 m.	Aquatic receptor without human presence: PPV and PPL thresholds from DFO.

a) This table lists all the receptors within the vibration study area that were identified during community engagement activities. Receptor numbering is non-continuous because some of the locations identified during community engagement activities were beyond the vibration study area.

b) Receptor description provided during community engagement activities.

c) This is a conceptual receptor that represents the minimum separation between Patterson Lake and anticipated Project blasting (i.e., 345 m).

PPL = peak pressure level; PPV = peak particle velocity; ECCC = Environment and Climate Change Canada; ANZEC = Australian and New Zealand Environment Council; DFO = Fisheries and Oceans Canada.

2.3 Temporal Boundaries

The temporal scope of the vibration analysis focuses on the 43-year period from initial Construction to the end of Decommissioning and Reclamation (i.e., Closure) as defined by the following Project phases (EIS Section 6.4.2, Temporal Boundaries):

- **Construction Phase (Construction):** includes site preparation; mine, process plant, and additional infrastructure development; transportation of people and materials to and from the Project; and all activities associated with commissioning the Project up until Operations commences. The duration of Construction is expected to be four years.
- **Operations Phase (Operations):** includes all activities associated with mining and processing ore; tailings management; management of waste rock, domestic waste, and hazardous materials; water management; release of treated effluent; site maintenance; progressive reclamation; and transportation of staff and materials to and from the Project up until Decommissioning and Reclamation commences. The duration of Operations is expected to be 24 years.
- **Decommissioning and Reclamation Phase (Closure):** includes two stages expected to occur over 15 years:
  - **Active Closure Stage:** includes active decommissioning and reclamation activities that occur post-Operations, such as backfilling mine workings, removal of physical infrastructure, recontouring and revegetating disturbed areas, waste disposal and removal, and any other activities deemed necessary to achieve decommissioning objectives and return the site to a safe and stable condition prior to the Transitional Monitoring Stage. The duration of the Active Closure Stage is expected to be five years.
  - **Transitional Monitoring Stage:** includes monitoring and reporting activities that occur post-Active Closure that would continue until monitoring and reporting verifies that the performance criteria have been met. Once performance criteria have been fully demonstrated, an application to be released from the Canadian Nuclear Safety Commission licence would be submitted to the Canadian Nuclear Safety Commission for approval. Once that is achieved, and upon Provincial approval, the land would be transferred back under Provincial management through the Institutional Control Program. The duration of the Transitional Monitoring Stage is nominally 10 years; however, NexGen acknowledges this duration would be dependent on the achievement of performance criteria.

The temporal boundaries applied to cumulative effects include the period during which explosive blasting at the Patterson Lake South Property may overlap Project blasting.

Explosive blasting is anticipated during Construction and Operations of the Project, but not during Closure. As such, quantitative vibration modelling focused on Construction and Operations to capture maximum predicted PPV and PPL from Project-related activities.

2.4 Prediction Methods

Empirical formulae from a blast vibration reference handbook (Richards and Moore 1995) were used to predict vibration levels that may cause cosmetic damage to buildings and/or human annoyance. The empirical formula used to predict PPV (expressed in mm/s) is presented in Equation 1, where D is the distance between the blast location and the receptor (expressed in metres), Q is the instantaneous charge mass (expressed in kilograms), k is a unitless “site constant”, and e is a unitless “site exponent”. The site constant (k) is used to represent general site conditions and the site exponent (e) is used to represent the blasting substrate. Assumed values of constants are described in the following subsection. The empirical formula used to predict PPL (expressed in dBL) is presented in Equation 2.

$$PPV = k\left(\frac{D}{\sqrt{Q}}\right)^{-e}$$ **(Equation 1)**

$$PPL = 20\log_{10}\left(3300 \times \left(\frac{D}{\sqrt[3]{Q}}\right)^{-1.2} / (20 \times 10^{-6})\right)$$ **(Equation 2)**

Empirical formulae presented in the DFO guideline document (Wright and Hopky 1998) were used to predict vibration levels for fish habitat. The empirical formula used to predict PPV (expressed in mm/s) is presented in Equation 3. The empirical formula used to predict PPL (expressed in kPa) is presented in Equation 4, where PPV is obtained from Equation 3, d_W is the density of water (expressed in g/cm^3), d_R is the density of the blasting substrate (expressed in g/cm^3), c_W is the speed of sound in water (expressed in cm/s), and c_R is the speed of sound in the blasting substrate (expressed in cm/s).

$$PPV = 1000 \times 10^{\left(-1.6\times\log_{10}\left(D/\sqrt{Q}\right)\right)}$$ **(Equation 3)**

$$PPL = \frac{PPV \times d_W c_W d_R c_R}{10^5 \times (d_R c_R + d_W d_R)}$$ **(Equation 4)**

2.4.1 Inputs and Assumptions

For active facilities, site-specific values for the site constant (k), site exponent (e), substrate density (d_R), and substrate sound speed (c_R) can be determined based on a statistical analysis of multiple blasts. Because Project blasting has not yet occurred, the vibration analysis for the Project used conservative estimates for the input constants (i.e., values that would tend to overestimate vibration effects from Project blasting). In particular, the vibration analysis assumed:

- site constant (k) of 5,000, which is representative of heavily confined charges (Richards and Moore 1995);
- site exponent (e) of 2.1, which is representative of blasting in granite (Richards and Moore 1995);
- substrate density (d_R) of 2.64 g/cm^3, which is representative of blasting in rock (Wright and Hopky 1998); and
- a substrate sound speed (c_R) of 457,200 cm/s, which is representative of blasting in rock (Wright and Hopky 1998).

Because Project blasting requirements would evolve throughout Construction and Operations, the vibration analysis focused on the maximum instantaneous charge masses for three different types of stope blasting:

- transverse production stopes, in which long hole stopes are extracted perpendicular to the strike of the ore body;
- longitudinal production stopes, in which long hole stopes are extracted parallel to the strike of the ore body; and
- development of the UGTMF chambers.

Focusing on the maximum instantaneous charge masses anticipated for the Project is a conservative approach to analyzing vibration effects (i.e., effects are likely overestimated).

Vibration levels were also predicted for blasting associated with the Patterson Lake South Property (Fission 2019). Blasting data for the Patterson Lake South Property were not publicly available at the time this vibration analysis was completed; therefore, blasting at the Patterson Lake South Property was assumed to be similar to anticipated blasting associated with the Project. In particular, the vibration analysis assumed blasting at the Patterson Lake South Property would use the same instantaneous charge masses anticipated for the Project and applied the same conservative estimates for site-specific constants (i.e., k, e, d_R, and c_R) in the empirical formulae.

Publicly available information about the Fission Patterson Lake South Property indicates that tailings would be stored above ground and there would be no underground tailings management facility associated with this development (Fission 2019). However, the Patterson Lake South Property would require underground blasting below Patterson Lake; vibration levels from this underground blasting activity were predicted using the same instantaneous charge mass as UGTMF blasting for the Project.

Table 2-3 presents the instantaneous charge masses used to predict vibration levels for Project blasting and for blasting at the Patterson Lake South Property.

Table 2-3: Charge Masses for Vibration Analysis

Project Blasting		Blasting at Patterson Lake South Property	
Type of Blasting	**Maximum Instantaneous Charge Mass (kg)**	**Type of Blasting**	**Maximum Instantaneous Charge Mass[c] (kg)**
Transverse	282.7[a]	Transverse	282.7
Longitudinal	282.7[a]	Longitudinal	282.7
UGTMF	519.0[b]	Underground	519.0

a) Espenberg 2021.

b) Halliday 2021.

c) Blasting at the Patterson Lake South Property was assumed to be similar to anticipated blasting associated with the Project.

UGTMF = underground tailings management facility.

For each receptor identified in Table 2-2, PPV and PPL vibration levels from the Project and from the Patterson Lake South Property were predicted for transverse, longitudinal, and UGTMF/underground blasting using instantaneous charge masses from Table 2-3. Vibration levels were predicted for Project blasting at the production shaft and the exhaust shaft. Vibration levels were also predicted for Project blasting at the nearest anticipated location to Patterson Lake.

2.5 Analysis Cases

Analysis cases were applied to the vibration study area to estimate the incremental and cumulative effects from the Project and the Patterson Lake South Property. The approach incorporated temporal boundaries for analyzing the potential effects from previous, existing, and approved projects and RFDs before, during, and after the anticipated lifespan of the Project. Analysis cases included a Base Case, Application Case, and RFD Case.

Base Case is represented by existing conditions. The Base Case describes the existing environment in the vibration study area before application of the Project to provide an understanding of the current conditions that may be influenced by the Project.

Application Case represents predictions of the combined effects of the previous and existing projects/activities and natural factors in the Base Case plus the potential effects from the proposed Project. This case was also used to identify and assess incremental, Project-specific changes that are predicted to occur.

Reasonably Foreseeable Development (RFD) Case includes the Base Case, Application Case, and the Patterson Lake South Property.

3.0 RESULTS

3.1 Base Case

There are no sources of explosive blasting currently active within the vibration study area. Therefore, PPV and PPL for the Base Case are effectively zero for all receptors.

3.2 Application Case

Table 3-1 presents predicted vibration levels for blasting at the Project production shaft. Table 3-2 presents predicted vibration levels for blasting at the Project exhaust shaft. Table 3-3 presents predicted vibration levels for blasting at the nearest anticipated location to Patterson Lake.

Table 3-1: Predicted Vibration Levels for Blasting at the Project Production Shaft

Receptor Identification Code	Transverse Blasting				Longitudinal Blasting				UGTMF Blasting			
	Vibration Predictions for ECCC and ANZEC Analysis		Vibration Predictions for DFO Analysis		Vibration Predictions for ECCC and ANZEC Analysis		Vibration Predictions for DFO Analysis		Vibration Predictions for ECCC and ANZEC Analysis		Vibration Predictions for DFO Analysis	
	PPV (mm/s)	PPL (dBL)	PPV (mm/s)	PPL (kPa)	PPV (mm/s)	PPL (dBL)	PPV (mm/s)	PPL (kPa)	PPV (mm/s)	PPL (dBL)	PPV (mm/s)	PPL (kPa)
R-04	0.0	93.3	n/a[(a)]	n/a[(a)]	0.0	93.3	n/a[(a)]	n/a[(a)]	0.0	95.4	n/a[(a)]	n/a[(a)]
R-05	0.0	92.8	n/a[(a)]	n/a[(a)]	0.0	92.8	n/a[(a)]	n/a[(a)]	0.0	94.9	n/a[(a)]	n/a[(a)]
R-06	0.0	91.9	n/a[(a)]	n/a[(a)]	0.0	91.9	n/a[(a)]	n/a[(a)]	0.0	94.0	n/a[(a)]	n/a[(a)]
R-07	0.0	87.3	n/a[(a)]	n/a[(a)]	0.0	87.3	n/a[(a)]	n/a[(a)]	0.0	89.4	n/a[(a)]	n/a[(a)]
R-08	0.0	91.1	n/a[(a)]	n/a[(a)]	0.0	91.1	n/a[(a)]	n/a[(a)]	0.0	93.2	n/a[(a)]	n/a[(a)]

Table 3-1: Predicted Vibration Levels for Blasting at the Project Production Shaft

Receptor Identification Code	Transverse Blasting				Longitudinal Blasting				UGTMF Blasting			
	Vibration Predictions for ECCC and ANZEC Analysis		Vibration Predictions for DFO Analysis		Vibration Predictions for ECCC and ANZEC Analysis		Vibration Predictions for DFO Analysis		Vibration Predictions for ECCC and ANZEC Analysis		Vibration Predictions for DFO Analysis	
	PPV (mm/s)	PPL (dBL)	PPV (mm/s)	PPL (kPa)	PPV (mm/s)	PPL (dBL)	PPV (mm/s)	PPL (kPa)	PPV (mm/s)	PPL (dBL)	PPV (mm/s)	PPL (kPa)
R-09	0.0	94.7	n/a[(a)]	n/a[(a)]	0.0	94.7	n/a[(a)]	n/a[(a)]	0.1	96.8	n/a[(a)]	n/a[(a)]
R-22	n/a[(b)]	95.7	0.1	0	n/a[(b)]	95.7	0.1	0	n/a[(b)]	97.8	0.2	0
R-26	0.0	95.0	n/a[(a)]	n/a[(a)]	0.0	95.0	n/a[(a)]	n/a[(a)]	0.1	97.1	n/a[(a)]	n/a[(a)]
R-30	0.0	97.2	n/a[(a)]	n/a[(a)]	0.0	97.2	n/a[(a)]	n/a[(a)]	0.1	99.3	n/a[(a)]	n/a[(a)]
R-31	0.0	94.6	n/a[(a)]	n/a[(a)]	0.0	94.6	n/a[(a)]	n/a[(a)]	0.1	96.7	n/a[(a)]	n/a[(a)]
R-40	n/a[(b)]	89.0	0.0	0	n/a[(b)]	89.0	0.0	0	n/a[(b)]	91.1	0.1	0
R-41	n/a[(b)]	98.2	0.2	0	n/a[(b)]	98.2	0.2	0	n/a[(b)]	100.3	0.3	0
R-42	n/a[(b)]	93.6	0.1	0	n/a[(b)]	93.6	0.1	0	n/a[(b)]	95.7	0.1	0
R-43	n/a[(b)]	91.8	0.1	0	n/a[(b)]	91.8	0.1	0	n/a[(b)]	93.9	0.1	0
R-48	n/a[(b)]	100.5	0.3	0	n/a[(b)]	100.5	0.3	0	n/a[(b)]	102.7	0.4	1
R-49	n/a[(b)]	97.2	0.2	0	n/a[(b)]	97.2	0.2	0	n/a[(b)]	99.3	0.2	0

a) DFO vibration analysis is not required for terrestrial receptors.

b) ECCC and ANZEC analysis of PPV is not required for human receptors at angling locations.

UGTMF = underground tailings management facility; PPL = peak pressure level; PPV = peak particle velocity; ECCC = Environment and Climate Change Canada; ANZEC = Australian and New Zealand Environment Council; DFO = Fisheries and Oceans Canada; kPa = kilopascal; dBL = linear decibel.

Table 3-2: Predicted Vibration Levels for Blasting at the Project Exhaust Shaft

Receptor Identification Code	Transverse Blasting				Longitudinal Blasting				UGTMF Blasting			
	Vibration Predictions for ECCC and ANZEC Analysis		Vibration Predictions for DFO Analysis		Vibration Predictions for ECCC and ANZEC Analysis		Vibration Predictions for DFO Analysis		Vibration Predictions for ECCC and ANZEC Analysis		Vibration Predictions for DFO Analysis	
	PPV (mm/s)	PPL (dBL)	PPV (mm/s)	PPL (kPa)	PPV (mm/s)	PPL (dBL)	PPV (mm/s)	PPL (kPa)	PPV (mm/s)	PPL (dBL)	PPV (mm/s)	PPL (kPa)
R-04	0.0	93.1	n/a[(a)]	n/a[(a)]	0.0	93.1	n/a[(a)]	n/a[(a)]	0.0	95.2	n/a[(a)]	n/a[(a)]
R-05	0.0	93.2	n/a[(a)]	n/a[(a)]	0.0	93.2	n/a[(a)]	n/a[(a)]	0.0	95.3	n/a[(a)]	n/a[(a)]
R-06	0.0	92.2	n/a[(a)]	n/a[(a)]	0.0	92.2	n/a[(a)]	n/a[(a)]	0.0	94.3	n/a[(a)]	n/a[(a)]
R-07	0.0	87.6	n/a[(a)]	n/a[(a)]	0.0	87.6	n/a[(a)]	n/a[(a)]	0.0	89.7	n/a[(a)]	n/a[(a)]
R-08	0.0	91.3	n/a[(a)]	n/a[(a)]	0.0	91.3	n/a[(a)]	n/a[(a)]	0.0	93.5	n/a[(a)]	n/a[(a)]
R-09	0.0	94.7	n/a[(a)]	n/a[(a)]	0.0	94.7	n/a[(a)]	n/a[(a)]	0.1	96.8	n/a[(a)]	n/a[(a)]
R-22	n/a[(b)]	95.0	0.1	0	n/a[(b)]	95.0	0.1	0	n/a[(b)]	97.1	0.2	0
R-26	0.0	95.2	n/a[(a)]	n/a[(a)]	0.0	95.2	n/a[(a)]	n/a[(a)]	0.1	97.3	n/a[(a)]	n/a[(a)]
R-30	0.0	96.4	n/a[(a)]	n/a[(a)]	0.0	96.4	n/a[(a)]	n/a[(a)]	0.1	98.5	n/a[(a)]	n/a[(a)]
R-31	0.0	94.6	n/a[(a)]	n/a[(a)]	0.0	94.6	n/a[(a)]	n/a[(a)]	0.1	96.7	n/a[(a)]	n/a[(a)]

Table 3-2: Predicted Vibration Levels for Blasting at the Project Exhaust Shaft

Receptor Identification Code	Transverse Blasting				Longitudinal Blasting				UGTMF Blasting			
	Vibration Predictions for ECCC and ANZEC Analysis		Vibration Predictions for DFO Analysis		Vibration Predictions for ECCC and ANZEC Analysis		Vibration Predictions for DFO Analysis		Vibration Predictions for ECCC and ANZEC Analysis		Vibration Predictions for DFO Analysis	
	PPV (mm/s)	PPL (dBL)	PPV (mm/s)	PPL (kPa)	PPV (mm/s)	PPL (dBL)	PPV (mm/s)	PPL (kPa)	PPV (mm/s)	PPL (dBL)	PPV (mm/s)	PPL (kPa)
R-40	n/a(b)	88.7	0.0	0	n/a(b)	88.7	0.0	0	n/a(b)	90.8	0.1	0
R-41	n/a(b)	99.1	0.2	0	n/a(b)	99.1	0.2	0	n/a(b)	101.2	0.3	0
R-42	n/a(b)	93.2	0.1	0	n/a(b)	93.2	0.1	0	n/a(b)	95.3	0.1	0
R-43	n/a(b)	91.7	0.1	0	n/a(b)	91.7	0.1	0	n/a(b)	93.9	0.1	0
R-48	n/a(b)	99.5	0.2	0	n/a(b)	99.5	0.2	0	n/a(b)	101.6	0.3	0
R-49	n/a(b)	96.4	0.1	0	n/a(b)	96.4	0.1	0	n/a(b)	98.5	0.2	0

a) DFO vibration analysis is not required for terrestrial receptors.

b) ECCC and ANZEC analysis of PPV is not required for human receptors at angling locations.

UGTMF = underground tailings management facility; PPL = peak pressure level; PPV = peak particle velocity; ECCC = Environment and Climate Change Canada; ANZEC = Australian and New Zealand Environment Council; DFO = Fisheries and Oceans Canada; kPa = kilopascal; dBL = linear decibel.

Table 3-3: Predicted Vibration Levels for Project Blasting at the Nearest Anticipated Location to Patterson Lake

Receptor Identification Code	Transverse Blasting				Longitudinal Blasting				UGTMF Blasting			
	Vibration Predictions for ECCC and ANZEC Analysis		Vibration Predictions for DFO Analysis		Vibration Predictions for ECCC and ANZEC Analysis		Vibration Predictions for DFO Analysis		Vibration Predictions for ECCC and ANZEC Analysis		Vibration Predictions for DFO Analysis	
	PPV (mm/s)	PPL (dBL)	PPV (mm/s)	PPL (kPa)	PPV (mm/s)	PPL (dBL)	PPV (mm/s)	PPL (kPa)	PPV (mm/s)	PPL (dBL)	PPV (mm/s)	PPL (kPa)
R-Fish(a)	n/a(b)	n/a(b)	8.0	10	n/a(b)	n/a(b)	8.0	10	n/a(b)	n/a(b)	12.9	17

a) Conceptual receptor located 345 m from the blast site.

b) ECCC and ANZEC vibration analysis is not required for aquatic receptors without human presence.

UGTMF = underground tailings management facility; PPL = peak pressure level; PPV = peak particle velocity; ECCC = Environment and Climate Change Canada; ANZEC = Australian and New Zealand Environment Council; DFO = Fisheries and Oceans Canada; kPa = kilopascal; dBL = linear decibel.

Table 3-4 compares maximum predicted PPV values from Project blasting to ECCC and ANZEC thresholds for each terrestrial receptor. Table 3-5 compares maximum predicted PPL values from Project blasting to ECCC and ANZEC thresholds for each terrestrial receptor and each human receptor at an angling location.

Table 3-6 compares maximum predicted PPV values from Project blasting to the DFO threshold for each aquatic receptor. Table 3-7 compares maximum predicted PPL values from Project to the DFO threshold for each aquatic receptor. By focusing on the maximum predicted PPV or PPL value at each receptor, the results presented in Table 3-4, Table 3-5, Table 3-6, and Table 3-7 represent a precautionary analysis of vibration effects from the Project.

Table 3-4: Comparison of Peak Particle Velocity from Project Blasting to Environment and Climate Change Canada and Australian and New Zealand Environment Council Thresholds

Receptor Identification Code	PPV Thresholds (mm/s)		Blasting Scenario with Maximum PPV	Maximum PPV (mm/s)	Result
	ECCC[(a)]	ANZEC[(b)]			
R-04	12.5	5.0	UGTMF blasting at Project production shaft	0.0	Maximum PPV is less than ECCC and ANZEC thresholds
R-05	12.5	5.0	UGTMF blasting at Project exhaust shaft	0.0	
R-06	12.5	5.0	UGTMF blasting at Project exhaust shaft	0.0	
R-07	12.5	5.0	UGTMF blasting at Project exhaust shaft	0.0	
R-08	12.5	5.0	UGTMF blasting at Project exhaust shaft	0.0	
R-09	12.5	5.0	UGTMF blasting at Project exhaust shaft	0.1	
R-26	12.5	5.0	UGTMF blasting at Project exhaust shaft	0.1	
R-30	12.5	5.0	UGTMF blasting at Project production shaft	0.1	
R-31	12.5	5.0	UGTMF blasting at Project exhaust shaft	0.1	

a) PPV threshold from ECCC document (Environment Canada 2009).

b) PPV threshold from ANZEC document (ANZEC 1990).

UGTMF = underground tailings management facility; PPV = peak particle velocity; ECCC = Environment and Climate Change Canada; ANZEC = Australian and New Zealand Environment Council.

Table 3-5: Comparison of Peak Pressure Level from Project Blasting to Environment and Climate Change Canada and Australian and New Zealand Environment Council Thresholds

Receptor Identification Code	PPL Thresholds (dBL)		Blasting Scenario with Maximum PPL	Maximum PPL (dBL)	Result
	ECCC[(a)]	ANZEC[(b)]			
R-04	128.0	115.0	UGTMF blasting at Project production shaft	95.4	Maximum PPL is less than ECCC and ANZEC thresholds
R-05	128.0	115.0	UGTMF blasting at Project exhaust shaft	95.3	
R-06	128.0	115.0	UGTMF blasting at Project exhaust shaft	94.3	
R-07	128.0	115.0	UGTMF blasting at Project exhaust shaft	89.7	
R-08	128.0	115.0	UGTMF blasting at Project exhaust shaft	93.5	
R-09	128.0	115.0	UGTMF blasting at Project exhaust shaft	96.8	
R-22	128.0	115.0	UGTMF blasting at Project production shaft	97.8	
R-26	128.0	115.0	UGTMF blasting at Project exhaust shaft	97.3	
R-30	128.0	115.0	UGTMF blasting at Project production shaft	99.3	
R-31	128.0	115.0	UGTMF blasting at Project production shaft	96.7	
R-40	128.0	115.0	UGTMF blasting at Project production shaft	91.1	
R-41	128.0	115.0	UGTMF blasting at Project exhaust shaft	101.2	
R-42	128.0	115.0	UGTMF blasting at Project production shaft	95.7	
R-43	128.0	115.0	UGTMF blasting at Project exhaust shaft	93.9	
R-48	128.0	115.0	UGTMF blasting at Project production shaft	102.7	
R-49	128.0	115.0	UGTMF blasting at Project production shaft	99.3	

a) PPL threshold from ECCC document (Environment Canada 2009).

b) PPL threshold from ANZEC document (ANZEC 1990).

UGTMF = underground tailings management facility; PPL = peak particle level; ECCC = Environment and Climate Change Canada; ANZEC = Australian and New Zealand Environment Council; dBL = linear decibel.

Table 3-6: Comparison of Peak Particle Velocity from Project Blasting to Fisheries and Oceans Canada Thresholds

Receptor Identification Code	DFO PPV Threshold[a] (mm/s)	Blasting Scenario with Maximum PPV	Maximum PPV (mm/s)	Result
R-22	13.0	UGTMF blasting at Project production shaft	0.2	Maximum PPV is less than DFO threshold
R-40	13.0	UGTMF blasting at Project exhaust shaft	0.1	
R-41	13.0	UGTMF blasting at Project exhaust shaft	0.3	
R-42	13.0	UGTMF blasting at Project production shaft	0.1	
R-43	13.0	UGTMF blasting at Project exhaust shaft	0.1	
R-48	13.0	UGTMF blasting at Project production shaft	0.4	
R-49	13.0	UGTMF blasting at Project production shaft	0.2	
R-Fish	13.0	UGTMF blasting 345 m from Patterson Lake	12.9	

a) PPV threshold from DFO guidance document (Wright and Hopky 1998).

UGTMF = underground tailings management facility; PPV = peak particle velocity; DFO = Fisheries and Oceans Canada.

Table 3-7: Comparison of Peak Pressure Level from Project Blasting to Fisheries and Oceans Canada Thresholds

Receptor Identification Code	DFO PPL Threshold (kPa)[a]	Blasting Scenario with Maximum PPL	Maximum PPL (kPa)	Result
R-22	50	UGTMF blasting at Project production shaft	0	Maximum PPL is less than DFO threshold
R-40	50	UGTMF blasting at Project exhaust shaft	0	
R-41	50	UGTMF blasting at Project exhaust shaft	0	
R-42	50	UGTMF blasting at Project production shaft	0	
R-43	50	UGTMF blasting at Project exhaust shaft	0	
R-48	50	UGTMF blasting at Project production shaft	1	
R-49	50	UGTMF blasting at Project production shaft	0	
R-Fish	50	UGTMF blasting 345 m from Patterson Lake	17	

a) PPL threshold from DFO guidance document (Wright and Hopky 1998).
UGTMF = underground tailings management facility; PPL = peak pressure level; DFO = Fisheries and Oceans Canada; kPa = kilopascal.

3.3 Reasonably Foreseeable Development Case

Table 3-8 presents predicted vibration levels for blasting at the Fission Patterson Lake South Property. Because the duration of blasting events is very short (on the order of milliseconds), it is unlikely that Project vibration effects would occur at the same time as vibration effects from the Patterson Lake South Property. Notwithstanding, as a precautionary analysis, Table 3-9 presents predicted cumulative vibration levels during simultaneous blasting at the Project and the Patterson Lake South Property. Cumulative values in Table 3-9 were obtained by summing predicted vibration levels from blasting at the Patterson Lake South Property (Table 3-8) with maximum predicted vibration levels from Project blasting (Table 3-1, Table 3-2, Table 3-3).

Table 3-8: Predicted Vibration Levels for Blasting at the Patterson Lake South Project

Receptor Identification Code	Transverse Blasting				Longitudinal Blasting				Underground Blasting			
	Vibration Predictions for ECCC and ANZEC Analysis		Vibration Predictions for DFO Analysis		Vibration Predictions for ECCC and ANZEC Analysis		Vibration Predictions for DFO Analysis		Vibration Predictions for ECCC and ANZEC Analysis		Vibration Predictions for DFO Analysis	
	PPV (mm/s)	PPL (dBL)	PPV (mm/s)	PPL (kPa)	PPV/ (mm/s)	PPL (dBL)	PPV (mm/s)	PPL (kPa)	PPV (mm/s)	PPL (dBL)	PPV (mm/s)	PPL (kPa)
R-04	0.0	89.1	n/a[(a)]	n/a[(a)]	0.0	89.1	n/a[(a)]	n/a[(a)]	0.0	91.2	n/a[(a)]	n/a[(a)]
R-05	0.0	86.9	n/a[(a)]	n/a[(a)]	0.0	86.9	n/a[(a)]	n/a[(a)]	0.0	89.0	n/a[(a)]	n/a[(a)]
R-06	0.0	86.3	n/a[(a)]	n/a[(a)]	0.0	86.3	n/a[(a)]	n/a[(a)]	0.0	88.4	n/a[(a)]	n/a[(a)]
R-07	0.0	82.6	n/a[(a)]	n/a[(a)]	0.0	82.6	n/a[(a)]	n/a[(a)]	0.0	84.7	n/a[(a)]	n/a[(a)]
R-08	0.0	85.8	n/a[(a)]	n/a[(a)]	0.0	85.8	n/a[(a)]	n/a[(a)]	0.0	87.9	n/a[(a)]	n/a[(a)]
R-09	0.0	90.6	n/a[(a)]	n/a[(a)]	0.0	90.6	n/a[(a)]	n/a[(a)]	0.0	92.7	n/a[(a)]	n/a[(a)]
R-22	n/a[(b)]	101.8	0.3	0	n/a[(b)]	101.8	0.3	0	n/a[(b)]	103.9	0.5	1
R-26	0.0	89.1	n/a[(a)]	n/a[(a)]	0.0	89.1	n/a[(a)]	n/a[(a)]	0.0	91.2	n/a[(a)]	n/a[(a)]
R-30	0.1	99.6	n/a[(a)]	n/a[(a)]	0.1	99.6	n/a[(a)]	n/a[(a)]	0.1	101.7	n/a[(a)]	n/a[(a)]
R-31	0.0	90.6	n/a[(a)]	n/a[(a)]	0.0	90.6	n/a[(a)]	n/a[(a)]	0.0	92.7	n/a[(a)]	n/a[(a)]
R-40	n/a[(b)]	90.5	0.1	0	n/a[(b)]	90.5	0.1	0	n/a[(b)]	92.6	0.1	0
R-41	n/a[(b)]	86.9	0.0	0	n/a[(b)]	86.9	0.0	0	n/a[(b)]	89.0	0.1	0
R-42	n/a[(b)]	98.7	0.2	0	n/a[(b)]	98.7	0.2	0	n/a[(b)]	100.8	0.3	0
R-43	n/a[(b)]	90.0	0.0	0	n/a[(b)]	90.0	0.0	0	n/a[(b)]	92.1	0.1	0
R-48	n/a[(b)]	95.8	0.1	0	n/a[(b)]	95.8	0.1	0	n/a[(b)]	97.9	0.2	0
R-49	n/a[(b)]	98.2	0.2	0	n/a[(b)]	98.2	0.2	0	n/a[(b)]	100.3	0.3	0
R-Fish	n/a[(c)]	n/a[(c)]	0.1	0	n/a[(c)]	n/a[(c)]	0.1	0	n/a[(c)]	n/a[(c)]	0.1	0

a) DFO vibration analysis is not required for terrestrial receptors.

b) ECCC and ANZEC analysis of PPV is not required for human receptors at angling locations.

c) ECCC and ANZEC analysis is not required for aquatic receptors.

PPL = peak pressure level; PPV = peak particle velocity; ECCC = Environment and Climate Change Canada; ANZEC = Australian and New Zealand Environment Council; DFO = Fisheries and Oceans Canada; kPa = kilopascal; dBL = linear decibel.

Table 3-9: Predicted Cumulative Vibration Levels for Simultaneous Blasting at the Project and the Patterson Lake South Property

Receptor Identification Code	Transverse Blasting				Longitudinal Blasting				UGTMF/Underground Blasting			
	Vibration Predictions for ECCC and ANZEC Analysis		Vibration Predictions for DFO Analysis		Vibration Predictions for ECCC and ANZEC Analysis		Vibration Predictions for DFO Analysis		Vibration Predictions for ECCC and ANZEC Analysis		Vibration Predictions for DFO Analysis	
	PPV (mm/s)	PPL (dBL)	PPV (mm/s)	PPL (kPa)	PPV (mm/s)	PPL (dBL)	PPV (mm/s)	PPL (kPa)	PPV (mm/s)	PPL (dBL)	PPV (mm/s)	PPL (kPa)
R-04	0.0	94.7	n/a(a)	n/a(a)	0.0	94.7	n/a(a)	n/a(a)	0.0	96.8	n/a(a)	n/a(a)
R-05	0.0	94.1	n/a(a)	n/a(a)	0.0	94.1	n/a(a)	n/a(a)	0.0	96.2	n/a(a)	n/a(a)
R-06	0.0	93.2	n/a(a)	n/a(a)	0.0	93.2	n/a(a)	n/a(a)	0.0	95.3	n/a(a)	n/a(a)
R-07	0.0	88.8	n/a(a)	n/a(a)	0.0	88.8	n/a(a)	n/a(a)	0.0	90.9	n/a(a)	n/a(a)
R-08	0.0	92.4	n/a(a)	n/a(a)	0.0	92.4	n/a(a)	n/a(a)	0.0	94.6	n/a(a)	n/a(a)
R-09	0.0	96.1	n/a(a)	n/a(a)	0.0	96.1	n/a(a)	n/a(a)	0.1	98.2	n/a(a)	n/a(a)
R-22	n/a(b)	102.8	0.4	0	n/a(b)	102.8	0.4	0	n/a(b)	104.9	0.7	1
R-26	0.0	96.2	n/a(a)	n/a(a)	0.0	96.2	n/a(a)	n/a(a)	0.1	98.3	n/a(a)	n/a(a)
R-30	0.1	101.6	n/a(a)	n/a(a)	0.1	101.6	n/a(a)	n/a(a)	0.2	103.7	n/a(a)	n/a(a)
R-31	0.0	96.1	n/a(a)	n/a(a)	0.0	96.1	n/a(a)	n/a(a)	0.1	98.2	n/a(a)	n/a(a)
R-40	n/a(b)	92.8	0.1	0	n/a(b)	92.8	0.1	0	n/a(b)	94.9	0.2	0
R-41	n/a(b)	99.4	0.2	0	n/a(b)	99.4	0.2	0	n/a(b)	101.5	0.4	0
R-42	n/a(b)	99.9	0.3	0	n/a(b)	99.9	0.3	0	n/a(b)	102.0	0.4	0
R-43	n/a(b)	94.0	0.1	0	n/a(b)	94.0	0.1	0	n/a(b)	96.1	0.2	0
R-48	n/a(b)	101.8	0.4	0	n/a(b)	101.8	0.4	0	n/a(b)	103.9	0.6	1
R-49	n/a(b)	100.7	0.4	0	n/a(b)	100.7	0.4	0	n/a(b)	102.8	0.5	0
R-Fish	n/a(c)	n/a(c)	8.1	10	n/a(c)	n/a(c)	8.1	10	n/a(c)	n/a(c)	13.0	17

a) DFO vibration analysis is not required for terrestrial receptors.

b) ECCC and ANZEC analysis of PPV is not required for human receptors at angling locations.

c) ECCC and ANZEC analysis is not required for aquatic receptors.

UGTMF = underground tailings management facility; PPL = peak pressure level; PPV = peak particle velocity; ECCC = Environment and Climate Change Canada; ANZEC = Australian and New Zealand Environment Council; DFO = Fisheries and Oceans Canada; kPa = kilopascal; dBL = linear decibel.

Table 3-10 compares maximum predicted cumulative PPV values to ECCC and ANZEC thresholds for each terrestrial receptor. Table 3-11 compares maximum predicted cumulative PPL values to ECCC and ANZEC thresholds for each terrestrial receptor and each human receptor at an angling location. Table 3-12 compares maximum predicted cumulative PPV values to the DFO threshold for each aquatic receptor. Table 3-13 compares maximum predicted cumulative PPL values to the DFO threshold for each aquatic receptor. By focusing on the maximum predicted cumulative PPV or PPL value at each receptor, the results presented in Table 3-10, Table 3-11, Table 3-12, and Table 3-13 represent a precautionary analysis of vibration effects from the Project and the Patterson Lake South Property.

Table 3-10: Comparison of Cumulative Peak Particle Velocity to Environment and Climate Change Canada and Australian and New Zealand Environment Council Thresholds

Receptor Identification Code	PPV Thresholds (mm/s)		Cumulative Blasting Scenario with Maximum PPV	Maximum PPV (mm/s)	Result
	ECCC[(a)]	ANZEC[(b)]			
R-04	12.5	5.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	0.0	Maximum PPV is less than ECCC and ANZEC thresholds
R-05	12.5	5.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	0.0	
R-06	12.5	5.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	0.0	
R-07	12.5	5.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	0.0	
R-08	12.5	5.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	0.0	
R-09	12.5	5.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	0.1	
R-26	12.5	5.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	0.1	
R-30	12.5	5.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	0.2	
R-31	12.5	5.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	0.1	

a) PPV threshold from ECCC document (Environment Canada 2009).

b) PPV threshold from ANZEC document (ANZEC 1990).

UGTMF = underground tailings management facility; PPV = peak particle velocity; ECCC = Environment and Climate Change Canada; ANZEC = Australian and New Zealand Environment Council.

Table 3-11: Comparison of Cumulative Peak Pressure Level Based to Environment and Climate Change Canada and Australian and New Zealand Environment Council Thresholds

Receptor Identification Code	PPL Thresholds (dBL)		Cumulative Blasting Scenario with Maximum PPL	Maximum PPV (dBL)	Result
	ECCC[(a)]	ANZEC[(b)]			
R-04	128.0	115.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	96.8	Maximum PPL is less than ECCC and ANZEC thresholds
R-05	128.0	115.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	96.2	
R-06	128.0	115.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	95.3	
R-07	128.0	115.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	90.9	
R-08	128.0	115.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	94.6	
R-09	128.0	115.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	98.2	
R-22	128.0	115.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	104.9	
R-26	128.0	115.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	98.3	
R-30	128.0	115.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	103.7	
R-31	128.0	115.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	98.2	
R-40	128.0	115.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	94.9	
R-41	128.0	115.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	101.5	
R-42	128.0	115.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	102.0	
R-43	128.0	115.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	96.1	
R-48	128.0	115.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	103.9	
R-49	128.0	115.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	102.8	

a) PPL threshold from ECCC document (Environment Canada 2009).

b) PPL threshold from ANZEC document (ANZEC 1990).

UGTMF = underground tailings management facility; PPL = peak pressure level; PPV = peak particle velocity; ECCC = Environment and Climate Change Canada; ANZEC = Australian and New Zealand Environment Council; dBL = linear decibel.

Table 3-12: Comparison of Cumulative Peak Particle Velocity to Fisheries and Oceans Canada Thresholds

Receptor Identification Code	DFO PPV Threshold[a] (mm/s)	Cumulative Blasting Scenario with Maximum PPV	Maximum PPV (mm/s)	Result
R-22	13.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	0.7	Maximum PPV is less than DFO threshold
R-40	13.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	0.2	
R-41	13.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	0.4	
R-42	13.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	0.4	
R-43	13.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	0.2	
R-48	13.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	0.6	
R-49	13.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	0.5	
R-Fish	13.0	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	13.0	Maximum PPV is equal to DFO threshold

a) PPV threshold from DFO guidance document (Wright and Hopky 1998).

UGTMF = underground tailings management facility; PPV = peak particle velocity; DFO = Fisheries and Oceans Canada.

Table 3-13: Comparison of Cumulative Peak Pressure Level to Fisheries and Oceans Canada Thresholds

Receptor Identification Code	DFO PPL Threshold (kPa)[a]	Blasting Scenario with Maximum PPL	Maximum PPL (kPa)	Result
R-22	50	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	1	Maximum PPL is less than DFO threshold
R-40	50	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	0	
R-41	50	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	0	
R-42	50	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	0	
R-43	50	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	0	
R-48	50	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	1	
R-49	50	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	0	
R-Fish	50	Simultaneous UGTMF blasting at the Project and underground blasting at the Patterson Lake South Property	17	

a) PPL threshold from DFO guidance document (Wright and Hopky 1998; Cott and Hanna 2005).

UGTMF = underground tailings management facility; PPL = peak pressure level; DFO = Fisheries and Oceans Canada; kPa = kilopascal.

4.0 CONCLUSION

Through NexGen’s community engagement program, Indigenous Groups and local communities selected the location of 16 terrestrial receptors and human receptors at angling locations. These receptors correspond to the closest known human presence within the vibration study area and were used to predict the effects of vibration from Project blasting on fish habitat and people.

The vibration analysis also predicted effects from Project blasting at a conceptual receptor. The conceptual receptor corresponds to the point within Patterson Lake nearest the anticipated location of Project blasting. This conceptual receptor was included to capture maximum vibration levels for comparison with DFO thresholds.

The vibration analysis considered vibration from Project blasting (Application Case) and vibration from simultaneous blasting at the Project and the Patterson Lake South Property (RFD Case). The Patterson Lake South Property is a proposed future development (RFD) in the vibration study area. Because the duration of blasting events is very short (on the order of milliseconds), it is unlikely that Project vibration effects would occur at the same time as vibration effects from the Patterson Lake South Property. Notwithstanding, by considering cumulative vibration levels, the results presented in the vibration analysis represent a precautionary analysis of vibration effects from the Project and the Patterson Lake South Property.

Results from the analyses predict that ground vibration (PPV) and overpressure (movement of air or water; PPL) from Project blasting and from blasting anticipated at the Patterson Lake South Property would be less than vibration thresholds from the ECCC guidance document (Environment Canada 2009) and the ANZEC guidance document (ANZEC 1990) at each of the 16 receptors identified by Indigenous Groups and local communities. These results indicate that vibration from blasting activities would not result in human annoyance or cosmetic damage to structures at any sensitive receptors in the vibration study area.

Similarly, results from the analyses predict that ground vibration and overpressure from Project blasting and from blasting anticipated at the Patterson Lake South Property would not exceed vibration thresholds from the DFO guidance documents (Wright and Hopky 1998; Cott and Hanna 2005). These results indicate that vibration from blasting activities would not result in adverse effects on general fish habitat or fish spawning habitat in the vibration study area.

Signature Page

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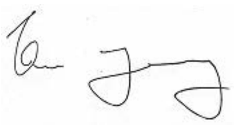

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